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FUSULINIDAE OF NORTH CHINA

BY

JONQUEI S. LEE

PLATES I-XXIV, 1 CHART AND 21 TEXT-FIGURES.

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ERRATA

p. 7 line 17 *for* "morely" *read* more
p. 15 line 31 and p. 38 line 34 *for* "LICALITY" *read* LOCALITY
p. 18 line 34 *for* "with" *read* width
p. 23 line 16 *insert* of *after* "type"
p. 27 line 23 *for* "then" *read* than
p. 31 line 25 *insert* the *after* "development"
p. 36 line 1 *for* "excedingly" *read* exceedingly
p. 38 line 3 *for* "Russian" *read* Russia
p. 40 line 32 *for* "structure" *read* structural
p. 56 line 28 *for* "macropheric" *read* macrospheric
p. 58 line 19 *for* "of the" *read* the height of
p. 62 line 17 *for* "seams" *read* seems
p. 78 line 21 *for* "comparision" *read* comparison
p. 80 line 18 *for* "chaber" *read* chamber
p. 82 line 30 *for* "l' Extreme Orient" *read* l'Étude etc.
p. 86 line 17 *for* "and and" *read* and the
p. 88 line 9 *insert* by *after* "described"
p. 93 line 7 and p. 94 line 30 *for* "preceeding" *read* preceding
p. 97 line 9 *for* "Fig. ?" *read* Fig. 17

FUSULINIDÆ
OF
NORTH CHINA

INTRODUCTION

Nearly four years have passed since the first microsection of fusulinoid Foraminifera from the Carboniferous rocks of North China was prepared in the Palæontological Laboratory of the National University, Peking. The material then available, though only of a trifling amount, gave out some indication that we were touching a field which, when systematically explored, might throw fresh light upon the development of the Upper Palæozoic rocks over the wide expanse of Eurasia and the life-history of these highly specialized Foraminifera.

As an aspiring response to a subsequent inquiry into the possible access to more material, Dr. W. H. Wong, the Director of the Geological Survey of China, happily placed at the author's disposal a few packets of "Fusulina Limestones" that had been gathered at different times and from different localities by the staff of the Survey, and had not received any particular attention in the laboratory.

Unfortunately the material was for the most part not labeled in such a way as is necessarily required for our purpose. A more systematic collection was then started, and has been carried on from time to time both by the field-staff of the Survey and the author himself paying particular attention, in each case, to the stratigraphical position of the material collected. Our field work naturally began from the north; for, in this part of the country not only is there a successive development of Fusulina-bearing limestones intercalated in the Coal Measures but nowhere in the large and small coal-basins do we encounter any complicated disturbance that might have thrown doubt on the stratigraphical succession of the fossiliferous beds.

At the same time no effort was spared on the part of the author in preparing microsections of different species and individuals with a view to securing their proper

orientation. Serial sections are also prepared of one and the same individual; and are found helpful, in some cases, for three dimensional interpretation of certain features revealed in the axial or median sections. They are however by no means essential for specific determination, and consequently are considered unworthy of photographic record. Up to this date more than 1500 pieces of oriented thin-sections have accumulated in our laboratory.

It is true that the material now in the author's possession only represents a very small fraction of the great masses of limestones of the Carboniferous and Permian Periods so extensively distributed all over China. But the specimens that have been so far prepared and examined are derived from materials collected from widely separated localities and various horizons so that it appears not unwarranted that herein something of the general faunistic character is to be found. The cumulative results obtained in the last three years ought then to mark the first step in the attempt of a more exhaustive investigation.

There is another reason, perhaps in a way more cogent, for publishing, at this stage, a summarized view of the materials from North China alone, namely the faunistic unity. Although we may not be inclined to attach much weight to E. Schellwien's remark on the "provincial character" of *Fusulinas*, yet informations from different parts of China seem to do this able writer some justice. When a comparison is made between the Fusulina-fauna of South China and that of the northern basins no unbiassed judge can fail to admit the remarkable difference between the two faunas. Those that flourished in North China are in numerous instances either identical with, or closely related to the species found in the Russo-Arctic region; while those that lived in the south generally show, with the exception of a few Alpine forms, a wide divergence from the northern fauna, and are often characterized by forms found in Indo-China. The long range of the Tsinling which runs across Central China nearly from the west to the east apparently marks the boundary between the two faunistic provinces. Only occasionally do we find in the northern province species that are characteristic of the Salt Range fauna. This faunal distribution suggests then a natural basis on which the subject-matter of the present work may be conveniently divided.

A third reason for publishing, at present, a partial result is its important, though still ill-understood bearing upon the problems of coal-mining in North China, which have just begun, in one way or another, to claim the attention of the mining engineer and far-sighted enterpriser. To the owner of a small productive area in which mining activity is already well under its way this statement may sound absurd; but when we

come to consider the development of the various coal-basins at large, and incidentally the distribution of the workable seams, etc. an accurate knowledge of stratigraphy would seem a factor of paramount importance.

It is partially from these considerations that I have published elsewhere a preliminary stratigraphical summary*. Here in this volume only the succession of the limestones and their contained Fusulinidæ are tabulated. Any assertion concerning the vertical range of an organic form must be necessarily qualified by the extent to which exploration is made. And it must be remembered that the specific identification of the organisms in question, unlike the case with megascopic forms, involves a rather lengthy process and consequently labour and time. The absence of a particular species in a handful of material collected from a higher horizon does not necessarily mean its extinction. Moreover it is an unquestionable fact that *Fusulinas* are gregarious animals. A single species may build up a whole stratum of limestone at one locality; while at another another species may crowd in the same rock. Against these possibilities the stratigrapher therefore has to be constantly on his guard. It is a matter of surprise that these fundamental considerations are sometimes apparently neglected by eminent writers.

Being bent on the effort in a general survey of the different species and their distribution, I have stressfully avoided in this early part of the work, discussions that should be properly attributed to the biological side of the problem. Such phenomena like dimorphism, cell-fusion, convergent development etc. are only incidentally mentioned or briefly discussed in so far as they affect specific determination. A special chapter is provided in the later part of this work for a fuller discussion of problems concerning morphology, physiology, physical and faunistic environment, evolution and eventually natural classification of the whole family of Fusulinidæ.

Some two years ago, I endeavoured to formulate a graphic method for treating more or less systematically the organisms to be dealt with in the present work. I am particularly happy to note that a similar method is independently developed and applied by Mlle. Colani whose recent contribution has indeed done much to further our knowledge regarding this particular group of Foraminifera. As my work proceeded, I find however that the specific characters of most species are quite manifest before they are subject to that systematic treatment. In ordinary cases, graphs showing the widths of the successive volutions are sufficient to distinguish a species from its related forms. Only when we come to consider the minute variations of the sufficiently well preserved

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* Lee, J. S. Classification and Correlation of the Palæozoic Coal-bearing Formation in North China etc., Bull. Geol. Soc. China, Vol. V, No. 2, pp. 113-134.

material, the whole series of graphs may be called to the aid. For the economy of time and labour, I have not therefore strictly followed this plan of working in preparing the present volume.

In making a brief acknowledgement, I would first of all tender my thanks to Dr. V. K. Ting and Dr. W. H. Wong, the Directors of the Geological Survey of China, for granting me the facility in all possible ways to carry on the present research; and to many competent members of the Survey who have brought home large quantities of material from the field. Of special importance and interest are the specimens collected by Mr. P. L. Yuan from the remote region of western Kansu. They are nearly all in a splendid state of preservation, and serve to assure the close faunistic relation between the Near and the Far East in the Upper Carboniferous time. Valuable assistance is also rendered by Mr. Y. T. Chao who has been, during my research, not only an ever-ready collaborator in the laboratory, but has made many important collections from North China. It is largely due to his and Mr. C. C. Tien's painstaking work on the stratigraphy of the coal-bearing series on the eastern side of the Taihang Range that we are enabled to obtain some notion as to the vertical distribution of many common species of *Fusulina*.

An interesting assemblage of primitive forms of Fusulinidæ was collected from a point 200 k. m. north of Kalgan by Pères Licent and Teilhard de Chardin whose epoch-marking discovery of Palæolithic remains in the Ordos has justly aroused a wide interest in the scientific world. Although this is not the place to discuss the relative significance of these finds it is certainly a matter of no small concern to a student of Palæozoic Foraminifera and palæogeography to have gained access to material from so remote a country. To the astute observation of these explorers I take this opportunity to express my indebtedness.

With equally high appreciation I received, through Mr. B. Toheida, several packets of material from the Geological Institute attached to the South Manchurian Railway Company. It is through this material that we are enabled to recognize for the first time the Moscovian age of the Penchihu Formation.

More especially I must mention with gratitude the cordial cooporation in connection with my research of our friends abroad. Prof. E. Stensiö of the Riksmuseum, Stockholm, and Prof. C. Wiman of the Upsala University have unreservedly sent to the Director of the Geological Survey of China large quantities of material obtained from Spitzbergen in the form of hand-specimen as well as prepared sections among which are the commemorable microslides once examined by Goës and Schellwien. The Materials were at once turned over to me on their arrival at the Survey.

Through the kindness of Dr. D. Barton, I have also had the good fortune of being able to communicate with Mrs. E. R. Applin and Mrs. F. B. Plummer who have encouraged the author to extend his field of investigation by actually allowing him to share their personal collections, without which it would have been impossible to determine the affinity or divergence between the Chinese fauna and that on the other side of the Pacific Water. I am particularly indebted to Mrs. Plummer for cordially supplying me with first hand information regarding the succession of the Fusulina-bearing beds in the Guadalupe Mountains.

While attending the bicentenary Jubilee of the Russian Academy of Science, I had the honour of receiving, as a friendly gift, several packets of classical material from the Comité Géologique in Leningrad, and from Prof. A. P. Pavlow of the Moscow University; and in a memorable excursion into the environs of Moscow I was given an opportunity to locate, through the most hospitable and able guidance of Mlle. Marie Bolkhovitinoff, Prof. N. N. Smirnoff, and Prof. D. Ilovaisky, a faunal zone which has since been proved to be almost identical with our Penchihu Formation. In this connection, I should mention, as a token of exceedingly pleasant companionship, Baron S. Nopca, the Director of the Hungarian Geological Survey, and Dr. D. L. Stamp of the Rangoon University who were also present in that excursion.

My thanks are due to Mr. Y. Akasegawa for the final drawing of the graphs; and to Mr. K. H. Hsü for assisting in the microphotographic work.

Finally, it is my privilege to express my deep appreciation for the cordial help of my experienced colleague, Dr. A. W. Grabau, in reading some of the proof sheets and in making the bold attempt of introducing the needed new terms for specific description.

I. GENERAL REMARKS.

DISTRIBUTION OF FUSULINIDÆ IN NORTH CHINA.

Of the numerous Palæozoic coalfields in North China there are only a few, for instance, those located in the area of north-western Chihli, wherefrom Fusulina Limestone is absent. And only a few of the Fusulina Limestones are not crowded, in one locality or another, with fusulinoid Foraminifera. At any given locality, the Fusulina Limestone, when developed at all, is usually represented by more than one layer; sometimes as many as seven or eight. These are always distributed stratigraphically in the lower part of the coal-bearing formation which, in the north-eastern part of the country, always rests disconformably upon the Ordovician Limestone and underlies a hard, massive quartz sandstone—the Millstone—probably of Permian age; in the Shansi plateau it is likewise underlain by the Ordovician Limestone and overlain by a group of barren sandstones and shales equivalent to the Millstone; and in the extreme north-west, *i. e.* along the northern foot of the Nanshan Range, it overlies the Nanshan Sandstone or granite of pre-Cambrian age and underlies a thick series of variegated sandstones belonging to the Permian Period.

The rocks interstratified with the Fusulina Limestones are usually shales, sandstones, claystones and coals totalling to a thickness of 100 to 300 m. These purely terrigenous sediments, as may be readily understood from their conditions of deposition, are always variable in their lithological character and thickness even within a limited area; whereas their intercalated Fusulina Limestones being essentially marine, generally persist to a considerable lateral extent. Only the thinnest layers sometimes thin out within a visible distance.

For the convenience of stratigraphical description it is therefore desirable to apply local names to the more persistent limestones in the coal-bearing formation. They are arranged in the accompanying chart in their natural order with a list of their imbedded Fusulinidæ.

It is to be understood at the outset that the tabulated localities and horizons are far from being exhaustive. All that we know at present concerning the distribution of the Fusulina Limestones in North China may be briefly stated as follows:

There are several layers that occur in the coalfields of Penchihu, Yentai and Wuhutsui, South Manchuria; one layer in the highland of Inner Mongolia, being exposed, according to Père Teilhard de Chardin, at a point about 200 k. m. north of Kalgan; and one or two layers in the Kaiping Basin.

In the western and south-western part of the province of Shantung three isolated areas are known, where Fusulina Limestones are developed. They are the Poshan-Heishan area, the Changchiu coalfield and the Yihsien coalfield. In the first area Fusulinidæ are rather rare, but brachiopoda abound. In the second and the third areas Fusulinidæ are often crowded in the limestones intercalated in the coal-bearing series. These marine beds probably extend discontinuously into the north-eastern part of the province of Anhui.

More connected and more extensive is their development in the area of southern Chihli, northern Honan, and in the numerous coalfields of Shansi. They are present practically in all the coalfields on the eastern and south-eastern sides of the Taihang Range. Several layers of them are found in the Chinhsin, Lincheng, Shaho, Tzechou and Liuhokou coalfields extending probably further to the south. As the Taihang Range sweeps round towards the west, the flanking coal-bearing series with one or two Fusulina Limestones are preserved in the basins of Chincheng, Hsinan, Mihhsien, Konghsien and Shenhsien. These coalfields arrange themselves approximately in the same trend as the range which is in fact the border of the table-land of Shansi.

In the province of Shansi the distribution of Fusulina Limestones is believed to be more or less co-extensive with the coal seams. As this province is practically a vast coalfield, so it is a vast area for the development of Fusulina Limestones. Their succession has been however only worked out in the Pinting Basin, the Paotehchou District and in several other productive areas on both sides of the Taiyuan Plain.

No Fusulina Limestone has yet been found in the province of Shensi. But it is believed to occur in the Carboniferous formation developed in the southern part of the province; for, further north-west, there are several isolated coalfields distributed along the foothills of the Nanshan Range, north-western Kansu. In these coalfields several beds of Fusulina Limestones usually occur. There, we find a channel of communication linking Eastern Asia on to Central Asia, Asia Minor and South-eastern Europe in the Carboniferous times.

As shown in the tabulated list, the Fusulinidæ so far found in these limestones belong to the lower members of the family. Apart from a few scattered occurrences of *Schwagerina*, the higher members or the deep water facies of the family, such as *Verbeekina*, *Neoschwagerina*, *Doliolina*, *Yabeina* and *Sumatrina* are altogether absent.

Among the 47 species described in this volume 17 are new; 7 were found in the Carnic Alps; 2 found in the upper part of the Lower Productus Limestone of the Salt Range; 2 found in the Darwas district, Central Asia; 6 have been hitherto found only in Eastern Asia; 1, namely *Schwagerina princeps*, is a true cosmopolitan form; and the rest are either identical with or closely related to those occurring in the Russo-Arctic region. Some of these northern species are extraordinarily abundant in individual, though specifically they do not represent the majority. The fauna as a whole points unavoidably to the conclusion that a more or less free faunal communication was maintained between China and Russia during the later part of the Carboniferous period. Strange is the fact that there are few elements in common with the Fusulinidæ-fauna of South-western China and Indo-China except those that flourished in the Moscovian time, such as *Fusulinella sphæroidea*, *Neofusulinella schwagerinoides* etc. And among the common elements there are those which are also found in Russia. Therefore they can be of no provincial significance. The inference would thus seem highly suggestive that in the Upper Carboniferous time a barrier either in the form of land or of deep water* must have existed somewhere across Central China, rendering the two faunæ remarkably distinct. The absence of Upper Carboniferous formation from the Gorge district of the Yangtze tends to show that the barrier was rather a land than deep water.

In the early days of my research I found certain forms that seemed to bear some resemblance to the North American forms. But after an extended survey of the materials, I failed to obtain any corroborating evidence. On the contrary, the excellent specimens collected by Mrs. F. B. Plummer and Mrs. E. R. Applin from Texas and the Guadalupe Mountains have convinced me that the relation between our fauna and that of North America, at least the South-western part of North America, is distantly remote. We may say that throughout the Upper Carboniferous time the Pacific water and the Greater Mediterranean were obviously kept apart as far as the evidence furnished by these Foraminifera is concerned.

Such are the essential facts regarding the broader relations of our fauna. We may now consider the vertical distribution of its more salient elements as observed in the several typical sections in North China with a view to establishing a palæontological classification of their containing rocks.

For reasons stated elsewhere (See p. v), I have refrained, at present, from attempting a detailed zoning by means of the fossils under consideration, though such a procedure is, in some cases, demonstrably possible. When however we view the several assemblages of Fusulinidæ procured from different localities and different horizons from a

* There is abundant evidence to show that the *Fusulina*-fauna is largely of shallow water habit.

broader perspective, they fall at once into two groups or faunæ between which a sharp demarcation cannot fail to impress itself upon our notice. These two faunæ, unlike the brachiopoda, arrange themselves in a well defined stratigraphical succession or chronological order. As far as North China is concerned, wherever the two faunæ occur in the same section there is no overlap or transition, as if there had been a break of life sequence at the horizon where the one replaces the other. The lower or the older fauna is characterized by *Fusulinella sphæroidea, Neofusulinella bocki, Girtyina konnoi, Girtyina cylindrica, Bradyina nautiliformis* etc. being obviously of Moscovian age; and the upper or the younger fauna comprises a large number of well developed species of *Schellwienia* and *Schwagerina*. The evidence is so overwhelming that in the foraminiferal fauna itself there seems hardly any ground to deny its Uralian age.

This palæontological fact together with the scarcity or absence of coal-seams from the lower part of the so-called Taiyuan Series of North China necessitates the establishment of a new division in the coal-bearing formation, and at the same time the restriction of the old term, Taiyuan. In general, the coal-bearing formation should then be classified into three series as follows:—

Upper, or Shansi Series	Almost entirely terrigenous deposits, sometimes contains a thick coal-seam; age: Permo-Carboniferous or Lower Permian.
Middle, or Taiyuan Series	Terrigenous deposits interstratified with marine limestones crowded with large and small individuals of *Schellwienia* and numerous thin coal-seams, sometimes with a thick coal near the base; age: Upper Carboniferous.
Lower, or Penchi Series	Terrigenous deposits seldom contains thin layers of coal, always with a few layers of limestones containing minute *Fusulinella* and *Girtyina* often almost invisible to the naked eye; age: Middle Carboniferous.

TERMINOLOGY OF THE COMMON STRUCTURAL ELEMENTS IN BOULTONIA, FUSULINELLA AND FUSULINA

The structure of the family Fusulinidæ, and more especially of its lower members, has been most exhaustively discussed by Möller, Schwager, Schellwien, Douvillé, Yabe, Staff and others. Of the writings of these authors concerning the anatomy of this particular group of Foraminifera von Staff's contributions are perhaps the most important. There is hardly any feature in these fossils observed under the microscope that can now evade the correct interpretation. Nevertheless palæontologists are still in the habit of using awkward phrases or indefinite and sometimes positively misleading terms in the description of several definitely understood structural elements as well as certain salient morphological characters.

To facilitate a systematic description and to remove the possible misconceptions on the part of the elementary students, it is deemed desirable to revise or redefine those old terms which merit that treatment or to introduce new ones in case of absolute necessity.

With this object in view the author made a general attempt sometime ago.* As the present volume only deals with the lower members of the family, some of the features which only appear in the higher forms may, for the present, be left out of consideration. We will then confine ourselves to the discussion of the following terms:— (Compare Pl. I).

Chambers.

All species of Fusulinidæ are internally divided by walls and partitions into numerous chambers. Each chamber marks a definite step of the animal's growth. The chambers may be distinguished as of two kinds. The central or initial or embryonal chamber is generally of a spherical or spheroidal form with an enclosing wall, termed the wall of the initial chamber, and an aperture for external communication. To the initial chamber are attached successively a

* Lee, J. S., Bull. Geol. Soc. China. Vol. III, No. 1, p. 14, 1924.

series of chambers being arranged, as a whole, in a spiral form. These chambers may be called the spiral chambers.

THECA.

All walls of the spiral chambers are collectively termed the theca which consists of three structural elements, *i. e.* tectum, osseum and tectorium, when fully developed; but sometimes only two, *i. e.* tectum and osseum, while rarely only one of them, *i. e.* tectum, is present. According to its position the theca may be divided in two parts named below.

SPIROTHECA.

The spiral or the superior part of the theca for each spiral chamber is called the spirotheca, formerly known as the "Wall", "revolving wall", "Kammerwandung", "Aussenwand" etc.

ANTETHECA.

The anterior or the radial part of the theca for each chamber is named the antetheca, equivalent to the old term "septa" or "cloison". As this part is the radial continuation of the same theca, and as the term, septa, can be used more appropriately when we come to deal with the higher forms of Fusulinidæ, it appears justifiable to introduce a new name for the radial wall, and reserve the term septa for the other purpose.

Unlike the spirotheca which is always non-porous throughout the family, the antetheca is usually punctured in its lower part both in *Schwagerina* and *Schellwienia;* but sometimes the pores are not observed in the latter subgenus.

TECTUM.

No matter how the theca is constructed, there is in it always an exceedingly thin and almost opaque layer of testaceous substance that forms invariably the exterior cover of the osseum (see below) in the spirotheca. As the spirotheca curves round, this dark lamella is either left alone or supported by some supplementary structure to form the antetheca. It has been styled a "lame spirale" or "Dachblatt". Since it does not always occupy the spiral position the first name is obviously unsuitable. I would then call it the tectum after the German term, Dachblatt.

OSSEUM.

This is the principal part or the thickest layer that enters into the composition of the spirotheca. It is always composed of a distinctly more

transparent substance than that of the tectum or of the tectorium. Careful examination shows that this lighter layer is by no means homogeneous, but always consists of a honey-combed structure (Wabenwerk, réseau alveolaire) with the individual and sometimes bifurcating tubes and pillars arranged more or less perpendicularly to the surface of the theca. The pillars (poutrelles) and tubes are, in the case of *Schellwienia* and *Schwagerina*, usually coarse and very distinct; but in the case of *Staffella, Neofusulinella, Girtyina* etc. they are usually exceedingly fine and indistinct, and often entirely unobservable—a fact which has led many previous observers erroneously to conclude that these forms possess a solid wall I have also formerly accepted this view, and proposed the term, macula, for this lighter layer when it is distinctly honey-combed. As a sharp demarcation in the distinctness of this feature does not exist I would withdraw my formerly suggested term macula, and replace it by osseum.

TECTORIUM.

The interior of the spiral chamber of all *Staffella, Neofusulinella, Girtyina* and even in the inner volutions of certain *Schellwienia* is sometimes thinly and sometimes morely thickly lined with a dark layer comparable with the plaster-layer of human dwellings. It is usually much thicker on the superior or spiral part of the wall; less so on the posterior and anterior parts of it; and thinnest on, or even sometimes absent from the floor which is the external surface of the spirotheca in the preceding whorl. The substance is generally uniform and rather opaque, but occasionally it appears to show traces of alveolar structure in the superior part similar to the osseum. It is on account of this peculiarity together with the fact that this feature is constantly present in the primitive forms of Fusulinidæ I find it difficult to accept Staff's view that this element is but a layer of deposit formed during the process of fossilization. Instead of the phrase "Deposition layer" * which seems to suggest a secondary formation, I would now, for the sake of simplicity and definiteness, call it tectorium.

As an illustration of this feature we may use Möller's classical figure. (Fig. 1). According to our interpretation and terminology, the layer *a* corresponds to tectum, *c* osseum, *b* and *d* tectorium, the last-named two layers are but different parts of the

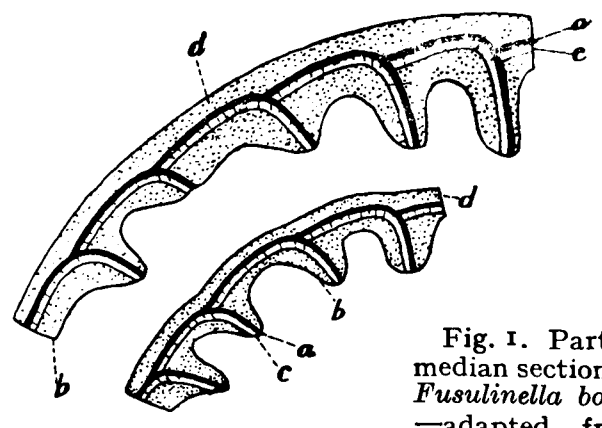

Fig. 1. Partial median section of *Fusulinella bocki* —adapted from Möller.

* Ozawa, Y., On the classification of Fusulinidæ, Journ. Coll. Scien. Tokyo, Vol. XLV, Art. 4, P. 5.

same structural element. Möller applied the term "Supplementärskelet" only to the outer layer *(a)* because he failed to recognize the fact that they were formed through one genetic process, and only differ from each other in that the one *(b)* was added on to the superior and lateral walls of the chamber while the other *(c)* was deposited as a pavement, as it were, on the floor of the same chamber. The fact that in the outermost whorl no tectorium is deposited on the external side of the spirotheca serves as clear evidence for this interpretation.

BUCCAL APERTURE.

With the exception of a few species of *Schellwienia* the lower part of the antethecæ in *Fusulinella* and *Fusulina* is generally left open in the median region. This opening or buccal aperture is either of a crescentic form or in the shape of a slit, and serves obviously as the main passage from chamber to chamber. In those ill-understood forms which appear to possess no special buccal aperture, the numerous anterior openings produced through the folding and up-turning of the lower edge of the antethecæ probably performed the same function as did the buccal aperture.

ANULI.

Throughout the lower members of Fusulinidæ including certain species of *Schellwienia* and *Schwagerina* a pair of low ridges exists in their median part. They follow the course of the spirotheca with an ever-widening tendency, and form, so to speak, two dams, one on each side of the main passage of the sarcode. In the axial section they appear as two dark patches or spots of semilunar or hemi-elliptic, or rectangular shape one on each side of the buccal aperture. They were noticed for the first time by Möller, but their significance had not been appreciated until a more detailed investigation was made by Staff who names them "Medialreifen". As there is no equivalent universal term I propose to call them anuli. Staff seems to believe that they are all of the same type of structure and the same origin, and interprets them as moraine-like deposit on both sides of the exuding sarcode. After a close investigation of the Spitzbergen, American and our Chinese material I begin to be impressed by the fact that there are two different types of structure that constitute the so-called "Medialreifen".

In the one case, the ridges or rings are positively solid. But in the solid masses there are numerous fine, dark lines radiating out from their bases when viewed in the axial section. On reaching the curved surface of the ridge, the lines are bent to such an extent as to arrange themselves almost perpendicularly to that portion of the surface at which they are to terminate.

Unfortunately I have not obtained any adequate oblique section so as to determine whether these lines represent a sectional view of a laminated arrangement or an alveolar structure. Nevertheless the latter is judged to be more probably the case because the radiating lines present exactly the same appearance as those in the adjacent osseum, and with them they are apparently connected. Such type of ridges are regarded as true anuli.

In the other case, the rings are evidently produced through the thickening of the antethecæ toward the edge of the buccal aperture and consequent fusion of their lower parts. In the serial sections one often sees that the border of the buccal aperture is thickened and strongly recurved. The recurved part is more or less completely filled with lime which reveals no such fine structure as in the true anuli. When such a feature is axially sectioned two black patches would appear on opposite sides of the buccal aperture. But if the infolded space is not entirely filled with lime, then there appear thickened loops in the axial section. This would account for the fact that in one and the same species of *Schellwienia*, and even in the different volutions of the same individual the buccal rings or anuli are some somestimes apparently present and sometimes absent. Such a feature which is evidently developed only through calcareous accretion in the infolded space on the apertural border of the antethecæ may be called pseudo-anuli.

Axial Ratio.

One of the important morphological characters of all Fusulinidæ is the ratio between the axial length of each whorl, namely the length from one umbilical end to the other and the width or breadth of the same whorl in the median position which gives *ipso facto* the maximum width of that whorl. This ratio is termed the axial ratio of that whorl in the absence of a better denotation. The axial ratio of the fully grown test may be called for the sake of simplicity merely the axial ratio.

II. DESCRIPTION OF SPECIES.

Genus **BOULTONIA** Lee (gen. nov.)

Test exceedingly minute, primitive in structure, developed through two distinctly different stages: The early stage is generally endothyroid with an axial ratio of less than 1:1 and with its axis of convolution making a large angle with that of the later whorls which are always elongately fusiform.

In the later stage of development, the antethecæ are regularly and very gently plicated in the median portion but rather notably infolded towards the umbilical ends. Spirotheca rather thin composed of tectum and osseum which latter only rarely reveals indistinct traces of an alveolar structure but more often appears to be homogeneous and solid. Anuli well developed; buccal aperture well defined.

The most remarkable feature of this genus is perhaps the skew arrangement of the axes of its inner and outer convolutions. A similar phenomenon is observed in certain forms of *Fusulinella* and *Verbeekina* indicating, in all probability, their derivation from a common ancestor, namely *Endothyra*. But the wide divergence in their later development is no less pronounced between the present genus and *Fusulinella* than between *Fusulinella* and *Verbeekina*.

The name of this genus and of the two species described below are chosen in honour of Prof. W. S. Boulton, Dr. L. J. Wills and Mr. F. Raw respectively, of the University of Birmingham. Genotype: *Boultonia willsi*.

Boultonia willsi Lee (sp. nov.)

Pl. II, Figs. 1-4

As noted in its generic diagnosis, test of this species is clearly divided into two stages: In the first stage which consists of no more than two whorls, the chambers are discoidally wound with a slightly overlapping tendency on the lateral sides as the whorl proceeds. Thus it suggests the type of structure of certain *Endothyra*. With the commencement of the second stage of growth, a remarkable change takes place in the shape of the test. Instead of being endothyroid, it now becomes distinctly fusiform. The striking phenomenon is that the axis of the whorls or the direction of elongation in the second stage of growth is turned for about 90° against the axis of the whorls in the first stage.

The first stage consists of about 15 to 16 chambers in the fully developed individuals. In some cases there appears to be no more than 10. Because of their minute size and ill-definition it is often not possible to count the number at all.

In the second, or the fusulinoid stage four whorls are observable in the adult individuals. The first whorl of this second stage is about 0.11 mm long, 0.09 mm wide; the second whorl 0.278 mm long 0.133 mm wide; the third whorl 0.56 mm long, 0.183 mm wide; and the fourth whorl 1 mm long, 0.244 mm wide.

Spirotheca very thin consisting distinctly of two layers: The outer layer is much thinner and almost opaque corresponding obviously to the tectum of *Fusulina;* the inner layer is comparatively thicker and more transparent, though no trace of the alveolar structure is observed.

Antethecæ are regularly and rather gently fluted in the second stage of development. Only in the umbilical parts twisting and bifurcating lines appear in the longitudinal section.

Anuli and buccal aperture are both manifest in the second stage, and are situated in the median region of the whorls; they appear to be present in the inner chambers as well, but run in a direction perpendicular to that of the second stage.

Initial chamber exceedingly minute and spherical with a diameter of no more than 0.03 mm.

HORIZON AND LOCALITY: This species is of frequent occurrence in the material collected by Mr. Y. T. Chao from one of the higher layers of "Fusulina Limestones" of the Wuhutsui coalfield, South Manchuria. Uncertain traces of it are also found in the second seam of "Fusulina Limestone" (counting from below) exposed at Yuehmenkou, West of Taiyuan, Central Shansi. Although the stratigraphical position of its containing rock is not yet certain in the Wuhutsui coalfield, there is no reason to believe that it is lower than the Uralian.

Boultonia rawi Lee (sp. nov.)

Pl. II, Fig. 5

Test fusiform, very small, sharply pointed toward the ends. One of our typical specimens measures 2.66 mm long and 0.63 mm broad.

Whorls closely coiled; number of volutions 9 in all; first two volutions Endothyra-like; from the third volution onward regularly fusiform; axis of convolution for the first two whorls makes an angle of 67^0 with that of the rest of the whorls.

Spirotheca very thin, composed of a layer of tectum and a layer of osseum; the latter is sometimes finely alveolar in structure, but can only be observed with difficulty.

That the antethecæ are gently undulated throughout the length of the test is inferred from the presence of darkish shades in the axial section. More or less notable folding only begins to develop towards the umbilical ends.

Diameter of initial chamber about 0.04 mm.

Fairly conspicuous is a pair of anuli between which lies a relatively low and narrow buccal aperture.

Although the present species suggests some resemblance to *Fusulina exigua* of Iowa as figured and described by Staff, important differences are observed in its size and internal structure. Our species is only 0.66 mm long and 0.63 mm broad, but the American species has a size of 3.4 mm: 1 mm. The former possesses not only numerous whorls, but the earlier whorls are distinctly endothyroid; whereas no such structure is observed in the American form. It is however not improbable that the two are genetically related.

HORIZON AND LOCALITY: *Boultonia rawi* has been found in the coalfields of Penchihu and Yentai, South Manchuria. Because of its constant association with *Girtyina konnoi* and other typical species of the Penchi Series it is believed to represent the Moscovian epoch.

Genus **FUSULINELLA** Möller

The genus *Fusulinella* was first described by Möller in 1877 with *Fusulinella bocki* as its genotype. In the following year the same author made a more extensive survey of its allied species, and incorporated in that genus several forms of distinctly different type. Since that time a fairly large number of species of *Fusulinella* have been found at numerous localities and in different formations of Carboniferous age outside of Russia. The prevalent type of these species does not exactly agree with that first described by Möller which is decidedly fusiform, but rather conforms with those spheroidal and lenticular types which were added to that genus in his later diagnosis.

Since Möller's time the conception seems to have become prevalent among the workers of fusulinoid Foraminifera that one of the principal features of *Fusulinella* is the coincidence of its shortest morphological axis with its axis of convolution. H. Staff has even gone so far as to state definitely "Die Aufrollungsachse ist der kürtzeste Durchmesser....." In this revised diagnosis of *Fusulinella*, Staff has obviously excluded the fusiform type from that genus, and seems to have paid no attention to *Fusulinella bocki* which is the genotype of Möller's *Fusulinella*.

Under the same misconception as regards the external shape of *Fusulinella*, Deprat found it necessary to propose a new generic name, *Neofusulinella*, for a part of his material which is closely related to the spheroidal and lenticular types of *Fusulinella* Möller, but differs therefrom in being fusiform. It is thus evident that Deprat's

Neofusulinella is precisely synonymous with Möller's *Fusulinella* in his original sense, and equivalent to a part of Möller's *Fusulinella* in his later generic diagnosis.

If Möller's generic diagnosis be adhered to by reason of priority, Deprat's genus *Neofusulinella* would seem to have no right to claim its existence. Recent advancement of our knowledge has however demonstrated that it is at once natural and practical to separate the two types of Möller's *Fusulinella*. Although structurally they are much alike, morphologically they are sharply distinct from each other. There is little doubt that the fusiform type marks one dicisive step of advancement in the phylogenic history of the whole family of Fusulinidæ. The line of demarcation is so definite that not a single transitional form has yet been found.

To uphold Möller's priority, and to comply with the facts brought out by recent researches it would be well to retain Möller's original diagnosis of the genus, and subdivide it into two or even more subgenera. Each of the distinct types would then be able to occupy a sufficiently independent position as is warranted by its distinctive features.

For the fusiform type of *Fusulinella* we may adopt Deprat's nomenclature *Neofusulinella* which has already won some standing in palæontological literature in consequence of the work done by I. Hayasaka, Y. Ozawa and M. Colani.

For the other, Ozawa's term *Staffella* seems to be an apt one. It is however still an open question whether we are justified in placing both the spheroidal and lenticular types in one subgenus especially in view of the fact that we have already assigned an independent subgeneric position to the fusiform ones. Should the necessity arise in future that these two types are again to be divided into two distinct subgenera, the name *Staffella* would be best devoted to the spheroidal type because Ozawa happens to have chosen *Staffella sphærica* Möller as its "genotype"; and the name *Ozawaina* would seem to be appropriate for the lenticular form.

It is further possible that such primitive, and as yet ill-understood forms like "*Schubertella*" may well fall within Möller's generic definition of *Fusulinella*, and at the same time, possess sufficiently distinctive features as to merit a subgeneric rank.

Subgenus **STAFFELLA** Ozawa

Staffella sphæroidea (Ehrenb.) Möller

Pl. I Fig. 1; Pl. II Figs. 8-11

1878. *Fusulinella sphæroidea* Möller; Mém. Acad. Science, St. Petersbourg, VII Sér. Tome XXV, No. 9, pp. 107-111; Pl, XV, Figs. 1a, 1b.

1913. *Fusulinella quadrata* Deprat; Mém. Serv. Géol. de l'Indochine. Vol. II, Fasc. 1, pp. 39-40, Pl. VII, Figs. 1-5.

This remarkable form of *Staffella* is characterized by its drum-like shape. The axial length of the complete test is either equal to or slightly smaller than the breadth. The axial section is therefore approximately a square. Axial length varies from 0.9 mm to 1.22 mm, and the breadth or diameter varies from 1.05 mm to 1.22 mm.

Number of volution usually 7 in adult specimens. Those which possess 5 or 6 whorls are probably young individuals as is shown by their proportionally smaller size.

Height of the spiral chambers increases comparatively slowly in the first two or three volutions; but the increase becomes more rapid in the outer whorls. This is shown by measurements made on specimens from Tangshan, Penchihu and other localities as tabulated below.

Width of successive volutions (in mm)							Specimen
I	II	III	IV	V	VI	VII	
.144	.255	.4	.565	.755	.986	1.216	(310)
.26	.38	.54	.76	1.07	1.40	—	(20)
—	.22	.35	.51	.70	.92	1.21	(2153)
.216	.384	.636	.950	1.248	1.62	—	Möller's
.16	.28	.45	.62	.88	1.20	1.56	Deprat's

Spirotheca rather thick as a whole composed of a thin, dark layer of tectum, a thicker and lighter layer of osseum which reveals faint traces of honey-combed structure in the outer whorls. These two layers are covered both internally and externally by the tectorium; the inner tectorium being usually thicker than the outer one.

Antethecæ perfectly plane; even in the very umbilical ends no plication is observable. They are, as a rule, slightly inclined backward. Number of antethecæ in each volution is only counted in a single specimen from Yuehmenkou, (2153) which gives the following series of figures:—

I, 9; II, 13; III, 16; IV, 19; V, 21; VI, 25; VII, 25 +

Very prominent is a pair of crescentic anuli with their thickest part set against the corner of the spirotheca in the inner five volutions, but become less prominent and only limited in the median part in the sixth whorl.

Between the anuli lies a clearly defined buccal aperture which in the inner five volutions extends laterally for about 1/5 of the length of the whorl and a little less than half of the height of the chamber; but becomes distinctly lower in the sixth volution although laterally it still maintains the same proportional length.

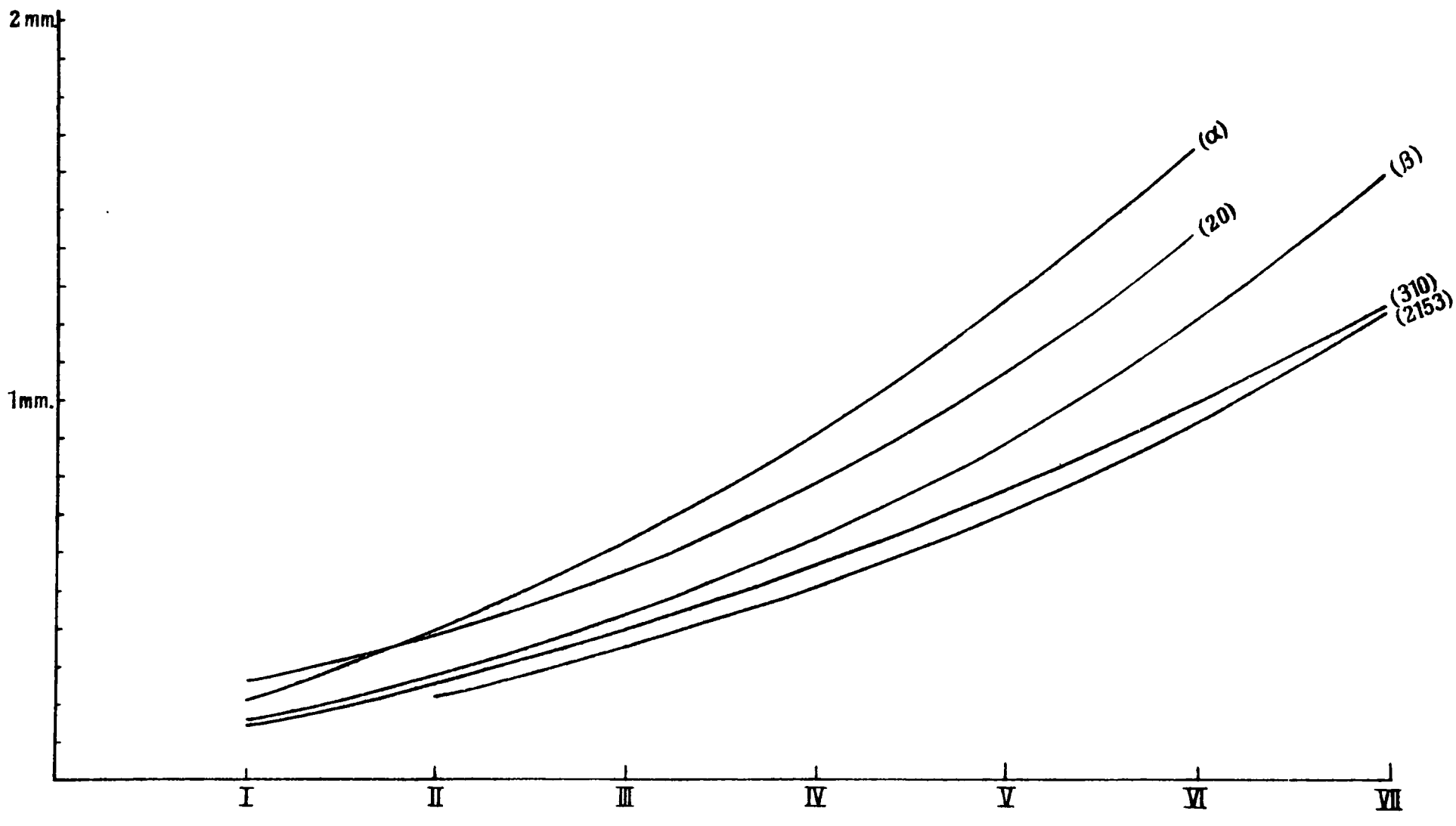

Fig.2

Width-graphs of *Staffella sphæroidea*. (20) macrospheric type; (310), (2153) microspheric type; (α) Möller's specimen; (β) Deprat's specimen.

[*To face page 14*]

Initial chamber perfectly spherical having a diameter usually varying from 0.055 to 0.074 mm, sometimes as large as 0.16 mm. Wall of the initial chamber is always composed of a dark layer of testaceous substance being darker than any part of the spirotheca. So constant is this character with all our specimens that it is difficult to attribute such a phenomenon to the state of preservation.

REMARKS: Although the external form of this species departs considerably from the usual type of *Fusulinella*, its internal structure, for instance, the composition of spirotheca, disposition of the antethecæ etc. is thoroughly characteristic of that genus. When a careful comparison is made between our specimens and that described and figured by Deprat one cannot fail to recognize the striking resemblance in all of the observable properties, particularly in the number of antethecæ for each volution, the size of the inital chamber and the mode of convolution. Regarding the last named feature the parallelism is emphatically brought out in the accompanying graphs (See Fig. 2).

Similar relationship holds between these Asiatic forms and the Russian one originally described by Möller. It is probably the poorness of Möller's figure that had led Deprat to overlook the fact that his species was identical with the Russian form. By reason of priory I have therefore abandoned Deprat's specific name and adopted Möller's original nomemclature in spite of the fact that Deprat's name is by far the more expressive.

If we examine closely the measured widths of the successive volutions as tabulated in the foregoing page it will be noticed that the figures are of the same order when taken in horizontal series; but the several series cannot be exactly correlated with references to the ordinal number of the whorls. Thus the specimen from Penchihu (20) is almost exactly one volution advanced as compared with those from Tangshan (310) and Yuehmenkou (2153). Möller's specimen is even more advanced than the Penchihu form. This anomaly is of such a rhythmic order that it cannot be readily attributed either to the fortuitous variation of the individuals or to the arbitrary choice of points on the spiral across which the measurements were made. The fact would be better explained if we assume a certain amount of "retardation" or "acceleration" in the development of the several forms.

HORIZON AND LICALITY: *Staffella sphæroidea* abounds in the Hsiaoyü Limestone of the Penchihu coalfield, South Manchuria, and occurs rather frequently in the Tangshan Limestone of the Tangshan Basin, the Pankou Limestone of the Western Hills of Taiyuan, Central Shansi, and in the Changchiakou Limestone of the Paoteh District. Uncertain traces of this species is also found in the material collected by Pères Licent and Teilhard from the northern part of Inner Mongolia. In the Tangshan and

the Hsiaoyü Limestones it is associated with *Girtyina konnoi, G. cylindrica, Bradyina nautiliformis* etc. In the Pankou Limestone I have not as yet found *Girtyina* but have obtained a single specimen of *Bradyina nautiliformis*. These forms are so closely associated that when one of them is found the others are rarely missing. They are always restricted to the lower beds of Fusulina Limestones in any given locality when they occur at all—that is in the Penchi Series. Their embedded limestone is usually penetrated by a mesh-work of minute veins of calcite and has a dirty, blistered appearance on the weathered surface.

By these faunal and lithological reasons I am inclined to believe that the species under consideration attains a much wider distribution over North China and perhaps Eurasia than is known at present.

According to Möller, *Staffella sphæroidea* occurs on the right bank of the Tschussovaja River, immediately below the mouth of the Koiva River; in the western slope of the Ural Mountain; in the Schiguli Mountain, Peninsula of Samara; at Schutilovo, Nischini-Novogorod, in the Miatschkovo Limestone and a number of other localities in Russia. The fact that it occurs in the Miatschkovo Limestone serves to assure its Moscovian age. Deprat has also independently assigned his "*Fusulinella quadrata*" to the Moscovian. The evidence seems fairly strong that we are here dealing with a widely distributed species of Moscovian age.

Subgenus **NEOFUSULINELLA** Deprat

Neofusulinella bocki Möller

Pl. I Fig. 2; Pl. II Figs. 12-17

1877. *Fusulinella bocki* Möller; Die Spiral-gewundenen Foraminiferen des russischen kohlenkalks, pp. 104-107, Pl. V, figs. 3 a-g, Pl. XIV, figs. 1-4.

1924. *Neofusulinella præcursor* (Deprat) Colani; Nouvelle Contribution à l'étude des Fusulinidés; p. 144, Pl. XVII, figs. 1-22 bis.

1925. *Fusulinella bocki* Ozawa; Palæontological and stratigraphical studies on the Permo-Carboniferous Limestone of Nagato, Part. II, pp. 17-18, Pl. III. Figs. 7, 9, 10.

Test usually fusiform, rarely ellipsoidal with its median part rather strongly vaulted in the former case but less so in the latter. The ratio of median width to the axial length ranges between 1: 1.8 and 1: 2.1; and the actual length varies from 2.55 to 3.8 mm, and the width from 1.4 to 1.6 mm.

Number of volutions usually 6, sometimes 5 and sometimes 7.

Whorls closely wound in the first four or five volutions, and tend to open out towards the last stage of growth. Widths of the successive volutions of a specimen from Inner Mongolia are as follows:—

I, .14; II, .24; III, .52; IV, .88; V, 1.4 in mm.

Antethecæ essentially plane, and only begin to show a gentle plication near the umbilical ends. Number of antethecæ in each volution appears to vary from individual to individual only within narrow limits. In a typical specimen from Inner Mongolia there are

8	in the 1st volution
11	,, ,, 2nd ,,
11	,, ,, 3rd ,,
13	,, ,, 4th ,,
16	,, ,, 5th ,,
24	,, ,, 6th ,,

Buccal aperture distinct, occupying about $\frac{1}{5}$ of the length of the preceding whorl up to the fourth volution, but becomes broader in the fifth, namely, about $\frac{1}{4}$ of the length of preceding whorl. Height of the aperture nearly equals one half of the height of each chamber. As a consequence of its greater lateral extension in the fifth volution the height is considerably reduced.

Anuli highly prominent except in the last volution.

Thickness of spirotheca varies both laterally and spirally. The median part is generally the thickest at any stage of growth. This thickening is largely due to an excessive development of the tectorium. In the first two volutions the spirotheca is fairly thin as a whole, but a steady increase in thickness follows up to the early part of the sixth volution where it is measured in several cases at no less than 0.8 mm. As the last part of the outermost volution is approached a rapid reduction of thickness invariably takes place.

Instead of being fusiform the first one or two volutions are often globular suggesting an endothyroid stage of development.

Initial chamber spherical having a diameter of about 0.07 mm.

REMARKS: Form, size and parts of the internal structure of the present species bear a strong resemblance to *Fusulina montipara* Ehrenb. The latter however possesses a distinctly alveolar osseum as indicated in Möller's figure; while in our species

the honey-combed structure of the osseum is so fine that it is often invisible. Only in the favourably preserved specimens we can find here and there faint traces of dark lines running across the lighter layer in the spirotheca. Some genetic relation between *Neofusulinella biconica* Hayasaka and the species under consideration is indicated by their structural similarity and the rude parallelism in the early parts of the width-graphs (see Fig. 3). But a closer examination will soon show that they are specifically distinct. Our species, for instance, possesses fewer antethecæ in each volution, less numerous and more rapidly expanding whorls and perhaps a more laterally extended form. The axial ratio in *Neofusulinella biconica* is said to be 1: 1.5 while in *Neof. bocki* this value often reaches 1: 2.1.

While the majority of the representatives of the present species so far found are essentially true to type, there are on the other hand occassional occurrences of forms that link the present one to its allied species. The mode of variation can be traced to three directions: By a median flattening and lateral elongation we get *Neofusulinella obsoleta;* by a stronger median vaulting, and lateral contraction we arrive at *Neof. schwagerinoides;* and finally by an appreciable development of folds in the antethecæ *Neof. præsimplex* is derived.

HORIZON AND LOCALITY: *Neofusulinella bocki* occurs abundantly at a locality in Inner Mongolia, about 200 k. m. north of Kalgan. There, it is associated with *Girtyina teilhardi, G. konnoi Bradyina nautiliformis* etc. It is also found in the coalfields of Penchihu and Tangshan in association with *Staffella sphæroidea, G. cylindrica G. konnoi* and *Spirifer mosquensis.* Its association with these fossils together with fact that it never occurs in the higher beds of the Fusulina Limestones of North China, namely those intercalated in the Taiyuan Series, and that it is distributed in Russia Japan, Indo-China and probably in the Sihu district, Central China, point to the probability that the Moscovian water had spread over a far more extensive area than has been assumed.

? **Neofusulinella obsoleta** Schellwien

Pl. II Fig. 19

1908. *Fusulia obsoleta* Schellwien; Monographie der Fusulinen; Palæontographica, vol. LV, pp. 186-187, Pl. XIX, Fig. 5-7.

Only a single specimen of the present species has been found among a copious fauna procured by pères Licent and Teilhard from a point 200 k. m. north of Kalgan. When viewed in the axial section this species strongly recalls *Neofusulinella bocki* with which it is associated. It differs however from the latter by its larger axial ratio. Thus in the present species the ratio of axial length to median with reaches 3:1, while in *Neof. bocki* this value never exceeds 2.1:1.

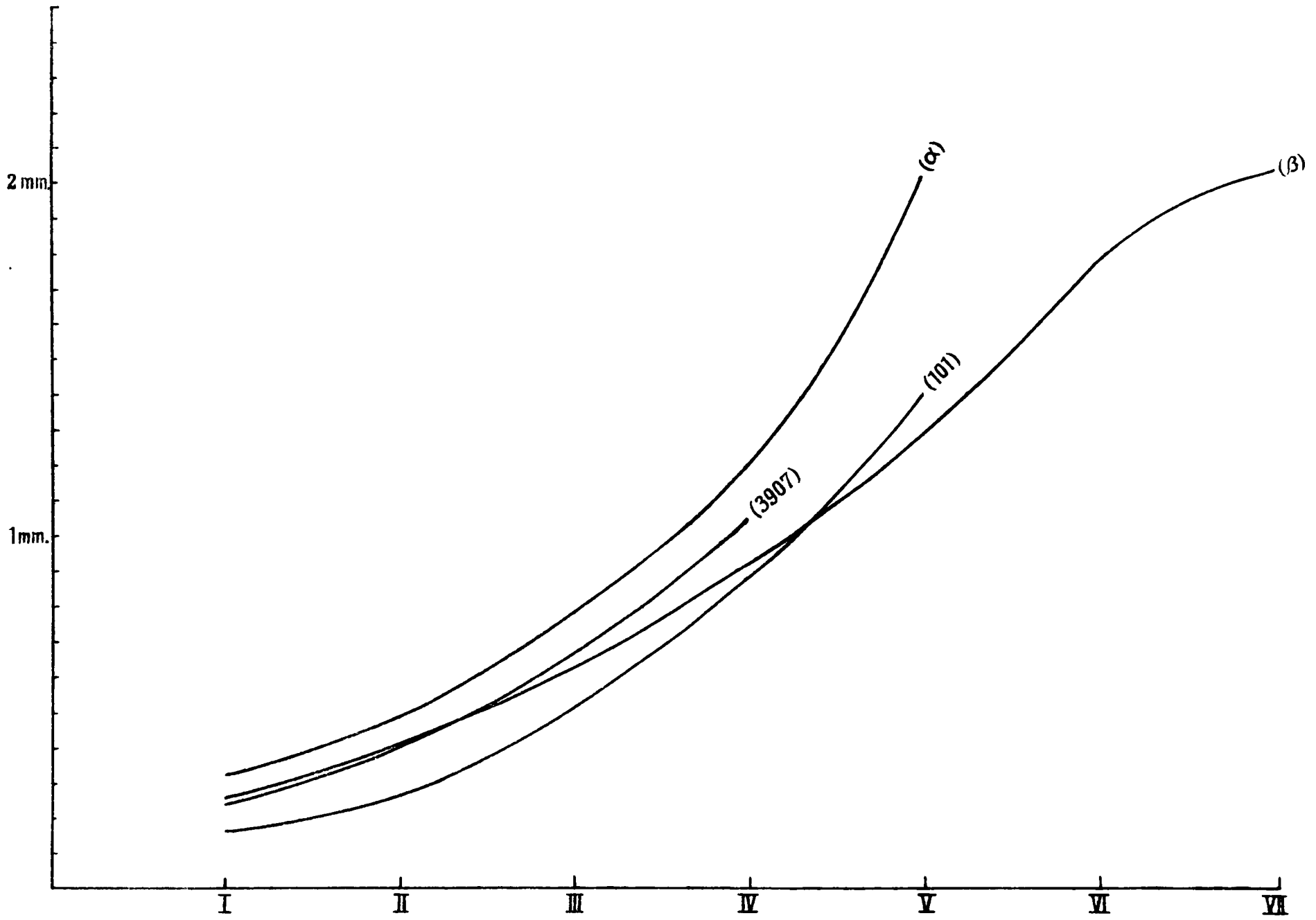

Fig.3

Width-graphs of *Neofusulinella bocki* and *Neof. præsimplex*. (101) *Neof. bocki*; (*α*) *Neof. bocki*—Möller's specimen; (3907) *Neof. præsimplex*; (*β*) *Neof. biconica* Hayasaka for comparison.

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Further distinctive features are its smaller size, more pronounced development of tectorium and extremely fine alveolar structure. So much so that the individual dark lines are hardly observable even in the last volution.

As the only section in the author's possession is not strictly axial but rather para-axial, it is impossible to measure the width of each whorl, nor is it possible to measure the diameter of the initial chamber. But judging from the shape and relative size of the innermost visible volution the complete test consists most likely of five whorls. The inner ones appear to be closely coiled while the last two show a sudden and marked increase in height. One more striking feature may be observed when we compare our specimen with Schellwien's figure. That is their lack of bilateral symmetry. This apparent asymmetry may however be due to an incurved umbilical end rather than the unequal length of the test on both sides of the median plane.

Although the evidence seems fairly conclusive that the Russian and Chinese forms referred in the above description are specifically identical, it does not appear altogether safe, in the absence of more material, to draw that conclusion without reserve.

Neofusulinella schwagerinoides Deprat

Pl. II, Fig. 18

1913. *Neofusulinella Schwagerinoides* Deprat; Mém. Serv. géol. Indochine, Vol. II, Fasc. I, pp. 42-43, Pl. VII, figs. 17-22.

As was the experience of Deprat, the only para-axial section of the present species gave the author at first the impression of a *Schwagerina* of the type of *Schwayerina fusulinoides* Schellwien. Detailed examination of its structure however shows that the antethecæ are perfectly plane except in the extremely terminal parts where the anastomosing effect due to truncated folds becomes more or less pronounced; and that the interior of the spirotheca is lined by a dark layer of tectorium. This latter feature is entirely absent from *Schwagerina*. The osseum is no doubt finely alveolar, but I have not observed any trace of it.

Height of the chamber in the successive volutions increases rather rapidly recalling the mode of spiral growth of *Schwagerina* in general. In the only para-axial section the widths of the second, third and fourth volutions were measured at 0.28, 0.61, 1.2 mm respectively. These values, particularly the first two of them, are necessarily lower than the true values because of the eccentricity of the section. Nevertheless they indicate unmistakably the rapidity of spiral expansion. This fact together with its size which is 3.9 mm long and 1.6 mm broad, leads the author to believe that our specimen is more closely related to *Neof. schwagerinoides* than to *Neof. lantenoisi* which, if judged by Deprat's figure alone, may appear to resemble our form more closely.

Buccal aperture and anuli are both well-defined. The former occupies about $\frac{2}{5}$ of the height of the respective chamber and $\frac{1}{8}$ to $\frac{1}{7}$ of the length of the respective whorl.

The present species has been found only in the Yentai coalfield, South Manchuria. Associated with it is *Girtyina pankouensis*. There seems no question that it represents the Moscovian time.

Neofusulinella præsimplex Lee (sp. nov.)

Pl. II, Figs. 20-22

1908. *Fusulina simplex* Schellwien in part? Monographie der Fusulinen; Palæontographica, Vol. LV, pp. 179-182, Pl. XVIII, Figs. 4-6, 12.

Test small, irregularly fusiform with a gentle median vaulting and more or less rounded umbilical ends. In the first three or three and half volutions the whorls are quite short and ellipsoidal in shape having an axial ratio of no more than 2.6:1, sometimes as low as 1.7:1. In the fourth and fifth volutions the test however suddenly becomes elongated; when it develops five volutions which appears to represent the maturity of growth, the ratio of axial length to median width varies, in the few specimens obtained from Kansu, from 3.33 mm: 1.11 mm to 3.9:1.27 mm, *i.e.* about 3:1 on the average. This is the maximum value reached by the Russian form of *Fusulina simplex* according to Schellwien.

Height of the chamber increases steadily and uniformly from the innermost to the outermost whorl. Widths of the successive volutions, as measured on a typical specimen from Yanghukou, Kansu, are as a follows:

I	II	III	IV	V	
.24	.41	.655	1.05	—	in mm.

Comparing graphically (See Fig. 3) the spiral expansion as based on these figures with that of *Neofusulinella bocki*, little difference will be found in the shape of the curves. Similar relation holds as regards a few other aspects. For instance the structure of their inner whorls and their general shape are much alike. It needs no further demonstration that these two species are intimately bound up with each other in genetic relation as well as in occurrence.

Spirotheca is composed of four layers, namely a tectum, an osseum and two layers of tectorium. The inner whorls are constructed exactly after the type of *Neof. bocki* with its osseum apparently homogeneous, but in the last whorl the alveolar structure of the osseum becomes distinct, moderately coarse though rather short. At the same time, the thickness of the tectorium is considerably reduced. In this respect, the present species seems to be more advanced than any other form of *Neofusulinella* described in this volume.

Antethecæ much thinner than the spirotheca, and very gently folded in the median region, but the folding becomes rather complicated towards the umbilical ends, especially so in the last whorl.

Anuli highly prominent, more or less of a rectangular shape in cross-section. They reach more than $\frac{2}{3}$ of the height of the chamber in the first two volutions, nearly half of the height in the third and about $\frac{1}{3}$ of the height in the fourth. As their height decreases, the buccal aperture which is situated in between, becomes rapidly extended in the axial direction. Length of the buccal aperture generally covers $\frac{1}{4.5}$ to $\frac{1}{5.5}$ of the length of the preceding whorl.

Diameter of the initial chamber measures 0.166 mm in a typical specimen.

Although I have cited above *Fusulina simplex* Schellwien for comparison and have assumed a part of Schellwien's material designated by that name to be specifically identical with our form, it is by no means certain that the Russian species is structurally identical with the species under consideration. On the contrary, the specimens from the Donetz Basin and from the Miatschkovo Limestone figured by Schellwien do not seem to show appreciable thickness of tectorium, but exhibit, particularly in the case of the Miatschkovo specimen, a rather distinct alveolar osseum of such thickness as is yet unknown in *Neofusulinella*. Unfortunately Schellwien's material is not fully illustrated. We cannot be sure if the two figures are wholly representative. Judging from the association of our species with such typical Miatschkovo forms as *Bradyina nautiliformis*, *Girtyina cylindrica* etc. in the Yanghukou fauna of Kansu, the suspicion is not absent that Schellwien might have included in his species, *simplex*, a form that should be properly referred to the present species.

Neofusulinella (? Schubertella) chaoi Lee (sp. nov.)

Pl. II, Figs. 6-7

This small *Neofusulinella*, 0.94 mm long and 0.5 mm broad, is only represented in our material by a single axial section found in the highest or next to the highest layer of the Fusulina Limestones developed in the Wuhutsi coalfield. Associated with it there are numerous individuals of *Schwagerina moungthensis* Deprat and a few scattered *Tetrataxis conica* Ehrenberg.

Test rather stumpy with its median part more or less strongly vaulted. Whorls fairly compact, four in number; width of each whorl measures 0.13, 0.21, 0.31, 0.5 mm from the first to the fourth volution; initial chamber spherical with a diameter of 0.08 mm; spirotheca moderately thick, measuring 0.013, 0.018, 0.022, 0.033 mm from the first to the fifth volution, being composed of tectum, osseum and tectorium; no trace of alveolar

structure is observable; anuli fairly prominent; buccal aperture relatively narrow occupying about $\frac{1}{7}$ of the length of each whorl; axial ratio of the complete test about 1:1.7.

The general shape of the test and the widths of the successive volutions of this species seem to suggest at first that it agrees with Deprat's species *Neofusulinella præcursor*. More careful examination however shows that Deprat's species is much larger in size and possesses 6 volutions. It is hardly necessary to remark on the improbability of the one being a microspheric type of the other; for if that be the case the macrospheric form which would be our species, ought to agree in its essential features, for instance, the width of the successive volutions, with the later whorls of the microspheric type. The fact is however to the contrary. There seems no question that we are dealing here with an independent species, though its specific characters are as yet not fully established.

Genus **FUSULINA** Fischer de Waldheim

Fischer's original diagnosis of the genus *Fusulina* was based on "*Fusulina cylindrica*". Unfortunately the material was not sufficiently well illustrated as to bring out its minute structures. A more careful investigation of the same species was subsequently made by Möller who had apparently paid some attention to the structure of the theca, for in his figures an alveolar structure similar to that of the common type of *Fusulina* such as *Fusulina longissima, F. verneuili* etc. is clearly indicated. After an extensive study of the Russian Material Schellwien however came to the conclusion that in *cylindrica* "Die Poren in der Kammerwandungen sind sehr fein und bei den meisten Vorkommen recht undeutlich". In spite of this striking structural peculiarity Schellwien still followed Möller's classification, and assigned *Fusulina cylindrica* to precisely the same genus as represented by *Fusulina verneuili, F. longissima* etc.

A point of some importance was brought out by Staff regarding the structure of the spirotheca of different types of *Fusulina*. He found that the spirotheca of certain American and Russian forms consists of a single layer of "poreless tectum," and assigned them to a new genus, *Girtyina*. This new genus, as may be gathered from Staff's diagnosis, differs in no way from the common type of *Fusulina* except for the fact that it possesses no alveolar osseum. The validity of Staff's new genus *Girtyina* would then entirely rest on the correctness of his interpretation as regards the structure of the spirotheca.

In his recent paper Ozawa has suggested that such structural difference probably does not exist among the lower members of Fusulinidæ. My observations have completely

confirmed this view. I have not only actually traced, under the microscope, the individual dark lines (poutrelles) in the outer whorls of *Staffella sphæroidea* but also in most of the whorls of *Girtyina schellwieni* and *G. konnoi*, a certain variety of which is undoubtedly related to the Russian species designated under the names *Girtyina* cfr. *ventricosa*. As far as the structure of the theca is concerned there is hardly any reason to believe that the material on which Staff founded his "genus" *Girtyina* differs to any extent from our specimens designated under the same name.

Thus it would appear unnecessary and even undesirable to retain Staff's genus *Girtyina*. The fact however must not be overlooked that the alveolar structure of the spirotheca in *Girtyina* is never so distinct as in the higher types of *Fusulina* and that the tectorium is an important element which enters into the composition of its spirotheca. Both of these features demonstrate primitiveness. On the other hand, the antethecæ of *Girtyina* are always intensely folded; and its size is usually comparable with many common species of *Fusulina*, often considerably larger than *Neofusulinella*. As we understand now, there is in fact no difference of generic value between *Fusulina* of the type *F. cylindrica* Fischer and *Girtyina*. For these reasons I find it difficult to accept Ozawa's view that Staff's *Girtyina* should be placed under *Fusulinella* Möller. There is little doubt that *Girtyina* represents the most primitive type of *Fusulina* but far more advanced than *Neofusulinella* in the evolutional series.

Since it is illogical to regard *Girtyina* as an independent genus, and since it is desirable to retain a common designation for such a group of intimately related species, it seems that we cannot do better than to regard it as a subgenus of *Fusulina*. The reasons are obvious: Firstly, it is more closely related to the common type of *Fusulina* than to any other genus of the family; and secondly, it includes the species *cylindrica* on which the original diagnosis of the genus *Fusulina* was based.

So far we have only considered the lower forms of the genus. There are again those which distinguish themselves from the common type of *Fusulina* by a much higher rate of spiral expansion, a more globular shape, comparatively thinner spirotheca and generally larger size. To this group of forms Möller applied the generic name *Schwagerina* with *Schwagerina princeps* as its genotype. In view of the occurrence of certain intermediate forms between the common type of *Fusulina* and the so-called *Schwagerina*, Staff and Wedekind have proposed to unite the two in a single genus under the common generic name *Fusulina*, but subdivide this genus into two subgenera, namely *Schellwienia* and *Schwagerina*. The former name was introduced as a substitute for the name *Fusulina* in its usually accepted sense,

The discovery of more intermediate forms between *Schwagerina* and *Fusulina* such as *Schwagerina wongwenhaoi* and *Schw. tingvenkiangi* would seem further to strengthen Staff and Wedekind's view that there is no sharp demarcation between the two. It appears therefore unnatural to maintain *Schwagerina* as an independent genus. Nevertheless the aggregated characters of a typical *Schwagerina* such as *Schw. princeps* are, taken as a whole, so widely different from those of a common *Fusulina* that it is not possible to disregard their remarkable difference when the two are brought together for comparison. The difference is by no means of a fortuitous nature, but is evidently derived from different physical conditions under which the two forms had to subsist. There is not much doubt that the common type of *Fusulinas* are exclusively of benthonic habit, while *Schwagerina* is at least in its young and adult stages a plankton, and may have fallen on the sea floor in its senile stage. If we are justified in separating *Girtyina* from the common type of *Fusulina*, and regarding the former as a subgenus, we should be even more fully justified to adopt the same procedure with *Schwagerina;* for the difference between "*Fusulina*" *(Schellwienia)* and *Girtyina* is by no means more marked than between "*Fusulina*" *(Schellwienia)* and *Schwagerina*.

Thus as far as our material is concerned, the genus *Fusulina* may now be subdivided into three subgenera; namely *Girtyina, Schellwienia* and *Schwagerina*. In this classification it must however be noted that *Girtyina* in its revised sense should include a part of Staff and Wedekind's *Schellwienia*, consequently a number of species which were included in *Schellwienia* by Staff and Wedekind are now to be referred to *Girtyina*.

Subgenus **GIRTYINA** Staff et Wedekind

Girtyina konnoi Ozawa

Pl. III, Figs. 1-10, 12

1925. ***Fusulinella konnoi*** Ozawa; on the classification of Fusulinidæ; Jour. Coll. Sci. Tokyo, Vol. XLV, Art. 4, Pl. IV, figs. 6, 7.

1925. ***Fusulinella (Girtyina) konnoi*** Ozawa; Journ. Geol. Soc. Tokyo, Vol. XXXII, P. 23, Pl. X, figs. 1-3.

Test more biconical than fusiform being rather sharply vaulted in the median zone and acutely pointed towards the poles. Size of the test varies from 4.24 mm: 1.45 mm to 4.54 mm: 1.81 mm, and the axial ratio ranges between 1:2.9 and 1:2.5 sometimes as low as 1:2.4 indicating that a fairly wide range of morphological variation prevails in this species.

Number of volutions also varies to some extent. The commonest form develops 7 volutions, but sometimes as many as 9 or 10. Those having more numerous volutions invariably possess a smaller initial chamber. Therefore they probably represent the microspheric type.

Antethecæ rather thin, more or less regularly and intensely folded from end to end and almost over their entire height not even excluding that portion which stretches over the buccal aperture. Number of antethecæ for each volution is remarkably constant in the several specimens tabulated below.

Volution	I	II	III	IV	V	VI	VII	Specimen
Number of Antethecæ	12	19	22	33	32	36		(306)
	12	18	23	28	30	35		(316)
	12	18	21	23	30	31	35	(305)
	11	19	23	27	30			(23)
	10	19	22	29	33			(86)

The anomaly observed in the fourth and fifth volutions of the specimen (306) is probably due to some abnormal disturbance during the time of its growth, and the displacement of figures towards the right hand side in specimen (305) is undoubtedly the result of retarded development.

Whorls are rather compactly coiled as a whole. Their gradual and uniform expansion is clearly shown by the following figures and the accompanying graphs (Fig. 4):—

Volution	I	II	III	IV	V	VI	Specimen
Width of successive volutions in mm.	.36	.55	.77	1.04	1.4	1.82	(74)
	.35	.5	.7	.95	1.3		(86)
	.29	.44	.62	.85	1.16	1.5	(307)
	.33	.52	.77	1.05	1.44	1.83	(8)
	.32	.5	.73	1 0	1.4	1.72	(1606)

It will be noticed in the foregoing table that the values for the Tangshan specimen (86) are appreciably lower in comparison with the others. But they are lower as a whole. When plotted on a proportionally smaller scale the resulting graph still

maintains the same gradient. Its specific identity with the other specimens is thus definitely proved. The first three figures for the specimen from Penchihu (8) may be slightly lower than the real value because of the fact that the section on which the measurements were made is not strictly axial but rather para-axial. The inner volutions having a greater curvature than the outer ones are necessarily affected to a greater extent for the same amount of eccentricity of the section.

Spirotheca very thin, composed of a layer of tectum, a layer of osseum and two layers of tectorium. The aggregate thickness of tectum and osseum varies from 0.022 to 0.033 mm; that of the tectorium varies to a greater extent. But in no case does it exceed the thickness of the osseum. The outer layer of tectorium is usually thinner than the inner one, and sometimes appears to be absent from the outer volutions. The osseum is positively alveolar, although it is not always possible to trace such a minute structure especially when the specimen is not in a favourable state of preservation.

From the structural point of view we cannot then distinguish the present species and indeed all the species belonging to *Girtyina* from *Neofusulinella* unless we stress upon the fact that the outer layer of tectorium is exceedingly thin and the osseum is sometimes more or less distinctly alveolar in *Girtyina*.

Anuli very prominent up to the fourth or fifth volution; but become insignificant, though still recognizable, from the sixth volution onward.

Buccal aperture well-defined throughout, the test being nearly as high as broad up to the fourth or fifth volution, but becomes low and slit-like in the last but one volution.

Initial chamber usually perfectly spherical with an external diameter ranging from 0.15 to 0.17 mm, occasionally as large as 0.23 mm in the macrospheric type and as small as 0.09 mm in the microspheric. Thickness of the wall of the initial chamber averages 0.044 mm.

REMARKS: The present species shows some affinity to *Neofusulinella præsimplex* in its shape, in the presence of a pair of prominent anuli and in the structure of spirotheca; but differs therefrom by its larger size and rather intensely folded antethecæ and more whorls. The folding in the antethecæ is however not quite so intense as in *Girtyina ventricosa* Meek of Illinois, though not incomparable with *Girtyina* cfr. *ventricosa* of the Donetz Basin, Russia. If not for the more globular form of the latter I would have identified a certain variety of our species with the Russian one. In the absence of American and Russian material it is not possible at present to determine the true relation

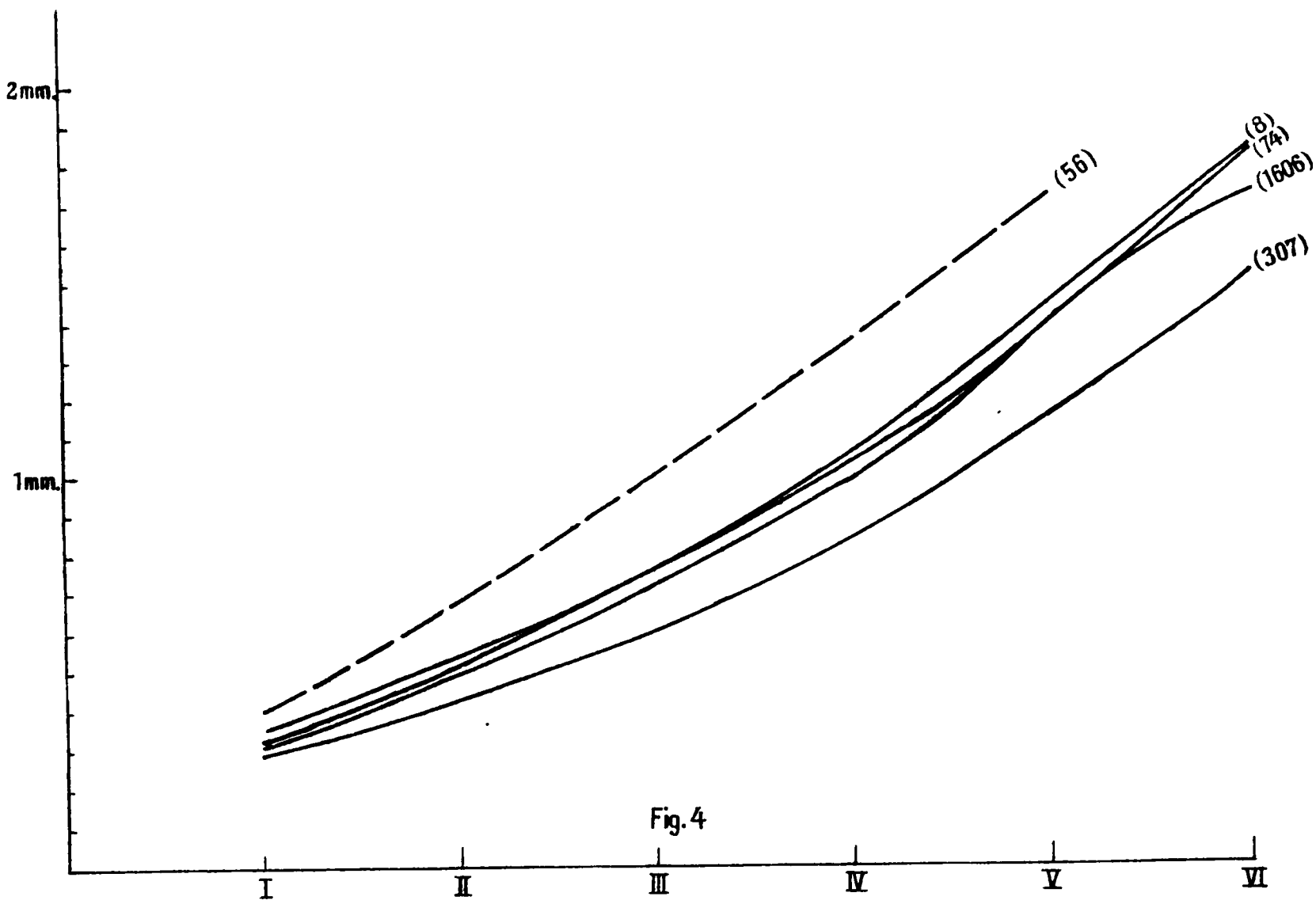

Fig. 4

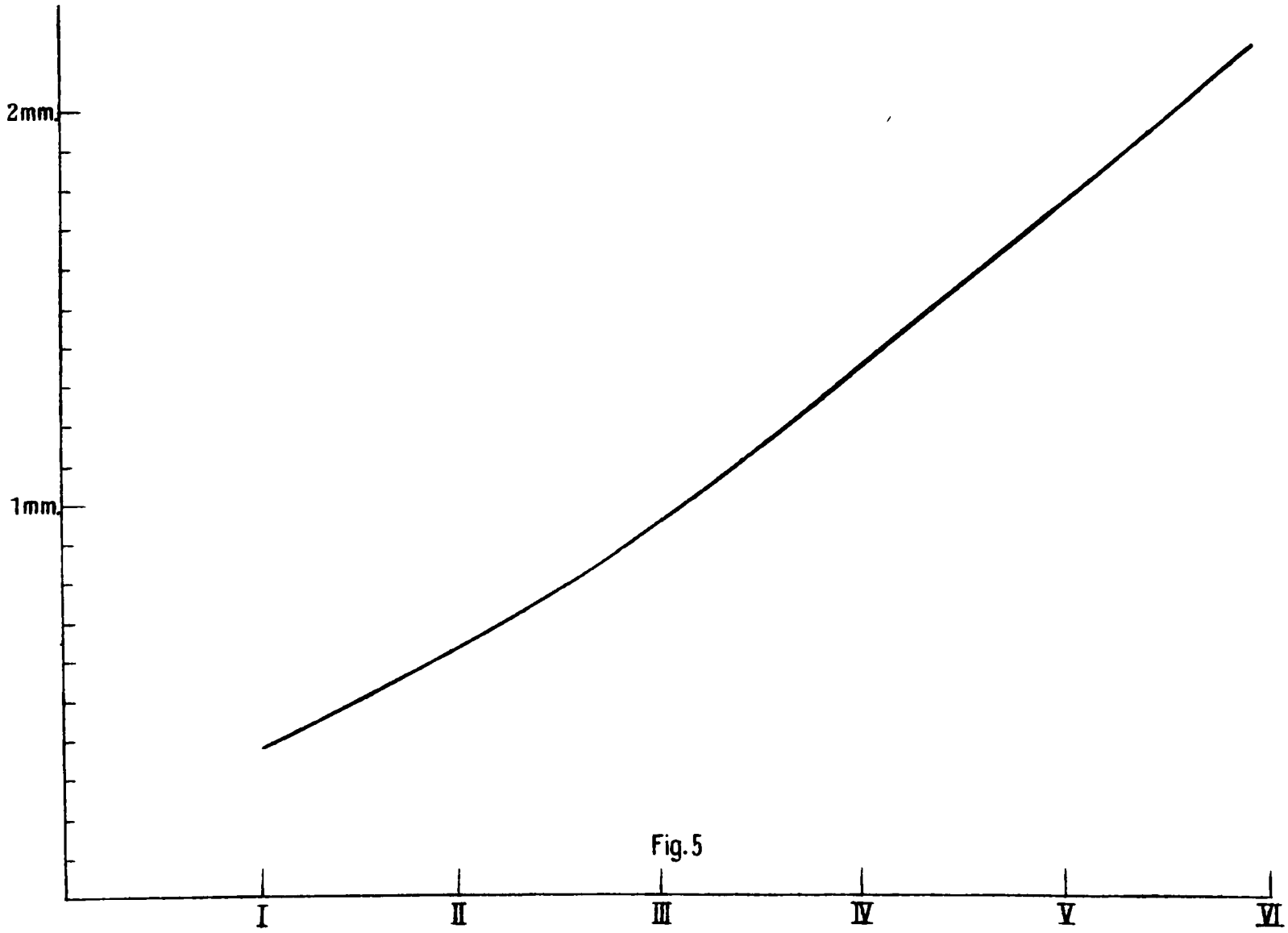

Fig. 5

Fig. 4. Width-graphs of *Girtyina konnoi* (8, 74, 307. 1606) and *Girtyina schellwieni* (56).

Fig. 5. Width-graph of *Girtyina teilhardi*.

[*To face page 26*]

between *Girtyina ventricosa* Meek and *Girtyina* cfr. *ventricosa* Staff, but the published micro photographs suffice to show that the species under consideration is certainly far more closely related to the Russian than to the American form.

HORIZON AND LOCALITY: *Girtyina konnoi* is widely distributed in north-eastern China. It was first recognized and figured by Y. Ozawa among the material procured from the Penchihu coalfield under the name *Fusulinella konnoi*. The few pieces of limestone brought back by Père Teilhard from Inner Mongolia also contain a large number of individuals belonging to this species. In those pieces of limestone they are associated with *Neofusulinella bocki*, *Bradyina nautiliformis*, *Girtyina teilhardi*, etc. In the Tanghsan Limestone of the Kaiping Basin *Girtyina konnoi* is also of frequent occurrence. There, it is again associated with *Staffella sphæroidea*, *Bradyina nautiliformis*. *Girtyina cylindrica* *Tetrataxis lineata*, etc. The same fauna has been found in the Penchihu coalfield, South Manchuria wherefrom Ozawa obtained his original specimen. In the Pinting Limestone of the Pinting Basin, North-east Shansi, scattered individuals of *Girtyina konnoi* are found together with *Bradyina nautiliformis*. Doubtful traces of the present species have been recently discovered in the Chihsia Limestone of the Nanking Hills.

It appears therefore that *Girtyina konnoi* is one of the best index fossils of the Penchi Series. Judging from its associated species there is not much doubt that it represents the Moscovian epoch.

Girtyina schellwieni Staff

Pl. IV, Figs. 11, 13, 14.

1912. *Girtyina Schellwieni* Staff; Palæontographica, Vol. LIX, p. 165, pl. XVIII, Fig. 1.

Test more globular then fusiform with a broad median vaulting and somewhat pointed umbilical ends; length of test varies from 3 mm to 2.8 mm, width varies from 1.8 mm to 1.72 mm in the several specimens procured from the lowest layer of the Fusulina Limestones in the Penchihu coalfield and also from the Pankou limestone of Central Shansi. The ratio of axial length to median width is approximately 1:1 on the average.

Number of whorls 5 to 6.

In a typical specimen the widths of the successive whorls measure as follows:—

I, 0.41; II, 0.69; III, 1.01; IV, 1.35; V, 1.72 in mm

Spirotheca very thin, with two thin layers of tectorim and without observable aveolar structure in the osseum.

Antethecæ rather gently and regularly folded. The folds extend for about two thirds of the height of the chamber, and only become slightly more complicated towards the umbilical ends.

Number of antethecæ in a typical specimen counts 11 in the first volution, 19 in the second, 24 in the third, 27 in the fourth and 29 in the fifth.

Highly prominent is a pair of anuli between which is situated a rectangular shaped buccal aperture.

Initial chamber relatively large and spherical having an external diametre of about 0.18 mm.

This species is distinguished from *G. konnoi* by its more globular form, more open coiling of the whorls and generally larger initial chamber.

Found only in the Penchi Series.

Girtyina teilhardi Lee (sp. nov.)

Pl. I, Fig. 6; Pl. III, Figs. 15-21

Test regularly fusiform to subcylindrical with its umbilical ends more or less sharply pointed. Axial length varies from 4 to 4.8 mm and median width from 1.6 to 2.15 mm; axial ratio ranges between 1:2.5 and 1:2.23; inner volutions are generally more vaulted than the outer ones.

The whole test, particularly the median part of it, is marked by deep furrows owing to the arching effect of the spiral wall of each spiral chamber.

Number of whorls usually 5 to 6.

Antethecæ intensely and rather irregularly folded throughout their entire length and height. Number of antethecæ somewhat variable from individual to individual. On the average there are

11 in Volution I
19 ,, ,, II
23 ,, ,, III
25 ,, ,, IV
30 ,, ,, V

Thickness of antethecæ also variable being slightly thicker than the spirotheca in the second and third volutions, but slightly thinner in the last one.

Height of chamber fairly constant throughout the successive whorls. Width of each whorl varies

from 0.36 to 0.38 mm in Volution I
,, 0.59 ,, 0.63 ,, ,, ,, II
,, 0.88 ,, 0.94 ,, ,, ,, III
,, 1.11 ,, 1.33 ,, ,, ,, IV
about 1.7 ,, ,, ,, V
,, 2.15 ,, ,, ,, VI

Spirotheca consists of a thin layer of tectum, a layer of finely alveolar osseum and two layers of tectorium. The inner layer of tectorium is always thicker and more massive than the outer layer which is so thin in the last whorl that it is hardly distinguishable from the tectum. The alveolar structure of the osseum is, as a rule, unobservable. As a mere chance I have however discovered in a few favourably preserved specimens exceedingly fine, dark lines running across the osseum and arranging themselves in a parallel manner. They are always broadly spaced. In these few exceptional cases the dark lines are sometimes so distinct that they not only present unmistakably a sectional view of the honey-combed structure, but also prove that this species of *Girtyina*, like *G. cylindrica*, is decidedly approaching *Schellwienia*.

Thickness of spirotheca increases from the first volution up to the early part of the fifth, but again decreases towards the final stage of growth. The increase is not so much due to the thickening of the tectum and osseum but rather to the variation of the thickness of the inner tectorium. One series of measurements shows that the aggregated thickness amounts to

0.031 mm in Volution I
0.040 ,, ,, ,, II
0.044 ,, ,, ,, III
0.064 ,, ,, ,, IV
0.037 ,, ,, ,, V

A pair of fairly conspicuous anuli is present up to the third volution, but disappears almost completely from the fourth volution onward.

Buccal aperture extends for about half of the height of the chamber; comparatively narrow in the first three or four volutions, but becomes broader and lower from the fourth volution onward.

Initial chamber nearly always spherical with its external diametre varying from 0.2 to 0.33 mm. Those which possess six volutions generally have a smaller initial chamber; while those which possess five volutions are, as a rule, characterized by a larger initial chamber. They probably represent the microspheric and macrospheric types respectively.

Remarks: When I discovered distinct traces of alveolar structure in the osseum of the present species I was very much inclined to regard it as a true *Schellwienia*. But after a more careful comparison it was soon found that the dark lines when decipherable at all, are by no means comparable with those in any species of true *Schellwienia* either with respect to their definition or to their abundance. They are more comparable

with those in *G. cylindrica*. Furthermore, no species belonging to true *Schellwienia* possesses such a massive tectorium as does the present one. If we have reason to assign *cylindrica* to the subgenus *Girtyina*, there is no reason why we should not refer the present species to the same subgenus as well. Its faunistic association is also significant. Numerous individuals of this species have been found in the few pieces of limestone procured by Pères Licent and Teilhard from Inner Mongolian at a point about 200 k. m. north of Kalgan. There, as is stated elsewhere, the fauna consists entirely of Moscovian elements such as *Neofusulinella bocki*, *Girtyina konnoi* etc. equivalent to the faunæ of Penchihu and Tangshan which are characterized by the presence of *Fusulina cylindrica*. Thus it would appear at once logical and convenient to regard the present species as belonging to *Girtyina* rather than to *Schellwienia*.

So far I have only found this species in Père Teilhard's material. At a glance it suggests some resemblance to *Fusulina magnini* Deprat. Detailed measurements however disagree.

Some of the axial sections appear to be comparable with those of *Fusulina prisca* Möller. But the latter possesses a much more distinct alveolar osseum, at least in its outer whorls, and has not developed that massive inner layer of tectorium. The reverse is the case with the species under consideration. Moreover our species is generally smaller in size; the maximum length of Möller's *prisca* is said to be 8 mm, and according to Schellwien, the average length of *prisca* is no less than 6 mm; while the longest individual among the specimens of our species reaches but a length of 4.8 mm.

When we turn to the median sections the difference becomes still more manifest: In *prisca* the individual chambers are but slightly arched, whereas in the present species the arching effect is so pronounced that very deep and sharp furrows are always present on the surface of the test, particularly in its median part. This feature reminds us of *Fusulina brevicula* Schwager; the last named species differs however from the present one not only in its more strongly vaulted form and larger size, but in the absence of tectorium and anuli

Girtyina pankouensis Lee (sp. nov.)

Pl. V, Figs. 3-5

Test rather slender and recurved in the middle; umbilical ends more or less pointed and the median portion slightly depressed; axial length varies from 4.8 to 7.3 mm and median width from 1.06 to 1.44 mm; axial ratio ranges from 1:4.5 to 1:5.

Spirotheca and antethecæ exceedingly thin, and composed of three layers, namely the tectum, the osseum and the tectorium. Only very rarely does the spirotheca exhibit

traces of alveolar structure which is however never so distinct as to reveal clearly the individual dark lines in the section.

Antethecæ regularly plicated throughout the entire length of the whorls. The plication is always so gentle that in spite of the extraordinary thinness of the antethecæ, the truncated folds hardly ever appear as loops or arcs in the axial or para-axial sections but only as small dark patches, and the dark patches are never crowded.

Buccal aperture narrow and slit-like reaching about half the height of the respective chamber, being always well defined by a pair of anuli which, though not very stout, are nevertheless fairly conspicuous.

Very remarkable are two patches of a calcareous deposit spreading from the central part of the test to almost the extreme ends. When viewed in the axial section they appear to assume the shape of a fan.

Initial chamber usually spherical, sometimes slightly ellipsoid, or ovoid with a diametre usually varying from 0.16 to 0.22 mm, but occasionally as large as 0.3 mm.

Result of Measurements (in mm):

	Initial Chamber	Volutions						Specimen
		I	II	III	IV	V	VI	
Width	.16	.22	.356	.48	.63	.86	1.06	(2160)
	.2	.3	.43	.6	.83	1.16	1.44	(60)
	.3	.48	.65	.91	1.23			(1608)
Thickness of Spirotheca.		.01	.01	.02	.026	.033	.044	(2160)

REMARKS: A considerable variation will be observed in the above table as regards the width of each volution. But when we take them in series for each individual they are all of the same order. The apparent variation is in fact due to acceleration or retardation in development of the several individuals. The width of the first whorl in specimen (60) corresponds approximately to that of the second whorl of the specimen (2160); the width of the first whorl in the specimen (1608) corresponds to that of the third whorl in the specimen (2160) and to that of the second whorl in the specimen (60), and so on.

At a glance the present species recalls very strongly *Fusulina longissima* Möller. But the presence in the present species of a fairly thick tectorium on the internal side of

each chamber, of a pair of prominent anuli and the lack of distinctly alveolar structure in the osseum can serve at once as unmistakable distinction.

HORIZON AND LOCALITY: This species has been found in the Penchi Limestone, Penchihu, Fongtien; the Pinting Limestone, the Pinting Basin, N. E. Shansi, and the Pankou Limestone, West of Taiyuan, Central Shansi. In all these cases it is associated with *Girtyina konnoi*, *Bradyina nautiliformis* and other Moscovian species. Probably its vertical distribution is restricted to the Moscovian.

Girtyina cylindrica Fischer de Waldheim

Pl. I, Fig. 3; Pl. IV, Figs. 1-9

1829. *Fusulina cylindrica* Fischer; Ueber Fusulina; Bull. Soc. Nat. Moscou Vol. II, P. 330.
1830. *Fusulina cylindrica* Fischer; Oryctographie du Government de Moscou; P. 126, Pl. XIII, Figs. 1-5.
1876. *Fusulina cylindrica* Brady; Notes on a group of Russian Fusulinæ; Ann. Mag. Nat. Hist., Ser. IV, Vol. XVIII, P. 415, Pl. XVIII, Figs. 1-4.
1878. *Fusulina cylindrica* Möller; Die spiral-gewundenen Foraminiferen des russischen Kohlenkalks; Mém. Acad. Sci. St. Petersbourg. VII[e] Sér. Tome XXV, No. 9, pp. 51-54, Pl. I, fig. 2 a-b, Pl. VII, fig. 1 a-d.
1908. *Fusulina cylindrica* Schellwien; Monographie der Fusulinen, Palæontographica Vol. LV, pp. 161-163, Pl. XIII, figs. 1-4, 6, 7.

As rightly indicated by its specific name, the fully developed individuals of the present species generally possess a slender test of a cylindrical or subcylindrical form; but those which have not reached maturity of growth are often elongately fusiform.

Size of the test varies within a fairly wide range. The smaller individuals are so small that, when embedded in the rock, they are hardly recognizable by the naked eye; while the larger ones occasionally reach a length of more than 6 mm. A number of measurements made on individuals from different localities of North China shows that the ratio of axial length to median width of the complete test varies from 3.3 mm: 0.85 mm. to 6.4 mm: 1.2 mm, or 1:3.9 to 1:5.3. Forms having this ratio as low as 1:3.4 also occur, but are relatively rare. In the typical specimens the axial ratio ranges between 1:3.5 and 1:4.5.

Number of whorls usually varies from 6 to 5, rarely $6\frac{1}{2}$. Those only having three or fourth volutions are obviously individuals of immature growth.

Spirotheca very thin and fragile, for it is only in rare cases that the test is completely preserved. Thickness of the spirotheca is only slightly variable. In the last but one volution, namely the 4th or the 5th, which represents the thickest part of the spiratheca, the thickness generally falls under 0.045 mm, often as thin as 0.02 mm. Only occasionally, this figure rises above 0.045 mm owing to the development of a rather thick tectorium which is often thicker than the osseum, and reveals in rare instances faint alveolar structure.

Osseum, apparently homogeneous and solid in the usual case; only rarely shows indistinct traces of alveolar structure of such fineness as is barely recognizable under high power of the microscope.

Antethecæ either as thin as, or slightly thicker than, the spirotheca. They are more or less regularly and intensely folded even in the median part of the test. Towards the unbilical ends the folding becomes somewhat complicated as in most other species of *Fusulina*. The terminal parts of the test are nearly always free from calcareous accretion. Even in such rare cases when there are signs of successive deposition of lime in the umbilical ends, the deposit is never so massive and wide-spread as, for instance, in *Girtyina pankouensis*.

Numbers of antethecæ as counted in a specimen from Tangshan (303) are 10, 18, 24, 32, 36 in the I, II, III, IV, V volutions respectively. These figures seem to show an accelerated development from the second volution onward as compared with those in Möller's original specimens.

Whorl closely coiled in the first two volutions, rapidly widens out in the third; thence again the coiling becomes closer.

A number of measurements is given below so as to show the limits of variation of several structural features in specimens from different localities:

Dia. of Initial Chamber in mm.	Widths of the successive volution in mm.						Specimen
	I	II	III	IV	V	VI	
0.2	0.3	0.455	0.67	0.9	1.22		(303)
0.19	0.24	0.44	0.67	0.91			(300)
0.19	0.25	0.38	0.59				(301)
0.166	0.377	0.58	0.84	1.21			(64)
0.19	0.31	0.44	0.61	0.85			(3916)
0.192	0.24	0.36	0.54	0.816			Möller's
0.223	0.305	0.458	0.686	0.034			,,
0.15	0.244	0.37	0.59	1.877			Miatschkovo (a)
0.21	0.31	0.44	0.59	0.8			,, (b)
0.13	0.2	0.31	0.477	0.7	0.97		,, (c)

Rather conspicuous, though not particularly stout, is a pair of pseudo-anuli between which lies a well-defined buccal aperture. This last named feature is

approximately quadrilateral in cross-section and about twice as broad as high in the first and the second volutions, considerably broader than high in the third and the fourth. As a consequence of a gentle plication in the very median part, the upper edge of the buccal aperture in the last volution is often of a somewhat irregular shape. In the first three volutions the height of the buccal aperture reaches half or nearly so of the height of the respective chamber; but in the fourth the height is reduced to about $\frac{2}{5}$ of the height of the chamber as a necessary consequence of a considerably more lateral extension. Length of the aperture reaches, in the majority of cases, about $\frac{1}{1\frac{1}{2}}$ of the axial length of the respective whorl.

Initial chamber relatively large, almost perfectly spherical, having a diametre ranging from 0.194 to 0.22 mm. Those having a diametre of 0.2 mm are the commonest. Wall of the central chamber is usually about 0.025 mm thick; that is, only slightly thinner than the thickest part of the spirotheca.

REMARKS: As noted by Schellwien there is probably not another specific name of *Fusulina* that has been so frequently mentioned and misused by palæontologists at different times. As this unfortunate state of things has generally resulted from superficial observation, it indicates in no way any great difficulty in the identification of this species. In fact the description and figures given by Möller practically furnish all the microscopic characters, as they seem to me, required for that purpose.

The more salient features that characterize *cylindrica* are its slender form, often minute size, relatively large and perfectly spherical initial chamber, a pair of rather slender but prominent anuli and very thin spirotheca. The last named feature is perhaps somewhat exaggerated by Schellwien who has apparently included in it a closely allied but independent species that has an exceedingly thin apirotheca, namely *Girtyina quasicylindrica*.

In Möller's original figures of the present species the presence of an alveolar osseum in the spirotheca is indicated by numerous fine lines. Nothing however is mentioned of this structure in his description. If Möller's figures represent the true type of structure then there is some reason to assign this species to the subgenus *Schellwienia*. But in Schellwien's microphotograph of Möller's original specimen a somewhat different type of structure is to be observed. For instance, the spirotheca in the third volution obviously consists of two dark layers with a lighter layer in between. The dark layers are undoubtedly the tectorium, and the lighter layer the osseum which, as far as can be judged by the microphotograph, does not seem to reveal any perceptible trace of alveolar structure, at all events, not so distinct as is figured by Möller. In his description

Schellwien says "Die poren in den Kammerwandungen sind sehr fein und bei den meisten Vorkommen recht undeutlich". All our material entirely confirms Schellwien's observation. Again, both in the Russian specimen which I obtained from the Environs of Moscow and in those of Tangshan, Penchihu etc., a thick layer of tectorium is always developed on the internal side of the spirotheca. It would therefore seem inconvenient and unwarranted to class this species as a *Schellwienia*.

HORIZON AND LOCALITY: Representatives of the present species almost indistinguishable from Möller's specimen have been found in the Tangshan Limestone of the Kaiping Basin and in the several layers of Fusulina Limestones of the Penchihu and the Yentai coalfields, South Manchuria. In these limestones the faunal assemblage is almost identical with that in the Miatschkovo limestone of the Moscow district, *Fusulinella booki*, *Spirifer mosquensis* and the present species being among its dominant elements.

Other types which conform closely with some of Schellwien's specimens and with those which I have recently collected in the Moscow district are also found in Tangshan and Penchihu. These types though appear to be slightly different in shape from Möller's form, possess however no special characteristics on which a specific or even varietal distinction can be made.

A form of more notable modification, though still closely related to the present species has been found in the Pinting Limestone. It presents an appearance similar to one of Schellwien's figures (Palæontographica, Bd. LV, Taf. XIII, fig. 4). The only difference lies in the fact that in the Pinting form there is a heavier calcareous deposit along and around the axis.

Finally, a note must be made of the Yanghukou representative (Pl. IV, fig. 9). It is not possible to determine this single specimen with certainty whether it belongs to *cylindrica* or but a young individual of its closely related species *quasicylindrica*. At all events they must represent the same epoch as is warranted by their association with *Girtyina præsimplex* and *Bradyina nautiliformis*, namely Moscovian, and probably the later part of Moscovian.

Girtyina quasicylindrica Lee (sp. nov.)

Pl. IV, Figs. 10-19

1908. *Fusulina* sp. Palæontographica, Vol. LV, Pl. XVII, fig. 10.
1923. *Fusulina elongata* var. *minoris* Lee; Bull. Geol. Soc. China. Vol. II, No. 3-4, p. 74, Pl. II, fig. 7.

Test slender, cylindrical or elongately fusiform; Axial length varies from 3.3 to 8.2 mm, median width from 1.1 to 1.76; axial ratio ranges between 1:4.6 and 1:3.

Number of whorls usually 4 to 5, sometimes 6, rarely $6\frac{1}{2}$.

Spirotheca excedingly thin and fragile being composed of two thin layers of tectorium, a thicker and lighter layer of osseum and an opaque tectum which is so thin that even in well preserved specimens it is only barely recognizable with the aid of some imagination.

Osseum apparently homogeneous, only here and there presents a vague impression of being alveolar in structure.

Thickness of the spirotheca almost uniform throughout the successive volutions, about 0.02 mm on the average. Antethecæ either as thin as, or slightly thicker than, the spirotheca. They are in some forms (particularly the elongated and recurved ones) regularly and somewhat intensely folded, but less so in others. When they are regularly folded the truncated folds often takes the shape of a rectangle instead of an arc. Judging from the average height of the evenly spaced rectangles, at least $\frac{3}{5}$ of the height of the antethecæ is involved in the folding.

Number of antethecæ for each volution appears to vary considerably from individual to individual. The range of variation is indicated by the following figures obtained from a few typical specimens:—

Volution	I	II	III	IV	V	Specimen
Number of Antethecæ	11	21	24	27		(3908)
	10	18	20	22	24	(3909)
	10	20	25	25	30	(3919)

Whorl closely coiled in the first two volutions, rapidly widens out in the third, thence again it becomes closer. In this respect the present species does not differ appreciably from *Girtyina cylindrica*.

Pseudo-anuli rather thin but prominent; buccal aperture well defined, being nearly quadrilateral in cross-section. In the first and the second volutions the buccal aperture reaches about twice as high as its breadth, but becomes considerably broader than high in the third and the fourth.

Results of measurement (in mm):—

Dia. of initial chamber	Widths of successive volution						Specimen
	I	II	III	IV	V	VI	
0.2	0.33	0.48	0.66	0.91	1.2		(3909)
0.22	0.35	0.5	0.74	1.01	1.38		(3918)
0.2	0.366	0.54	0.32	1.16			(3902)
0.3	0.41	0.58	0.81	1.11	1.46		(3908)
0.2	0.31	0.44	0.66	0.94	1.26		(3904)
0.2	0.377	0.535	0.766	1.1	1.42	1.7	(3910)
—	0.278	0.42	0.59	0.89	1.24		(3912)
—	0.33	0.5	0.71	0.97	1.33	1.72	(3001)

Axial ratios for the successive volutions:

I	II	III	IV	V	VI	Specimen
2	2.86	3.36	4.25	4.86		(3904)
1.64	2.28	2.9	3.36	4.26	4.54	(3910)
1.8	2.25	2.7	3.3			(3918)

REMARKS: In his "Monographie der Fusulinen" Schellwien produces a figure of an undetermined species of *Fusulina* from Tschöngkiang left by Schwager who, like Schellwien himself, probably experienced some difficulty in the specific determination of such an isolated form. A careful comparison of Schellwien's microphotograph with our thin sections has however shown that this peculiar form is by no means due to an abnormal development but conforms, in all its essential features, with the form under consideration. Their specific identity is absolutely indisputable.

Schellwien compares Schwager's specimen with a certain thin-walled type of *cylindrica* of Russia, but remarks at the same time that the resemblance is more probably due to convergent development than to any true generic relation. Knowing nothing of the actual occurrence of typical *cylindrica* and other Miatschkovo species in North China it was quite natural for Schellwien to have expressed such a guarded opinion. The facts have however completely disproved Schellwien's assumption.

The problem then arises; should we treat the Tsöngkiang form and its representatives in North China as a variety of *cylindrica* or as an independent but allied

species? In Möller's measurements of *cylindrica* individuals reaching a length of 7 mm are recorded. This seems to suggest the possibility that the elongated variety of the present form might occur in association with the typical *cylindrica* in Russian as in Kansu, and that Möller might have attributed it to the same species. If this be actually the case, then it would be quite legitimate to include the present form in *cylindrica*. The apparently minor differences such as the size and number of volutions can be explained away by assuming the present form as belonging to that group of *cylindrica* which has reached a higher stage of ontogenetic development. In support of this argument we may point out the fact that the antethecæ in the sixth volution of the present form are usually folded in an exceedingly irregular manner, accompanied naturally by a lower rate of spiral expansion on the part of the spirotheca. In this last stage of growth the sarcode seems to have lost a part of its vigor and energy with which it had constructed the early whorls. This senile stage of development has never been observed in the typical *cylindrica* of the Miatschkovo Limestone. Thus the latter would appear to be more or less premature in its ontogenetic development.

On the other hand, of hundreds of thousands of individuals contained in a piece of Miatschkovo Limestone cordially furnished by Prof. Pavlow, not a single one is found that reaches a length of 5.6 mm, the majority being considerably under that size. The material examined by Schellwien who seems to have included more varied types in *cylindrica* than did Möller, is also said to be no more than 5.7 mm in length. The suspicion is therefore not absent that the elongated variety of Möller's *cylindrica* may not concur in all its internal structural features with the typical *cylindrica* as is figured by him.

Certain types of Schellwien's *cylindrica*, for instance those represented by figs. 5, 14, (Palæontographica, Vol. LV, Pl. XIII), seem to approach the form under discussion, but they are obviously much smaller in size, and therefore cannot be readily identified with our form.

Before the discovery of precisely the same form in the Miatschkovo Limestone it would seem to be more on the safe ground to treat the present form as an independent species for which the name *quasicylindrica* seems appropriate.

Certain stouter varieties of *Girtyina quasicylindrica* appear to approach *G. konnoi*, but the latter is generally more vaulted in the median part, and possesses more whorls. Other young individuals are sometimes almost indistinguishable from typical *cylindrica*.

Horizon and Locality: *Girtyina quasicylindrica* abounds in the Yanghukou fauna of N. W. Kansu, fairly common in the Pankou Limestone of Central Shansi and

rarely occurs in the lowest layer of Fusulina Limestones of Changchu, Western Shantung. In this last-named locality it reaches such an extraordinary length, that I formerly mistook it as a variety of *Fusulina elongata*. Dr. I. Hayasaka informs the author that the same form was found in one of the layers of Fusulina Limestones developed in the Poshan coalfield. Unfortunately I have not as yet obtained material to confirm this report.

In discussing the stratigraphical position of this species, we must naturally look for correlating data in the Yanghukou fauna which, as far as Foraminifera is concerned, largely consists of this species and its variety *brevis*. It is significant that of the numerous sections that I have prepared of the Yanghukou material no unquestionable *cylindrica* nor such common Moscovian species as *Girtyina konnoi*, *Staffella sphæroidea*, *Neofusulinella bocki*, etc. are represented. On the other hand, there are scattered individuals of *Bradyina nautiliformis* and *Neofusulinella præsimplex*. These are the characteristic fossils of the Penchi Series. The presence of these species together with *Spirifer mosquensis* and the absence of any *Schellwienia* of the Taiyuan Series from the Yanghukou fauna renders it fairly conclusive that *Girtyina quasicylindrica* must still belong to the Moscovian time, but probably to the latest part of that epoch.

Girtyina quasicylindrica var. **brevis.** Lee

Pl. V. Figs. 1-2

This variety differs from the typical *quasicylindrica* in having a closer type of coiling, often arcuate shape and more gentle folding in the median region of the test. This last named feature is so striking that, if not for its larger size, more whorls, much thinner spirotheca and more or less elongated form, the present variety might be easily mistaken as a variety of *Girtyina præsimplex*.

Number of whorls usually 6 sometimes $6\frac{1}{2}$.

As regards the width of the successive volutions two series of measurements are made, one on an individual from Yanghukou (3914) and the other (85) from a point 200 k. m. north of Kalgan. They are tabulated below:

Dia. of initial chamber in mm.	Widths of successive volutions in mm.						Specimen
	I	II	III	IV	V	VI	
0.22	0.36	0.5	0.66	0.9	1.18	1.5	(85)
0.19	0.31	0.467	0.678	0.922	1.21	1.52	(3914)

Comparing graphically these figures with those obtained from the typical specimens of *quasicylindrica* it will be noticed that the first parts of the graphs practically coincide. But in the last parts the graph for the present variety shows a decidedly lower gradient than those for the typical *quasicylindrica.*

Another point of demarcation is their relative length or axial ratios. In the typical *quasicylindrica* the axial length usually exceeds 7 mm. with an axial ratio of 1:5 when its number of volutions reaches 6; whereas, the present variety, though having 6 volutions, barely attains a length of 6 mm. with an axial ratio of only about 1:4.

So far this variety is only known to occur in the Yanghukou Limestone, N. W. Kansu, as an intimate ally of *Girtyina quasicylindrica,* and at a point 200 k. m. north of Kalgan. In the latter case the specimen (85) is of a stouter form and seems to be more closely related to *G. konnoi* with which it is associated. Thus it may represent a transitional form between *G. konnoi* and *G. quasicylindrica.*

As in the case of *quasicylindrica* the present variety is assigned to the Moscovian.

Subgenus **SCHELLWIENIA** Staff-Wedekind

Schellwienia simplex (Schellwien)

Pl. V, Figs. 6-11, 13

1908. *Fusulina simplex Schellwien;* Palæontographica, Vol. LV, pp. 179-182, Pl. XVIII, figs. 4-6, 10, 12.

Test slender, elongated, vaulted but slightly in the median portion, more or less rounded in the umbilical ends. The longest specimen in our collection measures 6.1 mm long and 1.33 mm wide. The length and width of the normal individuals however vary from 4.7 mm to 5.3 mm and from 1.41 mm to 1.5 mm respectively. The axial ratio of the complete test is about 1:3.4 on the average. In the highly elongated forms this ratio sometimes reaches 1:4.6.

Number of whorls 5 to $5\frac{1}{2}$ when fully grown, but often not more than 4.

Whorls are rather compactly coiled in the first two or three volutions, distinctly broader from the third volution onward. This change of the mode of coiling is accompanied by a change of the thickness of the spirotheca. In the second volution the thickness of the spirotheca is no more than 0.03 mm, while in the fifth it generally reaches 0.067 mm, sometimes as much as 0.09 mm.

Similar changes are observed in nearly all the other structure features suggesting two distinctive stages of growth. For instance, in the inner volution the antethecæ are

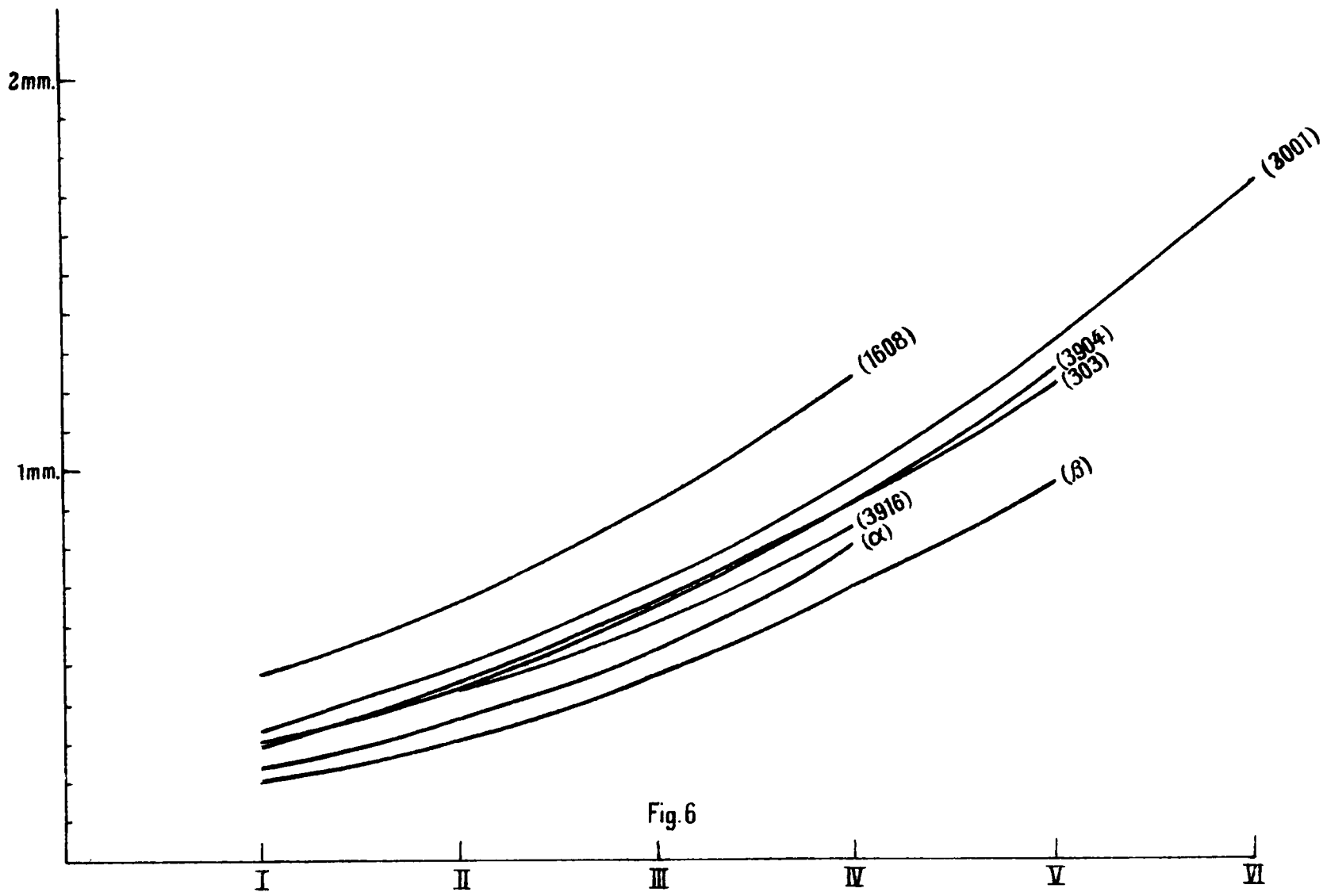

Fig. 6

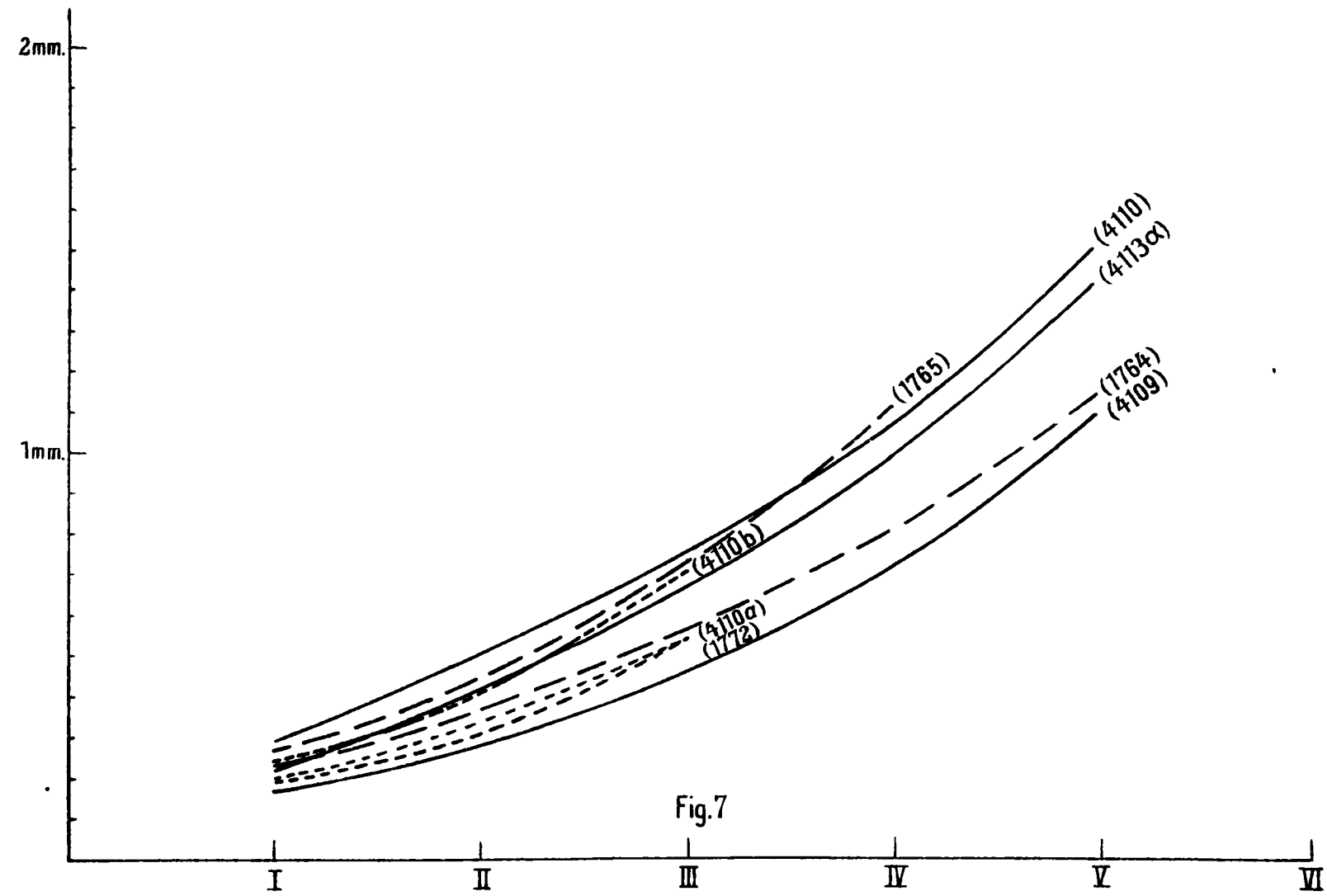

Fig. 7

Fig. 6. Width-graphs of *Girtyina cylindrica* (303, 3916, 1608?, α, β) and *G. quasicylindrica* (3001, 3904), α, β being specimens from Miatschkovo Limestone.

Fig. 7. Width-graphs of *Schellwienia simplex* (4109, 4110, 4113a), *Schell. simplex* var. *minuta* (1772, 4110a, b) and *Schell. parvula* (1764, 1765).

[*To face page 40*]

fluted to a more notable extent, though still very gentle as compared with other species; but in the outer ones they become almost plane, at least over the median region. The usual loops or twists arising from the truncation of the folded antethecæ are only observable in the axial section towards the terminal parts of the outer whorls, and then they are always broadly disposed. The outer whorls are often highly elongated in the umbilical region.

Buccal aperture small and narrow in the inner whorls, but becomes low and very broad in the outer ones. In one instance which appears to represent the average form, the width of the buccal aperture in the second whorl is only about $\frac{1}{9}$ of the axial length of that whorl; whereas in the fourth whorl which is much more elongated as compared with the second, the width of the aperture extends almost for about $\frac{1}{4}$ of the length of that whorl. A similar state of thing happens to the anuli. In the inner, or the compacter whorls, they appear to be very massive, but in the outer whorls they become less conspicuous, though somewhat broader.

Initial chamber usually spherical having a diametre varying from 0.09 mm to 0.18 mm, not infrequently deformed to all kinds of irregular shape.

Measurements relating to the widths of the successive volutions, axial ratios, the diametre of the initial chamber, etc. are tabulated below:—

	Initial Chamber	Volution					Specimen
		I	II	III	IV	V	
Width in mm	.09	.17	.28	.46	.71	1.08	(4109)
	.1	.17	.3	.51	.83	1.22	(4113)
	.11	.22	.43	.67	1.0	1.41	(4113a)
	.17	.29	.46	.74	1.06	1.5	(4110)
Axial ratio			2	2.7	3.9	4	(4110)
Number of Antethecæ		11	18	21			
		10	15	22			

REMARKS: There cannot be much doubt that our species essentially agrees with Schellwien's *F. simplex*. Unfortunately Schellwien's description is not sufficiently illustrated, nor do the few microphotographs given by him indicate the limit of specific variation such as suggested in his description. As far as Schellwien's published

material is concerned, there is an axial section of what he named *F. prisca* (Palæontographica, Vol. LX, Pl. XVIII, fig. 10) that seems to resemble our species even more closely than the only axial section of *simplex*. If, however, we take Möller's original figure of *prisca* as the typical form of that species it seems more natural to separate the form represented by fig. 10 (loc. cit.) from true *prisca*, and place it in the species under consideration (see p. 49). If it differs from our species at all, it is only in those minor features such as the alar prolongation and a slightly broader coiling of the outer whorls.

However, the possibility is not disproved that there may not be intermediate form linking the two.

Our species is characterized by almost unfluted antethecæ which stretch over a considerable portion of its median part, the prominence of anuli and the broad buccal aperture in the outer volutions. It can easily be distinguished from *Fusulina montipara* by its more slender shape, though the two probably stand in close relation.

HORIZON AND LOCALITY: *Schellwienia simplex* occurs abundantly in the "Fusulina Limestone" of Yaokou, Kaotaihsien, Kansu. The whole rock is crowded with this species and its variety *minuta*. Occasionally it associates with incipient or young forms of *Schellwienia longissima*. But in the large number of sections that I have prepared, no trace has been found of the fully-grown *longissima*. On the other hand representatives of Moscovian Foraminifera, such as *Bradyina nautiliformis*, *Neofusulinella booki* etc. are entirely absent. It is therefore judged that the Yaokou Formation probably represent either the lowest Uralian or the transitional stage between Moscovian and Uralian.

Schellwienia simplex var. **minuta** var. nov.

Pl. V, figs. 12, 14-19

Closely associated with *Schellwienia simplex* in the Yaokou fauna of Kaotaihsien, Kansu, there are numerous individuals of a small *Schellwienia* with 3 to $3\frac{1}{2}$ whorls strongly resembling the inner volutions of *Schellwienia simplex*. Their size varies from 1.3 mm : 56 mm to 1.82 mm. : 0.75 mm with a very thin spirotheca and gently fluted antethecæ. When compared with *Schellwienia simplex* it recalls, in all its essential features, (see the table below and the accompanying graph.) the early stage of that species. The question then arises : are we here dealing with a variety of *Schellwienia simplex* or but young individuals of the same species? Its persistence of conforming with a definite type of its own in the Yaokou fauna and its isolated occurrence in the Yaoku Limestone of the

Pinting Basin, N. E. Shansi, and also in the Chientaokou Limestone, Central Shansi, are facts which seem to be in favour of the former interpretation. I would therefore tentatively consider this form as the forerunner of *Schellwienia simplex*, and regard it as a definite variety.

The measurements tabulated below show how closely the figures agree, as a whole, with those obtained from typical *simplex*.

	Intial Chamber	Volution				Specimen
		I	II	III	IV	
Width in mm	.12	.19	.31	.54		(1772)
	.13	.22	.36	.56		(4108)
	.12	.19	.33	.54		(1773)
	.12	.2	.33	.54		(4110a)
	.12	.24	.42	.7		(4110b)
	.12	.21	.33	.56		(4112)
Axial ratio		—	2.4	—		(1772)
		—	2.3	—		(4108)
		—	2.5	—		(1773)
		—	2.3	—		(4112)

Schellwienia parvula Schellwien

Pl. VI, Figs. 1-4, 6, 9

1908. ***Fusulina prisca*** var. ***parvula*** Schell., Palæontographica, Vol. LV, p. 184, Pl. XIX, figs. 14-15.

1925. ***Fusulina prisca*** var. ***parvula*** Ozawa, Palæontological and Stratigraphical Studies on the Permo-Carbonierous Limestone of Nagato Part II, p. 39, Pl. V, fig. 3.

Test elongately fusiform, slightly vaulted in the median region rounded in the umbilical ends. Even the adult specimens are only of a minute size. In three typical forms which admit accurate measurement the axial lengths amount to no more than 3.6, 3.9, 4.4 mm, and the median widths 1.4, 1.16, 1.4 mm respectively. These give an axial ratio varying from 1:2.6 to 1:3.3.

Number of whorls usually 5 sometimes 6.

Whorls compactly coiled, particularly so in the inner volutions. Width of the successive volutions and axial ratio of the inner whorls are a follows:—

	I	II	III	IV	V	Specimen
Width in mm	.24	.4	.61			(1768)
	.2	.355	.63			(1767)
	.266	.44	.72	1.1		(1765)
	.255	.44	.74	1.11		(1771)
	.23	.37	.56	.81	1.14	(1764)
	.24	.41	.72	1.17		(1766)
	.22	.35	.55	.82	1.28	Nagato
	.27	.4	.7	1.0	1.47	Volonga*
Axial ratio	1.6	2.5	2.64			(1768)
	2.1	2.4	2.76			(1771)
		2.7	3	3.1		(1766)

* Measured by the author from Schellwien's microphotograph.

Spirotheca very thin, alveolar structure hardly visible in the first two or three volutions ; but becomes considerably thicker and quite distinctly alveolar from the third volution onward. In the fifth volution the thickness reaches about 0.06 mm.

Anthecæ are generally fluted in the shape of widely spaced folds, sometimes they are almost plane in the median region.

Number of antethecæ appears variable. They are counted in the first four volutions 11, 21, 29, 33 in one case, and in the first three volutions 11, 16, 18, in another. In the second case the figures agree more closely with the median section figured by Möller and those given by Ozawa.

Aperture small and narrow throughout the test ; anuli fairly prominent, and always present, probably of a real nature.

Initial chamber usually spherical, sometimes ellipsoidal with its major axis pointing towards the poles; diametre of initial chambre varies from 0.11 to 0.14 mm in our material.

HORIZON AND LOCALITY: All of the above described material is obtained from the limestone-layer (Yaokushi) immediately above the main coal seam of the Pinting Basin, N. E. Shansi. There, it is associated with *Schellwienia longissima*, and other Taiyuan forms. Therefore it belongs undoubtedly to the Taiyuan Series, and probably is restricted to the lower part of that formation; for no trace of it has been found in the several layers of limestones above the Yaoku Limestone.

Outside of the Pinting Basin there is only one significant case that deserves special mention in this connection (Pl. VI, fig. 6).

In a large number of microslides prepared from the material obtain by Mr. P. L. Yuan from the lower layer of "Fusulina Limestone" of Hsinho, Kansu, I have found, among many others, a somewhat oblique section which measures about 5 mm long and 1.73 mm broad. One side of the test appears rather unnaturally flattened, and the antethecæ slightly damaged probably through the compression of the rock-material in which it is embedded. It is therefore judged that the complete test must be slightly longer and broader in its natural shape. The axial ratio cannot, however, at all events be higher than 1:3.

There are five whorls in all. The first two or three volutions are rather compactly coiled. From the third volution onward the whorls steadily widen out. The widths of the successive volutions are as follows:—

I, 0.22; II, 0.41; III, 072; IV, 1.3; V, 1.74 in mm.

In the first two or three volutions the spirotheca is rather thin having a fine alveolar osseum; thence onward the spirotheca becomes quite thick and at the same time the alveolar structure grows distinctly coarser. In the last volution which is the thickest of all, the thickness actually reaches 0.09 mm.

Antethecæ appear fairly thin; only slightly but irregularly fluted in the median part, almost plane in the outer volutions.

Buccal aperture very low and relatively narrow in the inner volutions, but becomes considerably broader in the outer ones.

Anuli fairly stout and distinct, and present up to the last whorl.

Initial chamber thin-walled, spherical, having a diametre of 0.13 mm.

Comparing this form with that from the Yaoku Limestone of Shansi, it is not difficult to see that the two are closely related if not specifically identical. The only

difference lies in the fact that the Kansu form is somewhat larger in size, and its antethecæ more gently folded. Thus it approaches *Schellwienia simplex*. It is however admittedly a dangerous proposition to determine the general property of a form on a single section. Therefore the question of its identification or affinity must await further descovery of this problematic species in the Hsinho fauna.

REMARKS: Although it is rather difficult to compare the several features of the present species with those of *Fusulina prisca* var. *parvula* of Schellwien who gives but a very brief description of the said variety, a large number of sections has been prepared for comparison from the material derived from Zarew Kurgan and labeled by Nikitin as *F. prisca*, *F. longissima* and *F. verneuili*. Of these, I am fortunate enough to find numerous individuals that can hardly be distinguished from those of the Yaoku Limestone, Shansi. Presumably they were recognized by Nikitin as *F. prisca* (Ehrenb). For the reason to be explained below, it is better to separate this group of forms from true *prisca*, and assign them, together with the material under consideration, to an independent species, namely *Schellwienia parvula*.

It will be observed that anuli, be they real or false, are only developed in Möller's *prisca* up to the second volution, and then rather in a rudimentary form; while in Schellwien's *Fusulina prisca* var. *parvula*, as in our case, the anuli are well-developed up to the last part of the last whorl. If this feature is of some specific value as the author is inclined to believe, then it would be more natural, apart from all other considerations, to separate Schellwien's var. *parvula* from its supposed type-species *prisca*, and establish a new species *parvula* as I have done here.

Schellwienia incisa (Schellwien)

Pl. V, Figs. 21, 22

1897. *Fusulina incisa* Schellwien; Palæontographica, Vol. 44, pp. 252-253, Pl. XVIII, Figs. 5-9.
1912. *Fusulina incisa* Deprat Mém. Serv. Géol. Indochine, Vol. I, Fasc. 3, P. 34, Pl. VIII, figs. 4, 5.
1925. *Schellwienia incisa* Ozawa; Journ. Coll. Scien. Tokyo, Vol. XLX, Art. P. 37, Pl. V, Figs. 8, 9.

In the numerous microsections of the material from Hsinho, Kansu, there are only two sections representing this species. The one (4026) measures 4 mm long and 1.78 mm broad with but a slight median vaulting and rounded umbilical ends. The widths of the successive volutions measure 0.24, 0.42, 0.78, 1.22 1.78 mm from the first to the fifth volution respectively. These figures are obviously of the same order as those given by Schellwien except for the first few whorls which show a uniformly lower value in our case. This is however to be expected; for our section is clearly para-axial, and

therefore the measured values must depart more pronouncedly from the true widths because of their greater curvature.

The other section (4045) is almost, though not quite, exactly axial having a length of 4.8 mm and a breadth 1.78 mm, and shows clearly the characteristic features of *Fusulina incisa* Schellwien such as the gently fluted antethecæ, relatively thick spirotheca, rather coarsely alveolar osseum and well-developed, though not particularly massive, pseudo-anuli. Widths of its successive volutions measure 0.266, 0.53, 1.05, 1.75 mm from the first to the fourth volution respectively. Comparing these figures with those given by Schellwien it will be found that in our specimen the value for the first volution is lower, and none corresponds to the fourth. Such differences are however within specific variation, for similar variation is often observed in other species.

This species is undoubtedly related to *Schellwienia simplex*, but differs therefrom in having a stouter test, more whorls and higher rate of spiral expansion. Stratigraphically it probably appears in a higher horizon than that at which *Schellwienia simplex* reaches its acme of development.

Schellwienia prisca (Ehrenberg)

Pl. VI, Figs. 5, 7-23

1842. *Alveolina prisca*, Ehrenberg; Berichte der königl. preuss. Akad. der Wissenschaften, p. 274.

1878. *Fusulina prisca*, Möller; Die spiral-gewundenen Foraminiferen des russichen Kohlenkalks, pp. 56-59, Pl. III, figs. 1 a-c, Pl. VI, figs. 2 a-c.

1908. *Fusulina prisca*, Schellwien, in part, Monographie der Fusulinen, Palæontographica, vol. LV, pp. 182-184, Pl. XVIII, figs. 8, 9?. 11 (non fig. 10).

1925. *Fusulina prisca*, Ozawa, Palæontological and Stratigraphical Studies on the Permo-Carhoniferous Limestone of Nagato, Part II, p. 38, Pl. V, fig. 5.

Test asymmetrically fusiform, the median part being more pronouncedly vaulted on one side than on the other; umbilical ends usually pointed, sometimes more or less rounded. The common form is rather small having an average axial length and median width of 5 mm and 2 mm respectively. The largest specimen among our material measures 7 mm long and 2.3 mm broad. The axial ratio of the complete test varies from 1:2.5 to 1:3.

Number of volutions usually 5, sometimes only 4; the latter type probably includes individuals of immature growth.

Whorls moderately compact in the inner volutions, but steadily widen out towards the outer ones. The width, axial ratio and number of antethecæ in the successive volutions are as follows:—

	Volution						Specimen
	I	II	III	IV	V	VI	
Width in mm	.33	.6	1.04	1.6			(1748)
	.32	.58	1.05	1.6			(4018)
	.3	.53	.87	1.38			(4030)
	.33	.67	1.28	1.94			(1750)
	.3	.57	1.02	1.64	2.25		(1753)
	.43	.81	1.33				(1749)
	.33	.68	1.05				(1752)
	.31	.61	1.05	1.8			(1741)
	.28	.47	.83	1.45			(1742)
	.28	.42	.63	1.02	1.58	2.05	(1739)
	.31	.57	.92	1.39	2.0		Zarew-Kurgan (Möller)
	.49	.85	1.31				
	.43	.64	1.01	1.63	2.31		Nagato (Ozawa)
	.43	.73	1.20	1.85	2.61		
Axial ratio	2	2.4	2.6	2.8			(1748)
	1.6	2.3	2.3	2.4			(1750)
	1.8	2.05					(1749)
	1.8	2.2	2.3	2.7			(1742)
Number of Antethecæ	13	21	29	37			(1738)
	12	23	37				(1747)
	13	22	29	38			(1736)
	13	21	30	35			(1744)
	12	21	37				(1740)
	13	22	24	24	29		(1739)
	13	20	25				Zarew-Kurgan.
	12	21	26	28	28		Nagato

Spirotheca very thin, finely alveolar in the first two volutions; but it thickens steadily from the third volution onward; at the same time the alveolar structure becomes coarser. In the fourth volution the thickness generally varies from 0.66 to 0.08 mm being sometimes as thick as 0.09 mm. When the fifth volution is developed, it is often slightly thinner than the fourth showing the advent of the senile stage.

Antethecæ considerably thinner than the spirotheca, folded, as a rule, in an irregular manner; only in rare cases a slight degree of regularity of folding is to be observed in the median region. The individual chamber is but slightly arched in the spiral part; as a consequence, the surface of the test is marked by very broad and gentle furrows.

Buccal aperture small, often unobservable in the axial section, always ill-defined in the outer volutions.

Anuli only present on the wall of the initial chamber; and rarely developed in the first volution in a redimentary manner.

Initial chamber usually spherical sometimes in the form of an indented spheroid with a diametre of 0.2 mm on the average, varying between the limits of 0.16 mm to 0.23 mm.

REMARKS: While the foregoing description shows that our species agrees in all its essential characters with *Fusulina prisca* of Möller and Ozawa, and with a part of the material described by Schellwien under the same specific name, it remains to be noted that the overwhelming majority of our form are about 5 mm long and 2 mm broad. Those reaching the size of 7 mm. : 2.3 mm represent the rare exception. According to Möller and Schellwien, the largest Russian representative of this species has a length of 8 mm and width of 2.20 mm. I am not sure if Möller had ever examine the internal structure of such large forms, and if he obtained evidence that they were structurally identical with his microscopic figure. (Möller, op. cit. Pl. VI, fig. 2a). It is on the latter figure that I have based my identification. As far as I am able to judge, forms notably different from Möller's type-figure are included by Schellwien in one and the same species. This latter author gives a microphotograph, for instance, of a form that would seem to be better referred to *Schellwienia simplex* than to *Schellwienia prisca* and states that there are transitional types between the *simplex*-like form and the typical *prisca*.

In the Hsinho fauna of Kansu in which *simplex* and *prisca* occur side by side. I have however found no such transitional forms. Even if such intermediate forms do actually occur, there is no reason why we should not separate such widely different types.

One has always to guard against the ever-present prejudice arising from associated occurrences in specific determination.

As regards the number of antethecæ in the several whorls our form practically agrees with the Russian and the Japanese representatives up to the second volution; but from the third volution onward, the number is appreciably higher in our material as indicated in the foregoing table. It is a noteworthy fact that the numbers are practically constant in all our specimens except such variation as may be ascribed to retardation or acceleration. We do not know whether the Russian and Japanese forms are equally constant in their number of antethecæ or the few figures given by Möller and Ozawa are but examples of particular cases. The comparison therefore can hardly be regarded as on a sound basis. Thus it does not appear desirable to establish a new variety on that ground.

When compared with other associated species and their varieties several lines of modification seem to converge on the present one. Apart from *Schellwienia simplex* whose genetic relation with the present species is still problematic, there are forms in this species that, by a further axial elongation more regular folding of the antethecæ and incipient development of a network of folds in both ends, approach *Schellwienia richthofeni;* and others that, by intense and extremely irregular folding of the antethecæ, probably gave rise to *Schellwienia complicata*. A third line of variation is to be traced from certain regularly fusiform types of this species to *Schellwienia regularis* which is distinguished from the present one only by a much more regular type of folding of the antethecæ, thicker spirotheca and coarser alveolar structure. Although without further substantiating data we cannot be dogmatic about these broad inferences, the fact seems fairly evident that we are here dealing with a species which played a dominent rôle in the evolution of *Schellwienia* at large.

Some apparent resemblance may be observed between this species and *Fusulina exilis*. A closer examination will however show that the latter is generally of a larger size, and has more regularly folded antethecæ and more whorls.

Schellwienia regularis Schellwien

Pl. VII, Figs. 8-10

1898. *Fusulina regularis* Schell., Palæontographica, Vol. XLIV, pp. 250-251, Pl. XIX, Figs. 1-6.

Test rather small, regularly fusiform throughout the successive whorls; axial length of the complete test varies from 4.4 to 4.6 mm and median width from 1.7 to 2.0 mm; axial ratio about 1:2.6 on the average; number of whorls ranges from 4 to $5\frac{1}{2}$; spirotheca fairly thin in the first volution but steadily becomes thicker towards the last; alveolar

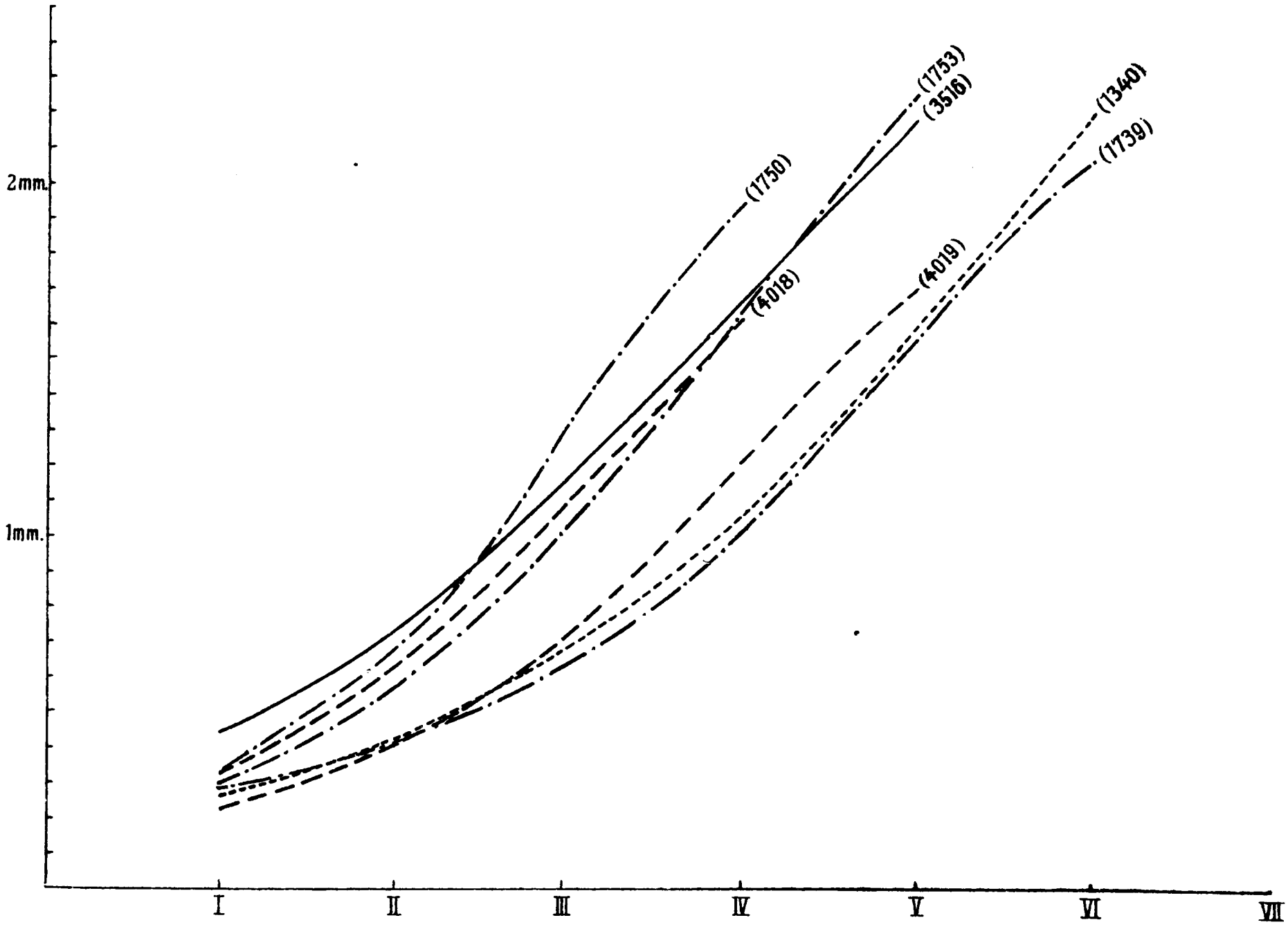

Fig.8

Width-graphs of *Schellwienia prisca* (1750, 1753, 1739), *Schell. regularis* (4018, 4019), *Schell. anderssoni* (1340) and *Schell. valida* (3516).

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osseum moderately coarse; whorls fairly broad; antethecæ regularly folded; buccal aperture small but high in the inner volutions becoming broader and lower in the outer ones; pseudo-anuli apparently present at least in the inner volutions; initial chamber perfectly spherical but variable in size.

Results of measurement :

	Initial Chamber	Volution					Specimen
		I	II	III	IV	V	
Width in mm	.27	.5	.78	1.29	2.00		(4042)
	.18	.33	.63	1.1	1.62		(4018)
	.13	.23	.41	.71	1.22	1.7	(4019)
Axial ratio			1.8	2.2	2.3		(4042)
		1.66	2.17	2.3	2.6	2.6	(4019)
Number of Antethecæ		12	16	26	31		(4018)
Thickness of spirotheca in mm			.05	.056	.01		(4042)

REMARKS : It will be observed in the above table that the widths of the successive volutions vary to some extent; but the variation among the majority of our specimens is well within the limits set forth by Schellwien. For example, the widths of the whorls in our specimen (4042) are of the same order as those of Schellwien's specimen II which measures 0.57, 0.90 1.33, 1.90 mm from the first to the fourth volution respectively; and the widths of our specimen (4018) are comparable with those of Schellwien's specimen I, namely 0.36 mm for the second 1.00 mm for the third and 1.56 for the fourth. The axial ratios, the thickness of the spirotheca etc. also differ but slightly between the Alpine and the Chinese form.

What remains to be noticed is the fact that the largest individual among the Alpine form is said to attain a length of 8 mm and a width of 2.8 mm, but there is not a single specimcn in our material which reaches that size. Judging from Schellwien's figures such large individuals probably represent at exceptional case. Undoubtedly there are among the Alpine species individuals which agree in size with our form. It seems therefore quite safe to identify the species under consideration with *Fusulina regularis* of the Carnic Alps. (Auernigg Beds).

A rather puzzling problem however arises from the relationship between the present form and *Schellwienia prisca*. The general appearance of axial sections and the measurements of the two species almost completely agree in some instances.

The only notable difference lies in the fact that in the case of *Schellwienia regularis* the spirotheca is thicker, the antethecæ more regularly folded and the shape always strictly fusiform. It is because of these differentiating features that I have separated the species under consideration from *Schellwienia prisca*, and made it an independent species as Schellwien has done.

HORIZON AND LOCALITY: *Schellwienia regularis* occurs sparcely in the Yaoku Limestone of the Pinting Basin, N. E. Shansi, Miaokou Limestone, Central Shansi, and in the Hsinho fauna of N. W. Kansu. From its association with *Schwagerina fusulinoides* and *Schellwienia complicata* its stratigraphical position is believed to be no lower than the lower part of Uralian.

Schellwienia arctica (Schellwien)

Pl. VII, figs. 1-7

1883. *Fusulina cylindrica* Goës, Ofversigt cf. Kongl. Vetenskapens Akademiens Förhandlingar; Vol. 40, No. 8, p. 24, Fig. p. 35.

1908. *Fusulina arctica* Schellwien, in part, Palæontographica, Vol. LV, p. 173, Pl. XII, figs. 3-9.

1910. *Fusulina arctica* Staff-Wedekind, Bull. Geol. Inst. Upsala, Vol. X, No. 19-20, pp. 115-118, figs. 4-6.

Test regularly fusiform, moderately stout, axial length to median width 5 mm. 2 mm, or 2.5 : 1 on the average; umbilica slightly rounded.

Number of whorls usually 4 to 5, but may reach 6 in rare cases.

Whorls rather broadly coiled, width of the successive volution and the corresponding axial ratios are as follows:—

Volution	I	II	III	IV	Specimen
Width in mm	.56	1.06	1.72		(1758)
	.52	.91	1.5		(1924)
	.5	.78	1.22	1.73	(1921)
	.53	.83	1.22	1.7	Spitzbergen
Axial ratio	1.8	2.5	2.5		(1758)
	2.2	2.3	2.4	2.5	(1921)
	1.9	2.	2.6		Spitzbergen

Spirotheca fairly thin in the first volution, but becomes moderately thick from the second volution onward. In a typical specimen the thickness of the spirotheca measures 0.055 mm for the second volution, the same for the third, and 0.086 mm for the fourth.

Osseum rather finely alveolar, the individual dark lines are as a rule plainly discernible, only occasionally obscure. In the latter case it is probably due to the state of preservation rather than to the fineness of the structure.

Antethecæ much thinner than the spirotheca, more or less regularly folded in the median region, and tending to fuse into a complicated network towards the poles. Judging from the height of the loops and arcs appearing in the axial sections, the folds seem to affect the whole height of the antethecæ.

No accurate record of the number of antetheæ in the successive volutions has been obtained. Only in one imperfect median section I have counted 12 for the first volution, 26 for the second, and 32 for the third. These figures approximately agree with the majority of those given by Staff and Wedekind with the exception of that for the second volution which is absent in our case, probably due to the acceleration of development.

Buccal aperture low and narrow, nevertheless unmistakably indicated in axial sections. Anuli not observed in our specimen, they are probably absent.

Initial chamber spherical, comparatively large having a diameter varying from 0.3 to 0.33 mm. In a doubtful case, the diameter only measures 0.16 mm.

REMARK: The majority of the Spitzbergen specimens described by Schellwien, Staff and Wedekind under the specific name *arctica* appear at first sight, to differ from our Chinese representatives in several respects. Firstly they are generally of a somewhat larger size, and often possess more than four whorls; secondly, the antethecæ are more irregularly folded; and thirdly the anuli are apparently well-developed. As regards size, number of whorls and type of folding there is nothing in reality against our identification. Because of the fact that *Fus. arctica* is one of the most flourishing species of *Fusulina* occuring in the arctic district, it is to be expected that many of the individual enjoyed the healthy environment and developed themselves to their fullest extent; while among the Chinese fauna we have so far only found a few representatives, but that is no reason to exclude the possibility that forms attaining a larger size may not occur. Through the cordiality of Prof. Stensiö of the Riksmuseum, I have moreover found a large proportion of individuals which were originally labeled by Goës as *Fus. cylindrica*, and which should

be undoubtedly referred to *Fus. arctica* of Schellwien and Staff, agreeing almost completely with our form. I have photographed two of them as examples (See Pl. VII, figs. 6, 7).

The apparent presence of anuli is however a point that requires some considcration especially when it is recognized that this feature is one of those fundamental characters on which *Fusulinas* may be classified at large. With a view to elucidating the real nature of the two small dark patches appearing on both ends of the buccal aperture of *Schellwienia arctica* from Spitzbergen, serial sections have been prepared, and well-oriented axial sections have been examined with utmost care. Nearly all of the serial sections show that each of the antethecæ thickens on both sides of the buccal apertures and sometimes they fuse into a solid mass. At the same time several axial sections have been found, in which both ends of the buccal aperture are defined by a small loop or a U-shaped curve in the inner volutions, but in the outer volutions of the same individval two dark solid patches are present in a corresponding position. If these dark patches are due to the transverse section of the real anuli, then it would be impossible to explain why only loops or U-shaped curves are present at the two ends of buccal aperture in the inner volutions. We have numerous examples to illustrate the case that real anuli becomes weaker or altogether disappear from the inner towards the outer whorls. That can be readily understood. But we have no reason to suppose that this primitive feature suddenly makes its appearence at the adult stage in the animal's life-history.

Thus I am satisfied that the two dark spots appearing on many of Schellwien and Staff's microphotographs and on Goës original sections are but due, largely, if not entirely, to the thickening of the antethecæ at the margin of the buccal aperture. For this reason I am not inclined to accept Staff and Wedekind's view without reserve that *Schellwienia arctica* possesses anuli in the proper sense of the term. This would explain away the objection against identifying our form with that of the arctic district.

Moreover, among the material procured from the Yaoku Limestone of the Pinting Basin, and that from Spitzbergen I have found scattered examples of a form which associates itself with true *arctica*, and which in both cases are characterized by the presence of what appears to be a pair of real anuli. This form must be referred to *arctica* if we accept Schellwien's definition of that species in full. He might have regarded it as the microspheric type. (See Pl. VII, fig. 4). As regards the diameter of its initial chamber and the widths of the successive volutions of this particular form the following measurements were obtained:—

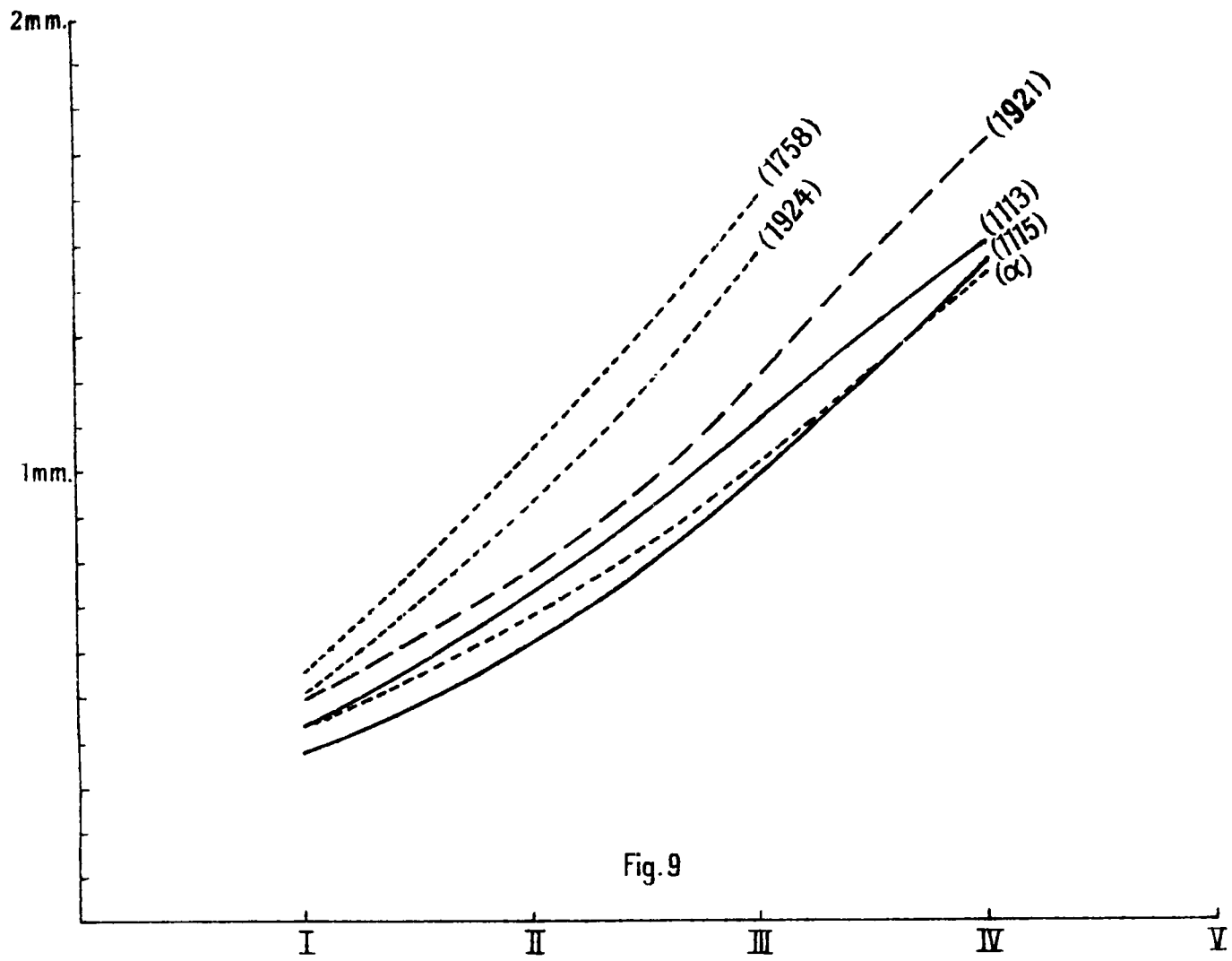

Fig. 9

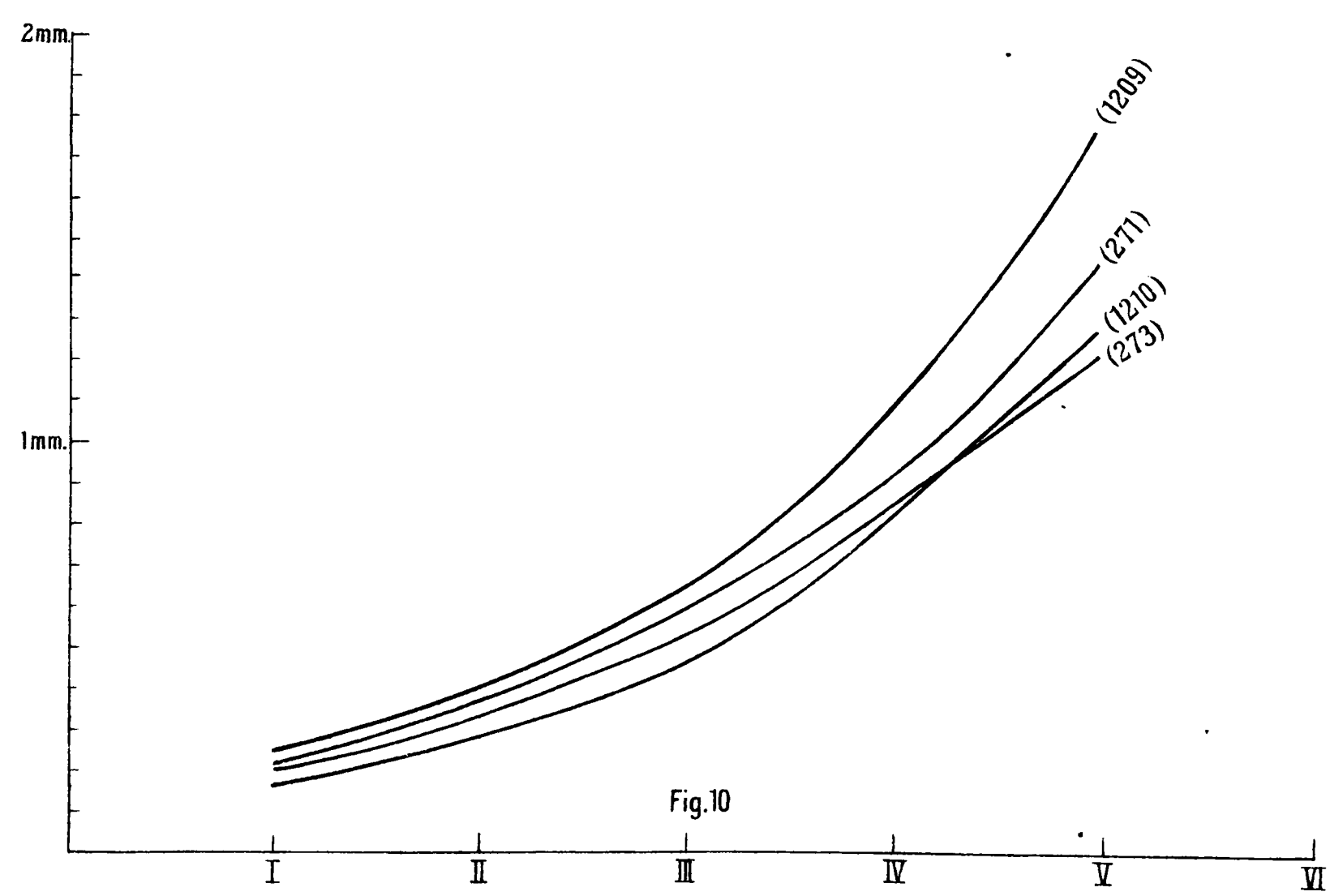

Fig. 10

Fig. 9. Width-graphs of *Schellwienia arctica* (1758, 1924, α), and *Schell. verneuili* var. *levidensis* (1113, 1115), α being a representative from Spitzbergen and (1921) an intermediate form between *Schell. arctica* and *Schell. verneuili* var. *levidensis.*

Fig. 10. Width-graphs of *Schellwienia nobilis.*

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Dia. of initial chamber. in mm	Widths of successive volutions. in mm					Locality
	I	II	III	IV	V	
.16	.22	.35	.55	.88		Shansi
.2	.38	.56	.89	1.33	1.8	Spitzbergen

The ratio of length to width for the third volution is 1 : 3.5 in the first case and 1 : 3.2 in the second. The results of measurement show that none of them can be correlated with those obtained from true *arctica*. Schellwien's view would then seem hardly justifiable. Had it been possible to obtain more material so as to show the persistence of a definite type I would have assigned this form to a new species for which the name *sinoarctica* might do.

At all events, the fact that this form accompanies *arctica* both in Spitzbergen and in Shansi demonstrates, with force, the close faunistic relation in the two places and therefore tends to strengthen our identification.

Apart from the problematic form which I have tentatively named *sinoarctica*, there is only one species so far as known, that resembles to some extent the species under consideration, that is *Schellwienia anderssoni*. By reason of its close association with *arctica* in the Arctic district it is highly probable that they are genetically related. *Schellwienia anderssoni* however differs from our species in having a larger size, stouter form and more whorls.

HORIZON AND LOCALITY: *Schellwienia arctica* occurs sparcely in the Yaoku Limestone but more abundantly in the Kushi Limestone of the Pinting Basin, N. E. Shansi. In the former case it is associated with *Schellwienia prisca, Schell. longissima* and *Schell. regularis*, characteristic of the Upper Carboniferous of Russia and the Auernigg Beds of the Carnic Alps; and in the latter case, it is accompanied by *Schellwienia erucaria*, a form indisputably identical with the so called *Fusulina longissma* (Schwager) from the lowest fossiliferous beds of the Lower Productus Limestone of the Salt Range. Only a single specimen of this species has been found in the Fuching Limestone of the Taichai district, South Chihli. There, it is associated with *Schellwienia acuta*. It seems beyond dispute that this species belongs to the Upper Carboniferous.

Schellwienia nobilis Lee (sp. nov.)

Pl, VII, figs. 14-18

Test regularly fusiform with its median portion moderately vaulted and umbilical region tending to elongate in the outer volutions. Size of the test varies rather

widely from individual to individual. The smallest, an apparently fully developed individual, is only 3.3 mm long and 1.16 mm broad, while the largest one attains nearly twice that size. The axial length and median width of the commonest form vary from 4 to 6 mm and 1.33 to 2 mm respectively with an average axial ratio of 1:3.

Number of whorls usually 5 to 6 rarely 7.

Whorls rather compactly coiled in the first two volutions, thence onward the rate of spiral expansion becomes more rapid, though still low as compared with many other species of *Schellwienia*.

Spirotheca moderately thick with a rather coarsely alveolar osseum. Its thickness grows steadily from the first volution to the last. In the normal case the values are 0.02, 0.022, 0.03, 0.044, 0.06, 0.07 mm from the first to the sixth volution.

Antethecæ relatively thick, particularly so in the inner whorls, intensely but regularly folded. Even in the median region the folds are usually developed to nearly the same extent as in the lateral parts. Practically the entire height of the antethecæ is involved in the folding. In the umbilical parts the crowded antethecæ are never so irregularly fluted as to cause the appearance of a complicated network in the axial section. Throughout the test the antethecæ are as a rule evenly spaced and almost perpendicularly set against the spirotheca.

Number of antethecæ relatively small. In a typical specimen, there are 7, 15, 18, 22, 28 in I, II, III, IV and V volutions respectively.

Buccal aperture narrow but fairly high in the inner whorls, slightly broader and comparatively lower in the outer ones. In all cases it reaches a little less than half the height of the chamber.

A pair of rudimentary anuli (probably pseudo-anuli) apparently present up to the second or third volution, but disappear thence onward.

Initial chamber perfectly spherical and rather thick-walled. Its external diameter varies from 0.08 mm to 0.14 mm. The former type possibly represents the microspheric generation, and the latter the macropheric.

Widths of the successive volutions (in mm) are as follows:—

I	II	III	IV	V	VI	Specimen
.25	.4	.64	1.09	1.76		(1209)
.14	.25	.42	.69	1.1		(1207)
.22	.37	.6	.91	1.44		(271)
.25	.44	.75	1.16	1.78		(272)
.21	.33	.52	.85	1.22		(273)
.21	.33	.55	.92	1.55		(1208)
.167	.28	.45	.82	1.28		(1201)

Axial ratios for the first of these measured specimens are:—

1:2.2	in the 2nd volution
1:2.6	,, ,, 3rd ,,
1:3.2	,, ,, 4th ,,
1:3.2	,, ,, 5th ,,

These figures probably represent the normal case.

REMARKS: This species resembles rather closely *Schellwienia regularis,* but differs therefrom by its more elongated shape, thinner spirotheca and somewhat rounded umbilical ends. The widths of the successive volutions are also quite different. With *Schellwienia prisca* it is likewise apt to be confused. A closer examination will however show that in the case of *prisca* the whorls are more uniformly spaced even in the inner volutions, and it never attains seven whorls. Moreover its antethecæ are as a rule less regularly folded.

HORIZON AND LOCALITY: In the highest layer of the "Fusulina Limestones" of the Taichai district, South Chihli, this species occurs rather frequently. It is again found in one of the "Fusulina Limestones" of Wuhutui, South Manchuria. In both of these localities no other determinable species has been procured. Although it is believed to represent the higher stage of Uralian its exact stratigraphical position must for the present be regarded as an unsolved problem.

Schellwienia anderssoni (Schellwien)

Pl. VII, Figs. 11-13

1900. *Fusulina cylindrica,* Andersson. Bull. Geol. Inst. Upsala, Vol. IV, p. 243.

1908. *Fusulina anderssoni* Schellwien, Palæontographica, Vol. LV, pp. 192-193.

1910. *Schellwienia anderssoni* Staff-Wedekind, Bull. Geol. Inst. Upsala, Vol. X, No. 19-20, pp. 119-120, Pl. III, figs, 1-5.

Test rather stout, regularly fusiform throughout all the whorls, the ratios of axial length to median width from the second, to the sixth volution are about 1 to 2.2, 2.4, 2.5, 2.5, 2.7; and the average length and width of the fully grown individuals are 6.1 mm and 2.2 mm respectively. The maximum width recorded in our material is 2.5 mm. In that case the axial ratio is probably somewhat lower.

Number of whorls usually 6, sometimes $6\frac{1}{2}$. They are closely coiled in the inner volutions becoming relatively broader in the outer ones. Widths of the successive volutions are (in mm):—

I	II	III	IV	V	VI	specimen
.267	.43	.69	1.07	1.6	2.2	(1340)
.256	.41	.68	1.04	1.59	2.3	(1341)

The range of variation of the width of each volution appears to be limited.

Spirotheca rather thin in the inner whorls, becoming steadily thicker towards the outer ones. In two typical specimens the thickness varies from 0.013 to 0.02 mm in the first whorl, about 0.03 mm in the second, 0.05 mm in the third, 0.05 to 0.053 mm in the fourth, 0.055 to 0.07 mm in the fifth, and 0.07 to 0.08 mm in the sixth. When it develops $6\frac{1}{2}$ whorls, the last part of the last whorl is usually thinner than in the sixth volution, indicating the presence of a senile stage.

Alveolar osseum fairly coarse, particularly so in the outer volutions.

Antethecæ moderately stout as a whole, but in the first two volutions as well as in the last one they are comparatively thinner. In the lateral parts the antethecæ are regularly and rather strongly fluted decreasing, however, in intensity towards the median part. As the buccal aperture is approached, the individual folds reach no more than $\frac{1}{3}$ of the height of the chamber. Number of antethecæ from the first to the sixth volution are 10, 16, 22, 28, 32, 35.

Buccal aperture occupies about $\frac{1}{8}$ of the length of each volution and a little less than half of the the respective chamber.

Anuli absent.

Initial chamber spherical having a diameter usually varying from 0.16 to 0.17 mm, sometimes as large as 0.22 mm. Wall of the initial chamber fairly thin, always slightly thinner than the spirotheca of the first whorl.

REMARKS: Little doubt can exist as to the specific identity between the species under consideration and Schellwien's species, *anderssoni* from the Arctic Region. Difficulty however arises when we compare it with *Schellwienia regularis* of the Alpine region on the one hand, and with *Schellwienia valida* on the other. Nevertheless, closer examination will show that the former possesses fewer whorls, and the inner whorls are less closely coiled. Moreover the numbers of antethecæ do not agree. As regards *Schellwienia valida* the rate of spiral expansion is likewise somewhat higher as revealed in the width-graphs. Although there are forms of the last-named species that approximately agree with the present one in the widths of the outer whorls, the inner whorls are as a rule much broader. Further, its initial chamber is smaller in the microspheric type and larger in the macrospheric than that of the present species.

While these distinctive features are considered to be sufficient to warrant the establishment of an independent species, it must at the same time be admitted that all these forms are in close genetic connection.

HORIZON AND LOCALITY: *Schellwienia anderssoni* occurs in association with *Schell. longissima* var. *tenuis*, *Schwagerina princeps*, *Schell. alpina* in Yatzetsi, Shenhsien, N. Honan. From these associated occurrences we may assign it without hesitation to the Uralian.

Schellwienia vulgaris (Schellwien)

Pl. VIII, Figs. 6-9, 11, 12; Pl. IX, Fig. 9

1909. *Fusulina vulgaris* Schellwien-Dyhrenfurth; Die Fusulinen von Darwas, Palæontographica, Vol. LVI, pp. 163-164, Pl. XIII, figs. 1, 2.

1924. ? *Fusulina chamchitensis* Colani; Nouvelle Contribution etc., Mém. Ser. Géol. Indochine Vol. XI, Fasc. 1, pp. 135-136, Pl. IV, figs. 1-25.

1925. *Fusulina vulgaris* Ozawa; Palæontological and Stratigraphical Studies on the Permo-Carboniferous Limestone of Nagato. Journ. Coll. Sci., Tokyo. Vol. XLV, Art. 6, pp. 23-24, Pl. VII, fig. 3.

Test subglobular, highly vaulted in the median part with a steep but inflated slope towards the umbilical ends which latter are often slightly extended and rounded off in the form a of a papilla.

In a nearly axial section of a large, well-preserved specimen from the Taching Limestone of S. Chihli, the axial length of the complete test is estimated at 7 mm, and the median width at 4.55 mm. These figures practically agree with the average dimension of the Darwas species and that of the Nagato Limestone. The predominant type in our material is however distinctly smaller, 5.15 mm : 3.5 mm being the average axial length and median width respectively.

Number of whorls varies from $5\frac{1}{2}$ to $6\frac{1}{2}$. In the large individuals the whorls are more or less loosely coiled throughout, though exact measurements show that the height of the chamber steadily increases in the direction of spiral growth. In the small type, viz. the predominant type, the outer volutions are coiled in the same manner, but the inner ones are much smaller in width and therefore they are considerably more compact. When it attains six volutions, the last part of the last volution always exhibits signs of senile decrescence, that is, the whorl becomes more closely coiled and the antetheæ irregularly folded.

Widths of the successive volutions (in mm) in the different types are as follows:—

	I	II	III	IV	V	VI	Specimen
Large type	—	1.12	1.94	2.7	3.67	4.55	(754)
	.7	1.13	1.8	2.66	3.66	—	Darwas
	0.81	1.47	1.25	3.42	4.46	5.85	Nagato (Ozawa)
Small type	—	.36	.76	1.45	2.27	3.16	(458)
	.16	.28	.5	1.06	2	2.82	(753)

The measurements of the Darwas species are obtained by the author from the microphotograph (Palæontographica Vol. LVI, Pl. XV, fig. 1,7) in Schellwien's "Monographie der Fusulinen". The first two rows of figures agree with each other so well that it is not possible to plot them separately on one and the same base. In the Nagato form the spiral obviously increases with a higher rate of expansion as is shown by a higher gradient of the width-graph. (See Fig. 11). Otherwise it does not seem to differ appreciably from the Darwas form and from that of Taichai.

Spirotheca extraodinarily thick, and consists of a thin tectum and usually coarse osseum. In the large type the thickness of the spirotheca in the successive volutions varies only to a limited extent; but in the small type the inner spirothecæ are considerably thinner than the outer ones. Nevertheless, in each case the maximum thickness is reached before the fifth or the latest, the sixth volution; and this maximum thickness appears fairly constant for both types. The following figures will serve to show the order of variation:—

I	II	III	IV	V	VI	Specimen
—	.078	.094	.11	.12	.11	(754)
—	.05	.078	.107	.111		(458)
.011	.027	.044	.067	.09	.11	(753)

As the first row of measurements are obtained from a section not strictly axial, the figures for the II and III volutions may be slightly higher than the true values. The difference however cannot be of any appreciable quantity.

Antethecæ exceedingly thin, more so they appear to be, when compared with the massive spirotheca. They often appear as thick, black, overhanging stripes in the median section, not because they are really of that thickness, but because of the fact that few of them are cut perpendicular to their surface as an inevitable consequence of folding. As a rule the antethecæ are inclined forward. Juding from the everlapping arcs that appear immediately above the spirotheca in an axial section, they are more or less intensely and rather irregularly folded particularly in the inner volutions. The usual

anastomosis due to this folding is however only limited to the very umbilical ends. From the first to the fourth volution the folding almost reaches the entire height of the chamber, but in the fifth volution it is restricted to the lower one third or at most, lower half of the antethecæ, and particularly low in the median region.

Number of antethecæ comparatively large, usually not much under 40 in the fifth volution. In a median section of a Taichai form which represents the small type, they are counted as follows:—

I, 9; II, 14; III, 20; IV, 25; V, 40; VI, 32 (partially preserved).

In the small type the first two volutions are distinctly fusiform, but axial ratio decreaces rapidly towards the outer volutions. This variation of the axial ratio is however less marked in the large type as may be contrasted in the following table:—

Volution	I	II	III	IV	V	VI	Specimen
Axial ratio	—	1.56	1.56	1.44	1.48	1.48	(754)
	—	2	1.6	1.5	1.3	1.4	(458)

Anuli are not observed in the large type, but their presence is distinctly indicated for the first two volutions in the small type. Buccal aparture is however fairly well-defined in each case. It is more or less of a semilunar shape up to the third or fourth volution. Thence onward it becomes a moderately elongated slit reaching less than half of the height of the respective chamber. In describing the *Fusulina* from the Darwas region, Dyhrenfurth writes that the present species has no special buccal aperture. On a closer inspection of the microphotographs of the Darwas representative dealt with by Dyhrenfurth it will be at once noticed that the presence of a buccal aperture is not only indicated in the median section by a clearance between the lower end of nearly all the antethecæ and the spirotheca, but its shape is to some extent defined in the median part of the axial section. In this respect the type species of Darwas do not differ from our Chinese material.

Among the several sub-median sections that I have obtained there is only one that belongs to the large type. From this single section it appears that the initial chamber of the large type is of a spheroidal shape, and has an external diameter of about 0.33 mm. This is also the average size observed in the Darwas form. Those belonging to the small type are on the other hand perfectly spherical with a diameter varying from 0.078 to 0.111, mm.

REMARKS: It may be questioned at the outset that if the large and small types as mentioned in the foregoing description, have differed from each other in so many

respects, why they should not be regarded as two distinct species. In fact that was what I had done in a preliminary determination. But these two types are *always* so closely associated that it is impossible to deny their intimate relation. Moreover, notwithstanding the fact that they started with a different size of initial chamber, they *always* tend to develop after the same pattern as is demonstrated by the parallellism between the later parts of the width-graphs. (see Fig. 11). Indeed, at the stage of the fifth volution all differences between the two types disappear except as regards size. It is true that the small type possesses longer and therefore apparently thinner antethecæ as compared with the median section given by Dyhrenfurth (loc. cit. fig. 2) or the median section of the Taichai form (See Pl. VIII Fig. 6). But exact measurements show that Dyhrenfurth's median section does not agree as far as the mode of coiling is concerned, with his axial section which has been taken as the standard type. Nor do I believe that the median section of the specimen from Taichai (Pl. VIII Fig. 6) agrees with its associated typical *vulgaris* (Pl. VIII Fig. 7). Both of these median sections are probably made from a variety of *vulgaris*. If a median section be prepared either from the type specimen of Darwas or from the Taichai form (Fig. 8), I have little doubt that it will differ in no way from those of the small type. As a whole the evidence seams fairly conclusive that we are here really dealing with the phenomenon of dimorphism so prevalent in other families of coiled Foraminifera. The large type may therefore be regarded as the macrospherie and the small type as the microspheric generation. According to this interpretation, the whole of Schellwien's material from Darwas described under the name *vulgaris* seems to belong to the macrospheric type. While the majority of our specimens belong to the microspheric.

As occurring in the Darwas region, *Schellwienia vulgaris* comprises a group of stout *Schellwienia* covering a fairly wide range of variation. They are recognized in the extremities of mutation, as three variaties by Schellwien. Firstly the globular form with intensely folded antethecæ is named var. *globosa*, secondly, the large fusiform ones are named var. *fusiformis*, and thirdly, the small fusiform ones as var. *exigua*. The Russian species *Fus. mölleri* Romanowski, and particularly its variety *æqualis*, is said to bear a close resemblance to *Fus. vulgaris* of Darwas. All of these varieties or related species have been found in N. China. Adequate data however have not been obtained to settle the problem whether *Fus. mölleri* is really identical with *Fus. vulgaris* var. *fusiformis* which gave arise to *Fus. vulgaris* s. str., and the latter in turn to var. *globosa* on the one hand, and to *Fus. vulgaris* var. *exigua* on the other as suggested by Dyhrenfurth; or the variation from *Fus. mölleri* to its variety *æqualis* in the Russian fauna is but a development parallel to the variation of an independent series of *vulgaris* in the Asiatic waters as

maintained by Schellwien. At all events some close relation must exist between the *vulgaris* series and *Fus. mölleri.*

There is another Russian species, namely *Fus. krotowi,* that also resembles the species under discussion, particularly of the microspheric type. So much so that a variety of *krotowi* from Batraki labeled by Schellwien as *krotowi* var. *minor* (Palæontographica Vol. LV, Pl. XX, Fig. 10) is almost identical with some of our varieties, e. g. that from the Chentaokou Limestone (included in the var. *minor*). Without a careful comparison between the actual material, it does not, however, seem advisable to include the Batraki specimen in the present species. On the whole *krotowi* differs from our species in that the former is more closely coiled and that its antethecæ are always strongly supported by incurved osseum in the region where the spirotheca is transformed into the antetheca; whereas in the case of *vulgaris* the antethecæ appear to be simply wedged into the osseum ("Einkeilung").

With *Fus. globosa* Deprat and *Fus. chamchitensis* Colani (these two names are probably synonymous) *Fus. vulgaris* is to some extent comparable, and may be genetically related. It may be noticed, for instance, that both in the *vulgaris* of the Darwas region and in the forms described by the French authors the internal structure is characterized by the presence of the so-called connecting lamella or "lame accessoire". This structural element can readily be conceived as a necessary mechanical compensation for the unusually fragile nature of the antethecæ. They are also found in forms having equally fragile antethecæ but are otherwise distinct in specific character. We cannot therefore attach much importance to them for specific identification. Moreover Deprat's and Colani's species can be distinguished from the typical *vulgaris* of the Darwas region and Taichai by their broader whorls, more irregular folding of the antethecæ and generally larger size. One of Deprat's specimen of "*globosa*" is said to be 2 cm. long and 1.76 cm broad. None of our material reaches even half of that size. If Deprat's species *globosa* and Colani's species *chamchitensis* are at all related to the group of *vulgaris* of the Darwas region, they would seem to be more closely related to the var. *globosa* than any other.

In his palæontological studies of the Nagato Limestone, Ozawa identifies the microspheric types of *Schellwienia vulgaris* from Shaho with his species *satoi*, and further compares it with *Fus. dussaulti* of Deprat. The Japanese species, as far as can be judged from Ozawa's microphotograph and description, is distinctly more fusiform, and possesses a pair of prominent anuli up to the fourth volution, while in our species only a vestige of them can be traced up to the second volution. Again, the Japanese species

appears to have a thinner spirotheca and more irregularly folded antethecæ. Apart from the general appearence of the median section the two seem to have few properties in common. Still more marked is the difference between *Fus. dussaulti* and the species under consideration. Although Deprat's original microphotographs of *dussaulti* are not the best that can be desired, they, together with the accompanying measurements present at once the impression that this Yunnan species has nothing to do whatsoever with *Fus. vulgaris* of North China.

HORIZON AND LOCALITY: Typical *Schellwienia vulgaris* has been found in a blue limestone intercalated in the coal-bearing series of the Yihsien coalfield, Shantung, and in the lowest layer of limestone intercalated in the lower part of a coal-bearing series as developed on the eastern side of the Taihang Range. This lowest layer of Limestone is known in the several coalfields as the Taching Limestone. Its distribution has been traced from the Liuhokou coalfield northward to Taichai, north of the Changho; Shimiao, about 15 *li* S. E. of Pengcheng; Yaopoh, about 40 *li* west of Shahohsien; and it probably extends further north towards the direction of the Lincheng coalfield. Very often this limestone is crowded with *Schellwienia longissima* and *Schell. vulgaris*. The latter particularly abounds in the Shaho-hsien coalfield.

As far as North China is concerned *Schellwienia vulgaris* always occurs in association with a unique fauna of Fusulinidæ. It seems to be restricted to a well-defined zone, namely the zone marked by the first appearance of *Schwagerina*. Although without a more extensive survey we cannot as yet define, with precision, the limit of its vertical distribution, there is not much doubt that its lower limit does not fall much under the base of the Taching Limestone, for below this limestone or its corresponding stage, the whole fauna is dominated by Moscovian elements, and does not contain a single species of such well-developed *Schellwienia* as *Schell. vulgaris*, *Schell. longissima* etc. In other words, a faunal break, as far as the Fusulinidæ are concerned, appears to exist between the zone wherein *Schell. vulgaris* makes its first appearance and the several layers of limestone appearing in a lower stratigraphical position. Since the latter group contains a Moscovian fauna, the former, namely the zone of *Schell. vulgaris* would then, be best attributed to the Uralian.

Schellwienia vulgaris var. **watanabei** Ozawa em. Lee

Pl. IX, Figs. 4, 8.

1923. *Fusulina watanabei* Ozawa, On some species of ***Fusulina*** from Honan, China, Jap. Journ. Geol. Geogr. Vol. II, 2, p. 38, Pl. V, Fig. 1a-b.

Form of test not nearly so globular as *Schellwienia vulgaris* s. str. and at the same time not nearly so fusiform as *Schell. vulgaris* var. *exigua* with which it is

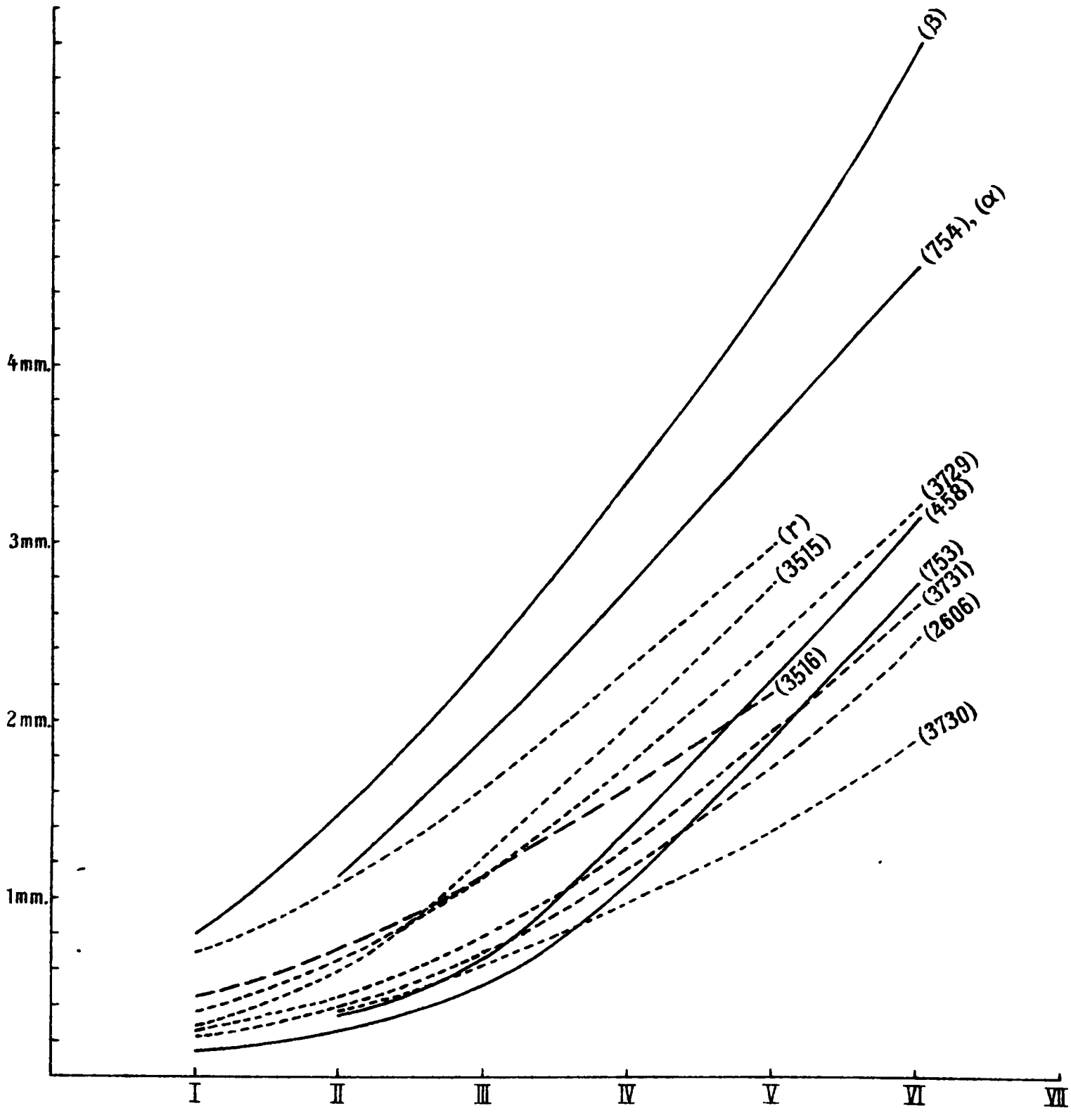

Fig.11

Width-graphs of *Schellwienia vulgaris* and its allied forms. (754) macrospheric type of *Schellwienia vulgaris*, *α*, *β* the same from Darwas and Nagato Limestones for comparison; (458, 753) microspheric type of *Schell. vulgaris*; (3729, 3731, r) *Schell. vulgaris* var. *watanabei* r being Ozawa's species *watanabei*; (3515) *Schell. vulgaris* var. *globosa*; (2606, 3730) *Schell. vulgaris* var. *minor* (3516) *Schell. valida*.

[*To face page 64*]

comparable in size. When compared with the typical *vulgaris*, the whorls of this variety are distinctly more compact as may be seen from the width-graphs (Fig. 11), and the antethecæ appear to be slightly thicker and less intensely folded. In this, and also other respects it resembles *Fusulina pseudobrevicula* Deprat* but differs therefrom in that it is more strongly vaulted in the median part, and its antethecæ in the outer volutions are not nearly so plain as in *pseudobrevicula*.

Size of the initial chamber, and width of the successive whorls:—

Dia. of initial chamber in mm.	Widths of successive volutions in mm.						Specimen
	I	II	III	IV	V	VI	
0.22	.36	.67	1.16	1.76	2.47	3.21	(3729)
0.156	.28	.46	.8	1.29	1.97	(2.64)?	(3731)

These two rows of figures, though ostensibly differ from each other, show an essentially similar rate of spiral expansion. They indicate that the two individuals probably belong to the same variety, but started their growth with an unequal size of initial chamber, It should also be noted that the sizes of the initial chambers of these two individuals represent the extremities of variation. It is larger than that of the microspheric type and smaller than that of the macrospheric type of *vulgaris* s. str.

Number of volutions varies from 5 to 6 as in the type species. Antethecæ fairly numerous. They are counted in one of the typical forms as follows:—

I, 13; II, 24; III, 29; IV, 39; V, 44; VI, 42 (partially preserved).

Standing between the present variety and *vulgaris* s. str. is a form from Kunghsien, Honan, described by Ozawa under a new specific name *Fusulina watanabei*. The fact that Ozawa included this Kunghsien form in the group of *Fusulina vulgaris* and at the same time regarded it as a new species shows the carefulness with which the said author dealt with his material. In Mr. Ozawa's splendid microphotograph of "*Fus. watanabei*" for which my thanks are due, I find few characters, save its smaller size and slower rate of spiral expansion, that can serve to distinguish the Kunghsien form from the typical *vulgaris*. The smaller size of the former may however be due to its immaturily of growth as is suggested by the absence of the slightest indication of senility in the last part of the last whorl. As to the difference in the mode of coiling between the

*Mêm. Serv. Géol. Indochine, Vol. II, Fasc. 1, p. 23, Pl. II, Fig. 4-9.

type species of *vulgaris* and *watanabei*, we need only to compare it with the difference between the type species and the Nagato form. If the latter which exhibits a higher "rate of evolution" as compared with the type species, is to be considered as being within specific variation, the Kunghsicn form, which shows, in the same respect, about the same amount of difference but of a negative sign must also be considered as one that falls within specific variation. For this reason I would treat Ozawa's species *watanabei* as a variety of *vulgaris* rather than as an independent species.

So much the more this treatment would seem desirable, if not necessary, when the fact is kept in view that we are here dealing with a rapidly varying group of forms. If a new species be established at each stage of minor variation, a mass of unlaudable names would inevitably result.

Proceeding from this standpoint, I find that the nearest approach among our material to *watanabei* is the variety under consideration. One of the Kansu forms exhibits a rate of spiral expansion almost identical with that of *watanabei* as is shown by the parallelism between the width-graphs for the two. It would seem therefore consistent to use Ozawa's specific name for this variety.

HORIZON AND LOCALITY: *Schellwienia vulgaris* var. *watanabei* has been found in Kunghsien, Honan, in association with "*Schwagerina princeps*" according to Ozawa, and again found by P. L. Yuan in Hungshanyao, Kansu, where it occurs together with *Schell. longissima*.

Schellwienia vulgaris var. **minor**

Pl. IX, Fig. 11

This small variety occurs in the Chientaokou Limestone east of Taiyuan, Shansi. It differs from *Schell. vulgaris* s. str. only in having a considerably smaller slze and even more compactly coiled whorls than in var. *watanabei*, six and half whorls being packed in a width of 2.8 mm. The widths (in mm) of the successive whorls of the Chientaokou form are measured as follows:—

Dia. of Central chamber	I	II	III	IV	V	VI	Specimen
.133	.23	.41	.72	1.19	1.72	2.5	(2606)

The complete test is on the average 3.73 mm long and 2.8 mm broad with an axial ratio of 1 : 1.33 indicating that the shape of the variety is distinctly globular.

The unbilical ends are however always pointed unlike the var. *globosa*. Among the Hungshanyao material I found a median section which, with its thick spirotheca and coarse osseum recalls very strongly the type of *vulgaris*. The whorls are however still more compactly coiled as shown by following figures:—

Dia. of Initial chamber in mm	Widths of the successive volutions in mm					
	I	II	III	IV	V	VI
.144	.244	.39	.65	1.01	1.41	1.9

If it does belong to the *vulgaris* group, for which there is yet no corroborating evidence, it should be more naturally referred to the var. *minor* than to any other.

Schellwienia vulgaris var. **globosa** (Schellwien)

Pl. IX, Fig. 12

Test globular; umbilical ends rounded; axial length to median width, 4.09 mm: 3.3 mm in a typical specimen found in the Yihsien coalfield, Shantung. Whorls $5\frac{1}{2}$ in number, loosely coiled, with a gradual, uniform spiral expansion. Spirotheca very thick in the last three volutions, and tends to thin down towards the umbilical ends. Osseum as coarse as in *vulgaris* s. str. Antethecæ thin, more or less intensely and regularly folded throughout their entire height. Buccal aperture not observed, probably absent; anuli rudimentary in the first volution, absent in the rest of the whorls. Initial chamber small, about 0.13 mm in external diameter representing the microspheric type. Widths of successive volutions are as follows:—

I, 0.29; II, 0.6; III, 1.25; IV, 1.97; V, 2.81.

This variety is so far only found in the Yihsien coalfield, Shantung where it occurs in association with *Schell. vulgaris* s. str. *Schell. vulgaris* var. *exigua*, *Schell. oblonga*, *Schell. longissima*, *Schwagerina princeps?* etc.

Schellwienia vulgaris var. **fusiformis** Schellwien em. Lee

Pl. IX, Figs. 3, 5

In the materials from Shaho, Honan, and Yihsien, Shantung, a few scattered individuals of stout *Schellwienia* are found that represent the intermediate form between its associated typical *Schellwienia vulgaris* and *Schell. vulgaris* var *fusiformis* Schellwien. The latter, for reasons explained elsewhere, should be elevated to an independent species.

This intermediate form is then best referred to the variety *fusiformis* (non Schellwien). Among my prepared material there is only one good axial section that represents this variety. It has an axial length of 4.55 mm and median width of 2.16 mm. Shape of the test distinctly fusiform, but strongly inflated in the median part. As the complete test only consists of four whorls it probably does not represent a fully grown individual. The initial chamber is perfectly spherical having a diameter of 0.33 mm. Undoubtedly it belongs to the macrospheric type.

Schellwienia vulgaris var. (cf. **kozui**)

Pl. IX, Figs. 7, 10

1914. ? *Fusulina kozui* Deprat; Étude des Fusulinidés du Japon etc.; Mém. Serv. géol. Indochine; vol. III, Fasc. I, p. 11, Pl. III, Figs. 4-8.

Test globular with pointed umbilica; axial length to median width 5 mm: 3 mm on the average; number of whorls 5; whorls compactly coiled in the first one or two volutions, thence the width of the whorl increases with a rapid rate. As described by Deprat, the third volution is twice as wide as the second, and the fourth twice as wide as the third. Widths of the successive volutions are as follows:—

I	II	III	IV	V		Specimen
.266	.478	1.06	2.07	3.11	in mm	(3520)
.233	.433	.8	1.6	2.5	in mm	(3519)

Spirotheca fairly thick, but not quite so thick as in *Schellwienia vulgaris;* osseum moderately coarse; antethecæ thin, and irregularly and more or less intensely folded; number of antethecæ 12, 18, 23, 28, 42 for the successive volutions; anuli only present in the first one or two volutions; buccal aperture undoubtedly present in those inner whorls where anuli are developed, but appears to be absent in the outer volutions; initial chamber nearly spherical, with an external diameter varying from 0.144 mm to 0.16 mm.

Remarks: At a glance, *Schellwienia vulgaris* var. *kozui* appears almost identical with the microspheric type of *Schell. vulgaris*. The former however generally possesses one more volution, namely six, lower rate of growth in the inner volutions, less irregularly folded antethecæ, thicker spirotheca and smaller initial chamber. Although absolute measurements do not agree with those given by Deprat, the rate of increase of the widths of the successive volutions is essentially the same as in Deprat's species. This fact is clearly indicated by the width-graphs.

According to Deprat, this form occurs in Laos, Indochina, together with *Schwagerina princeps*. In the Yihsien coalfield, Shantung, it also associates with *Schw. princeps*. Therefore, it is judged to be a Uralian representative.

Schellwienia valida nom. nov.

Pl. VIII. Figs. 1–3, 10

1909. *Fusulina vulgaris* var. *fusiformis* Schellwien-Dyhrenfurth, Die Fusulinen von Darwas, palæontographica, Vol. LVI, pp. 165-168, Pl. XV, Figs. 1-4.

This species was originally recognized by Schellwien and Dyhrenfurth as a variety of *Schellwienia vulgaris* with which it is associated in the Darwas region as it is also in North China. As in *Schellwienia vulgaris*, the present species is also characterized by its remarkably thick spirotheca, relatively thin antethecæ and very coarsely alveolar osseum. There is no question as to its intimate relation with *Schellwienia vulgaris*. For this reason it seems not unjustifiable to regard it as a variety of that species. After a careful comparison with the typical *vulgaris*, I find however that there are between them some differentiating features that are at least more marked than those between *Schellwienia vulgaris* s. str. and its other related species, for instance, *Schellwienia krotowi*. If the latter is to be placed in the rank of a species as Schellwien has done, it appears a fair treatment to regard the form under discussion as an independent species as well.

Test of this species regularly fusiform up to the fourth volution, thence it tends to assume a cylindrical shape with its umbilical ends more or less rounded. Axis of the whorls is, as a rule, rectilinear, but occasionally recurved in the median region. Axial length varies from 6 to 7.4 mm and median width from 1.9 to 2.5 mm with an average axial ratio of 1:3. The Darwas form seems somewhat larger than our representative, though the axial ratio is practically the same.

Number of whorls 5 to 6 for the macrospheric type, 7 to $7\frac{1}{2}$ for the microspheric.

From a typical specimen the following figures (in mm) are obtained:—

Volutions	I	II	III	IV	V	VI
Width	.45	.727	1.15	1.636	2.18	
Thickness of spirotheca	.03	.044	.055	.078	.09	.078

These measurements show that the rate of spiral expansion is much lower than in *Schellwienia vulgaris;* in other words, the whorls are more compactly coiled. Spirotheca is also slightly thinner than in *Schell. vulgaris.*

Osseum coarsely alveolar, but not quite so coarse as in *Schellwienia vulgaris.*

Antethecæ fairly thin, intensely and regularly folded.

Buccal aperture broad and comparatively narrow reaching about half the height of the chamber in the first three volutions, and about $\frac{2}{5}$ of the height of the chamber from the fourth volution onward. Only a vestige of anuli is observed in the axial section as two small black spots attached to the wall of the initial chamber.

Initial chamber spheroidal with an external diameter of 0.3 mm for the macrospheric type, and 0.11 mm for the microspheric.

The umbilical ends of the inner volutions often carry a small patch of calcareous deposit.

HORIZON AND LOCALITY: *Schellwienia valida* has been found so far only in the Yihsien coalfield, Shantung, where it is associated with a rich assemblage of *Schellwienia vulgaris, Schell. longissima* etc. Undoubtedly it occurs in the Shaho coalfield, Honan, and probably also in Hungshanyao, Kansu, for in these places the general appearance of the fauna is almost identical with that of Yihsien. There is not much doubt that it represents lower Uralian as in the case of *Schellwienia vulgaris.*

Schellwienia valida var. **exigua** (Schellwien)

Pl. VII, Figs. 4-5

1909. *Fusulina vulgaris* var. *exigua* Schellwien-Dyhrenfurth, Die Fusulinen von Darwas, Palæontographica. Vol. LVI, p. 168, Pl. XV, Figs. 5-8.

Test regularly fusiform, with pointed umbilical ends; average axial length 4.7 mm, median width 1.6 mm, and axial ratio 1:3; number of whorls 5 to $5\frac{1}{2}$, compactly coiled up to the fourth volution; in the fifth volution the chamber becomes distinctly higher. Measurements obtained from the typical specimen (in mm) are tabulated below:—

Volution	I	II	III	IV	V
Width	.39	.68	1.09	1.64	
Thickness of spirotheca	0.035	0.055	0.08	0.1	
No. of antethecæ	11	17	23	35	35

Alveolar osseum as in *Schellwienia valida* s. str.; antethecæ intensely and regularly folded as in *Schellwienia valida;* in the umbilical ends the folds are often so complicated and entangling that they are generally fused into a mass of lime.

Buccal aperture very low and fairly broad.

Anuli not observed, probably absent.

Initial chamber perfectly spherical having a diameter of 0.2 mm; that is, smaller than that of the macrospheric type of *Schell. valida* and larger than that of the microspheric type of the same species.

This variety has been found in the Yihsien coalfield, Shantung, and in the Chientaokou Limestone east of Taiyuan, Shansi It is probably restricted to the zone of *Schellwienia vulgaris.*

Schellwienia verneuili var. **obtusa** var. nov.

Pl. IX, Figs. 1, 2

Test subcylindrical with its median portion slightly vaulted and ends blunt. The lateral parts of the test are usually more or less bent towards one side. The only axial section of a typical specimen measures 9.9 mm long and 2.47 mm broad. This probably represents the larger individuals.

Number of whorls usually over 6, sometimes $7\frac{1}{2}$. They are compactly and uniformly coiled. The widths of the successive volutions are I, 0.48; II, 0.81; III, 1.16; IV, 1.54; V, 2.47 mm, and the diameter of the initial chamber measures about 0.22 mm. This appears to represent the average type.

Spirotheca fairly thin at the beginning, becoming steadily thicker as the spiral grows. Starting from the first volution the thickness increases in the following order: 0.03, 0.036, 0.042, 0.053, 0.06, 0.067 mm.

Alveolar osseum unusually fine considering the size of the test and the thickness of the spirotheca.

Antethecæ fairly thick and extraordinarily crowded, particularly in the last volution. In a submedian section 37, 39, 4^8, 63 are counted in the IV, V, VI, VII volutions. They are exceedingly regularly folded. In the last volution the folding affects the entire height of the antethecæ, but in the rest of the whorls they reach about half the height of the chamber as far as the median and to some extent the lateral parts are concerned. Towards the umbilical ends the axes of the folds are still more or less

perpendicular to the whorls instead of arranging themselves in a radiating manner as is usually the case with other species.

Anuli absent. Buccal aperture rather low and comparatively narrow. Unfortunately our specimen is fractured through the median plane, exact measurements being thereby rendered impossible. Nevertheless the fact can be clearly recognized that it broadens out towards the outer whorls.

Along the axial region a heavy deposit of lime is always present.

REMARKS: This species is undoubtedly related to *Schellwienia verneuili* of Russia and Alaska on the one hand, and to *Schellwiedia kaerimizensis* of Japan on the other. Its relation with certain varieties of *verneuili* is not only indicated by its form and dimension but by the peculiar dispositon of the antethecal folds towards the umbilical ends. They are more or less perpendicular to the axis of the whorls instead of being arranged in a radiating manner. It differs however from the true *verneuili* in having a closer and more uniformly coiled spirotheca, less embracing and blunt umbilical ends and lower and narrower buccal aperture.

With *Schellwienia kaerimizensis* Ozawa our species seems even more nearly related, for the middle portion of Ozawa's serial measurements practically agree with ours, and the antethecæ are also folded after the same type. The essential difference lies in the number of whorls. The Japanese species is said to have 8 to 10 volutions, while ours only possesses 7 or $7\frac{1}{2}$. It seems not improbable that this species is an ancestral form of Ozawa's *kaerimizensis*.

HORIZON AND LOCALITY: So far, this species is only found in the second seam of "Fusulina Limestone" (counting from below) exposed in Yuehmenkou, west of Taiyuan: It associates with *Schellwienia nathorsti*, and therefore it is assigned to the middle stage of the Uralian probably occupying a stratigraphical position lower than the horizon in which Ozawa found his species, *kaerimizensis*.

Schellwienia verneuili var. **levidensis** var. nov.

Pl. X, Figs. 1-4

Test slender, straight, cylindrical to sub-cylindrical in the median part, gently tapered towards the poles, umbilica usually pointed, occasionally more or less rounded. The largest individual in our collection measures 7.2 mm long and 1.52 mm broad having an axial ratio of 1:4.7. The commonest form is however much shorter. The normal

length is about 5.56 mm and normal width 1.58 mm. The average axial ratio of the complete test is therefore 1:3.5. •

Number of whorls usually 4, sometimes 5.

Whorls relatively narrow and compressed, height of the chamber varies but slightly from the second volution onward. Thus in a type specimen the height of the chamber measures 0.12 mm in the second volution, 0.15 mm in the third and 0.16 in the fourth.

Spirotheca fairly thin in the first volution, but gradually becomes thicker towards the last which however, never exceeds 0.06 mm. Alveolar osseum moderately coarse; the individual dark lines or pillars (poutrelles) are clearly observable in the thin sections.

Antethecæ regular and somewhat intensely folded throughout their whole length and height. Even in the median part of the test the folds are closely packed, and extend almost to the top of the chamber except in the last whorl. Towards the umbilical region they tend to fuse into a mass of complicated network, but the confusion never reaches such an extent as in *Schellwienia richthofeni*. This last named feature is particularly manifest in the last volution. In well oriented median sections the antethecæ appear to be considerably thinner than the spirotheca. Owing to the folding it is, however, difficult to measure the true thickness.

Each chamber is but slightly arched, so that the surface of the test is only marked by gentle furrows, and the superior portion of the antethecæ is but lightly supported by the radial extension of the osseum.

Number of antethecæ fairly large as a whole; they are particularly crowded in the second volution.

Buccal aperture low, narrow and ill-defined in the inner volutions, and apparently absent in the last one.

Anuli absent from the second volution onward, but are present in a rudimentary form in the first volution.

Initial chamber large, spherical, having a diameter varying from 0.23 to 0.3 mm, sometimes ellipsoidal with its major axis pointing towards the poles. Wall of the initial chamber very thick, often thicker than the spirotheca of the first volution. It measures 0.033 mm in normal cases, sometimes reaching 0.024 mm.

Results of measurement.

	Volution				Specimen
	I	II	III	VI	
Width in mm	.44	.73	1.12	1.51	(1113)
	.455	.71	1.16	1.68	(1102)
	.467	.73	1.13	1.64	(1109)
	.44	.75	1.25		(1101)
	.38	.61	1.0	1 47	(1115)
Axial ratio	2.62	2.95	4.3		(1113)
	2.5	2.7	3		(1101)
	2.5	3	3.3		(1115)
Thickness of Spirotheca in mm	.031	.04	.044	.056	(1115)
	.024	.04	.05	.058	(1109)
	.044	.055	.055		(1101)
	.028	.033	.055	.055	(1115)
No. of Antethecæ	14	29	36	39	(1114)

REMARKS: Because of the fact that there are few characters peculiar to the present form, some difficulty has been felt in its specific determination. Judging from the general shape of the test and the type of folding of the antethecæ, it appeared at first comparable to some extent to *Schellwienia exilis* Schwager[1] and *Schell. exilis* Deprat.[2] A closer examination however shows that these forms differ from the present one in having larger size and more numerous whorls. Moreover they are distinctly fusiform, while our species is more cylindrical than fusiform. A still closer resemblance is to be observed between the present species and a form from Tien-sen-Kouang described and figured by Deprat under the name *Fusulina richthofeni*.[3] The latter however is more inflated in the median part and less uniform in the height of the chamber in the

(1) Schwager, C. in Richthofen's China, Vol. IV, p. 125, pl. XVI, Figs. 4-5.

(2) Deprat, J. Étude des Fusulinidés du Japon etc. p. 17, pl. ii, Figs. 6-8; Étude géol. d. Yun-nan oriental, III partie, p. 24, pl. VIII, Figs. 13-14.

(3) Deprat, J. loc. cit, Pl. VIII, Figs. 15-16.

successive volutions; further, each chamber of Deprat's *richthofeni* is more strongly arched, and its antethecæ more crowded throughout the whole length of the spirotheca.

Failing to identify the form under consideration with any known species from the southern region, we may then turn to the Russian basins and the Arctic districts. H. v. Staff describes, after Schellwien, a variety of *Fusulina alpina* under the varietal name *rossica*, in which Staff recognizes two types: the one from Gshel is generally of a larger size, and approaches more closely to the type-species of the Alpine region, and the other from the Donetz Basin is generally of a smaller size, and resembles *Schellwienia arctica* of Spitzbergen and the Bear Island. It is to certain forms belonging to this latter type of var. *rossica* that the present species seems to bear some resemblance. They agree not only in size, form, axial ratio and number of whorls but also approximately concur in the dimension of the initial chamber, thickness of the spirotheca and even the shape of the buccal aperture. Yet we cannot overlook some important differences: Firstly the antethecæ are far more regularly folded in our variety than in the Donetz variety of *rossica*, and secondly the Danetz variety seems to be generally characterized, as in *Schellwienia arctica*, by a pair of fairly conspicuous pseudo-anuli, at least up to the second or third volution. We cannot therefore readily indentify the present form with any of the varieties of *rossica*.

As far as can be gathered from the existing literature, there is only one, namely *Fusulina verneuili* (Schellwien, non Möller) among the European species of *Schellwienia* that agrees with the present form in its essential characters, such as the elongated and slender shape of the test, the regular type of folding of the antethecæ, close coiling of the whorls, moderate thickness of the spirotheca, absence of anuli, etc. It seems that we have at last found elsewhere in the world a form that may be regarded, without much doubt, as belonging to the same species. The smaller size and fewer whorls on the part of our specimens rather suggest that we are here dealing with a variety of *Schellwienia veneuili* rather than *Schell. verneuili* s. str. of Schellwien.

HORIZON AND LOCALITY: This variety has been so far only found in the Fuching Limestone of Heishankou, in the Liuhokou coalfield, N. Honan. Forms essentially similar to those of Heishankou but with smaller axial ratio are also obtained from the Kushi Limestone of the Pinting Basin, N. E. Shansi. Their identity must, however, be regarded as somewhat doubtful for the present.

According to Schellwien, *Schellwienia verueuili* comprises a varied group of *Schellwienia* in the Russian basins. But all of them are restricted to the Uralian formation of that country.

Schellwienia cf. **lutugini** (Schellwien)

Pl. X, Figs. 5, 6

1908. *Fusulina lutugini* Schellwien Palæontographica, Vol. LV, p. 177, Pl. XVII, Figs. 2, 3, 7, 8, 12-14.

Among the numerous specimens procured from the Yaoku Limestone of the Pinting Basin, there is a fragmentary axial section with six and half volutions closely coiled except in the last two volutions and highly elongated in the axial direction. The widths of the successive volutions are 0.22, 0.36, 0.57, 0.92, 1.44, 2.13 mm, and the corresponding axial ratios are 1:2. 1:3, 1:3.07, 1:3.8, 1:4. The first two terms of these ratios are obtained by measuring the entire length of the whorls and their median width, the remaining three are calculated by doubling half the axial length. As our section is strictly axial the latter values ought not to differ appreciably from truth. In the same way, the length is calculated to be 8 mm, and the median width of the complete test is measured at 2.3 mm.

Alveolar osseum moderately coarse; thickness of the spirotheca increases steadily towards the outer whorls. In the sixth volution it reaches about 0.08 mm.

Antethecæ very regularly and rather intensely folded in the inner volutions, but apparently less regular in the outer ones. This is possibly due in part to the unfavourable state of preservation and partly to the defect caused in the process of preparing the microslide.

Initial chamber, small, nearly spherical having a diameter of about 0.13 mm.

Buccal aperture low and narrow in the inner volutions, but becomes considerably broader, though still low, from the fourth volution onward.

Apart from the slender form, compressed type of coiling and usually high axial ratios for the inner whorls, there is still a remarkable feature characteristic of our species and also of Schellwien's *lutugini;* that is the fact that in spite of a considerable elongation of the test, the antethecæ are not folded to any extent so as to produce a complicated twisting effect or network.

There is little doubt that our form is an immediate ally of *Schellwienia lutugini* Schell. It is only because of the absence of more material that I hold their identity as tentative.

Ozawa's *Schellwienia lutugini* from the Akiyoshi Limestone, also appears to approach our species very closely, but shows a closer coiling in the outer volutions. When a sufficient amount of materials is available it will not be surprising to find that the Russian, Japanese and the Chinese forms essentially belong to one and the same species.

Schellwienia cervicalis Lee (sp. nov.)

Pl. X, Figs. 13-17

Test slightly contracted in the median part and conical at two extremities. The umbilical ends are usually pointed but sometimes more or less rounded. The largest specimen measures 6.6 mm long and 3 mm broad. The average axial length and median width are however only 6.2 mm and 2.42 mm respectively. The latter figures give an axial ratio of 1:2.56. Those with rounded umbos generally have a smaller axial ratio.

Number of whorls varies from 7 to 9.

The first three or four volutions are closely coiled; from the fourth volution onward the whorls tend to widen out more or less abruptly with but a gradual increase of the height of the chamber in the following volutions. Although a large number of specimens has been prepared only a few of them admit exact measurements. The results of measurement (in mm) are as follows:—

Dia. of initial chamber	Widths of successive volutions								Specimen
	I	II	III	IV	V	VI	VII	VIII	
.078	.15	.22	.33	.5	.744	1.03	1.5	2.0	(617)
.167	.278	.42	.678	1.08	1.63	2.13			(1161)
.122	.205	.3	.43	.62	.92	1.32	1.84	2.35	(615)
.12	.2	.29	.42	.62	.9	1.28			(614)
.166	.267	.41	.62	1.03	1.56				

An analysis of these figures shows that the development of the several individuals is to some extent relatively retarded or accelerated, and that they fall into two groups: Those having a small initial chamber and 8 to 9 volutions probably represent the microspheric type, and those having a larger initial chamber and 6 to 7 volutions probably represent the macrospheric type. There is little doubt that they belong to one and the same species.

As a consequence of close winding the inner whorls are as a rule elongately fusiform with an axial ratio often somewhat higher than that of the fully grown test. Thus in a typical specimen this ratio is already as high as 1:2.5 in the second volution, and rises to 1:3 in the fourth.

Spirotheca fairly thin in those inner volutions in which the whorls are closely coiled, but becomes thicker in the outer ones. In the macrospheric form the thickest part occurs in the sixth volution where it measures at least 0.06 mm, but is sometimes as thick as 0.09 mm, and in the microspheric form the two or three outer volutions are nearly of equal thickness, and usually measure 0.05 mm.

Osseum rather coarsely alveolar in the macrospheric type, but moderately fine in the microspheric form.

Antethecæ slightly thinner than the spirotheca, rather crowded and fluted in a regular manner. The individual folds though, which often run through the entire height of the antetheca, are generally widely spaced, particularly so in the median region.

Buccal aperture small, and crescent-shaped in the inner, closely coiled whorls, but becomes less well defined toward the outer volutions. Serial sections however show that it is definitely present in the form of a broad but low slit.

A pair of rudimentary anuli surrounds the initial chamber and is sometimes present in the first volution, but completely disappears from the second volution onward.

Shape of the initial chamber usually spherical, rarely ellipsoidal with its major axis pointing towards the poles.

Between the terminal parts and the median region there always occurs a disc of calcareous deposit.

REMARKS: Among the numerous species of *Schellwienia* so far described, there is only one that may be cited here for comparision. That is *Schellwienia kraffti* found in the Darwas district. The latter species however differs from the present one in that it never develops so many whorls as 8 or 9, and that it possesses a much larger initial chamber i.e. 0.2 to 0.6 mm according to Schellwien and Dyhrenfurth. From the fact that dimorphic development of *Schellwienia cervicalis* is already recorded in our material, it does not appear plausible that the Darwas species represent the macrospheric type of our species. In general, it does not seem altogether safe to accept any theory of dimorphism unless the two forms are found side by side.

HORIZON AND LOCALITY: *Schellwienia cervicalis* has been collected by Mr. Y. T. Chao from the Shanching and Fuching Limestones of S. Chihli and N. Honan. It seems to be restricted to a definite zone in that area. The age that it represents is Upper Carboniferous or Uralian.

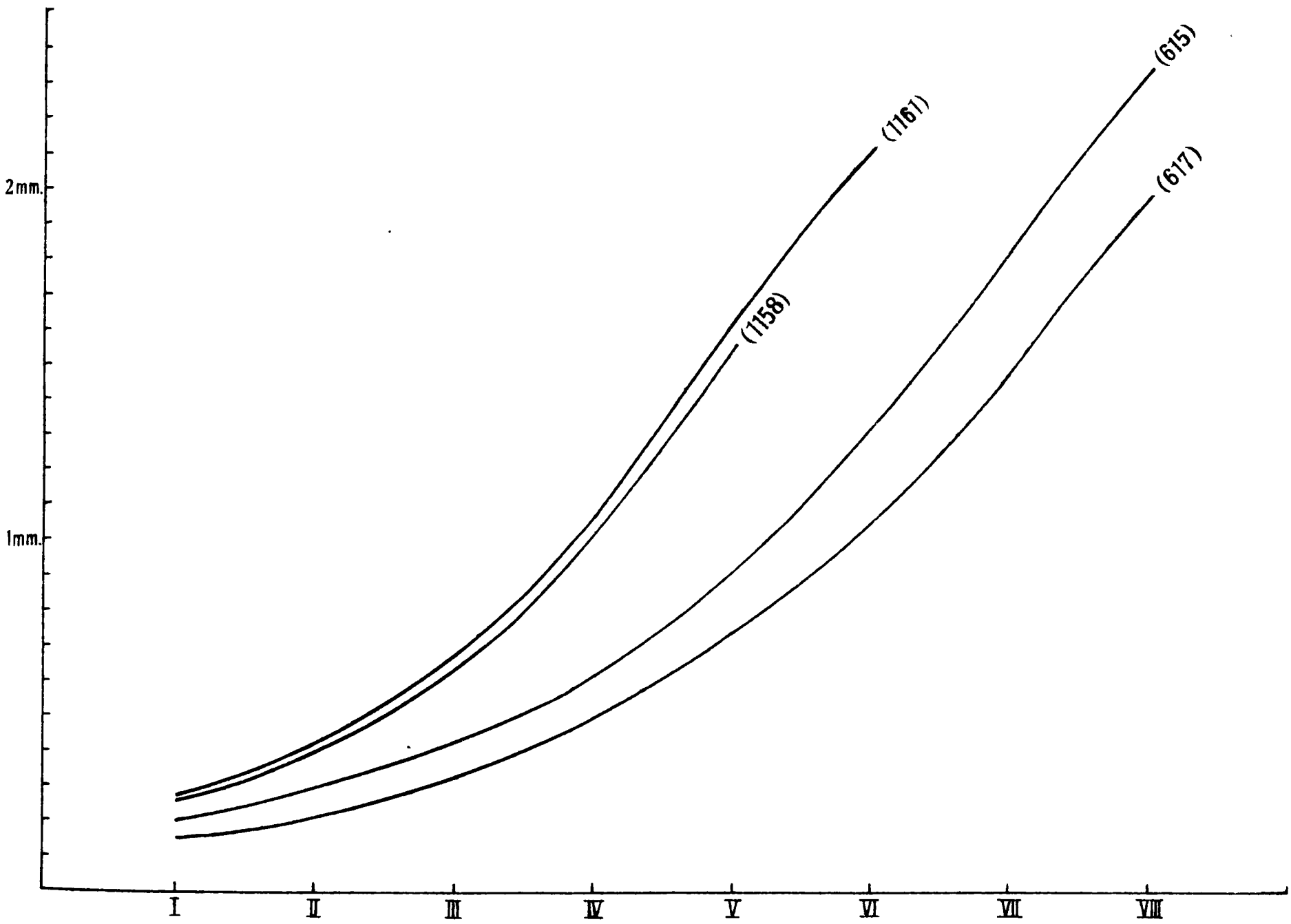

*Fig. 12

Width-graphs of *Schellwienia cervicalis*; (1158, 1161) macrospheric type, (615, 617) microspheric type.

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Schellwienia acuta Lee (sp. nov.)

Pl. X, Figs. 7-12

Test fusiform as a whole, sharply vaulted in the median part more or less slender towards the poles, umbilical ends always pointed. The adult individuals are on the average about 6 mm long and 2 mm broad with an axial ratio of 1:3 for the complete test.

Number of whorls usually 7 to 8, sometimes 6 in the fully developed individuals.

From several typical specimens the following figures are obtained (widths being in mm):—

	Initial chamber	Volutions I	II	III	IV	V	VI	VII	VIII	Specimen
Width	.156	.267	.4	.567	.8	1.11	1.38	1.74		(855)
	.156	.267	.44	.656	.92	1.22	1.6			(1120)
	.11	.19	.29	.42	.633	.9	1.17	1.5	1.83	(1119)
	.133	.267	.41	.62	.9	1.17				(1118)
	.133	.22	.367	.59	.88	1.2				(1104)
	.156	.267	.4	.6	.83	1.14	1.62	2.07		(854)
	.133	.22	.33	.52	.756	.98	1.3			(1113)
No. of antethecæ		11	18	22	27	29	40			(1117)
		11	19	22	30	33	40	46?		(1116)
		11	22	33	43	48	46			—

It may be seen from the above table and the accompanying graphs that the whorls are exceedingly compact, particularly so in the inner volutions. Among the several specimens measured there is only one in which the widths of the last two volutions increase more rapidly. This particular case probably represents an abnormal development rather than a type.

Spirotheca rather thick, and shows little variation in thickness throughout the test. Thus in the second whorl the average thickness measures 0.044 mm, and in the sixth or seventh it only rises to 0.056 mm in the majority of individuals. This unusual uniformity in thickness is at least partly due to the presence of an inner layer of tectorium in the first four volutions.

Osseum very finely alveolar, often indistinguishable in the inner volutions.

Antethecæ almost as thick as the spirotheca, they are rather gently and regularly fluted for about $\frac{3}{4}$ of their height. In the axial section the folded antethecæ often appear as ill-defined, low arcs because of their extraordinary thickness and because of the compact type of coiling.

The inner whorls are much shorter, and more vaulted than the outer ones. Thus in a type specimen the axial ratio, or the ratio of length to width, is found to be

1 : 1.7 for the 1st volution
1 : 2.3 ,, ,, 2nd ,,
1 : 2.4 ,, ,, 3rd ,,
1 : 2.7 ,, ,, 5th ,,

A somewhat sudden increase in length appears to take place always in the fifth or sixth volution.

Pseudo-anuli stout and broad always present up to the last whorl.

Buccal aperture small, narrow and crescentoid up to the last but one volution, much broader and slit-like in the last volution.

Initial chamber usually spherical, sometimes irregular in shape. Wall of the initial chaber very thick measuring no less than 0.033 mm in the normal case.

REMARKS: As far as the author's knowledge goes, there is not a single species of *Fusulina* so far described that shows any definite relation to the present one. It is distinguished from all the other new species described in this work by its exceedingly compact coiling, thick spirotheca, small but well-defind buccal aperture and prominent pseudo-anuli. The last-named feature together with the presence of a layer of tectorium in the inner volutions indicate that we are here dealing with a form which has a close genetic relation with the lower members of the family.

HORIZON AND LOCALITY: *Schell. acuta** occurs abundantly in the Fuching Limestone of Taichai and Heishankou, N. Honan, being always associated with *Schellwienia verneuili* var. *levidensis* and *Schell. longissima*. Hence it is believed to represent the Uralian.

Schellwienia expansa Lee (sp. nov.)

Pl. XI, Figs. 1-5

Test almost cylindrical or even slightly depressed in the median portion for about one half of its entire length, and distinctly conical for the remaining one fourth on

* This species was formerly mislabeled as *Fusulina sinoarctica* (See the report of Y. T. Chao & C. C. Tien on the Stratigraphy of the Tsechow and Liuhokou coalfields, Bull. Geol. Surv. Chiua, No. 6, Dec. 1924).

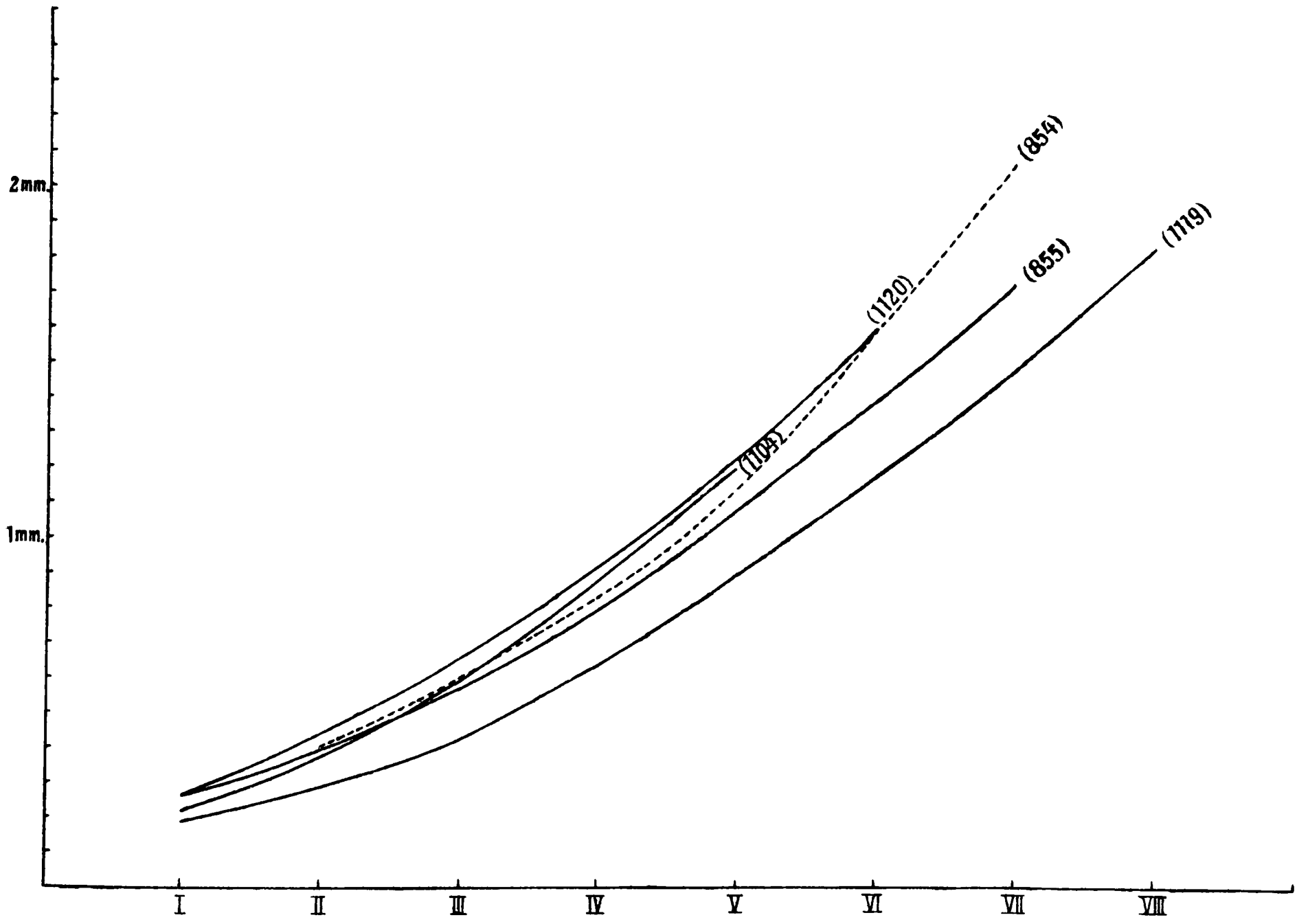

Fig. 13

Width-graphs of *Schellwienia acuta*; (855, 1119, 1104, 1120) showing the normal type of coiling, (854) with two outer volutions rather loosely coiled.

[*To face page 80*]

both sides. The largest form known has an axial length and median width of 10.3 mm and 3 mm, and the smallest 7.6 mm and 2.7 mm respectively. The axial ratio for the complete test therefore varies from 1:2.8 to 1:3. The former figures appear to represent the normal case.

Number of whorls 5 to 6 usually $5\frac{1}{2}$.

Whorls are, as a whole rather loosely coiled. The mode of coiling can be divided into two stages in the dominant type: The first three volutions are relatively compact, while the last two are distinctly wider, hence its specific name. From several typical respresentatives of this species I have obtained the following measurements:—

Dia. of initial chamber in mm	Widths of successive volutions in mm					Specimen
	I	II	III	IV	V	
.4	.67	1.15	1.7	2.4	3.2	(2077)
.32	.58	1.0	1.55	2.45	3.42	(757)
.29	.456	.83	1.37	2.12	3.01	(756)

Thickness of spirotheca gradually increases from the first whorl to the last. In the thickest part it amounts to no more than 0.066 mm. Osseum fairly fine, the individual dark lines (poutrelles) being often indistinguishable.

Antethecæ comparatively thin, irregularly and rather intensely folded. In the terminal parts the folding becomes so intense and complicated that, in the axial section, a confused, fine mesh-work is invariably to be observed. This effect is particularly striking in the last two volutions.

Number of antethecæ increases suddenly from the third volution as shown in the following table:—

I	II	III	IV	Specimen
17	28	43	41 (partially preserved)	—
16	27	42*	40	(2075)
16	24	41	43	(1051)

Buccal aperture often unobservable, only occasionally indicated by a low, narrow slit.

Anuli absent.

* This figure is partially obtained through interpolation.

Initial chamber large and perfectly spherical, usually over 0.3 mm in external diameter, sometimes as large as 0.4 mm.

REMARKS: As will be noted in connection with the description of *Schellwienia richthofeni*, the present species is undoubtedly its immediate ally. It differs from *richthofeni* only in having less extended umbilical ends, more rapid rate of spiral expansion, thinner spirotheca, more irregularly folded antethecæ in the median part, and a smaller number of whorls. Transitional forms are present representing the intermediate stages in the evolution of the two species.

To *Schellwienia japonica* the present species is likewise related, though the relationship is perhaps a little more remote than to *Schellwienia richthofeni*, for the latter hardly show that characteristic network of folds in the terminal parts of the test. Moreover, in *Schellwienia japonica* the median part is always more or less strongly vaulted, while in *Schell. expansa* the median part is as a rule cylindrical or slightly depressed.

HORIZON AND LOCALITY: This species has been found in the Taching Limestone of Taichai, Hsiaoching Limestone of Heishankou, Houshi Limestone of the Pinting Basin, and the second seam of Fusulina Limestone (counting from below) exposed in Yuehmenkou, west of Taiyuan. It is nearly always associated with *Schellwienia richthofeni* and *Schell. japanica*. Stratigraphically the present species probably ranges throughout the Taiyuan Series.

Schellwienia japonica (Gümbel)

Pl. XIII, Figs. 1-8

1883. *Fusulina japonica* (Gümbel) Schwager: China, Vol. IV, pp. 121-124, Pl. XV, fig. 1-11.

1906. *Fusulina japonica* Yabe, Contribution to the genus Fusulina, Journ. Coll. Sci. Tokyo. Vol. XXI, Art. 5, Pl. II, fig. 1.

1914. *Fusulina japonica* Deprat, Étude comparative des Fusulinidés d'Akasaka (Japon) etc. Mém. Serv. Géol. Indochine, Vol. III, Fasc. I, pp. 2-9, Pl. I, fig. 1-9.

1915. *Fusulina japonica* Deprat, Les Fusulinidés des Calcaires carboniferous et permiens du Tonkin, etc., Mém. Serv. Géol. Indochine, Vol. IV, Fasc. I, pp. 7-8, Pl. I. fig. 17, 19, 20, (18?)

1924. *Fusulina japonica* Colani, Nouvelle contribution à l'extreme-orient Mém. Serv. Géol. Indochine, Vol. XI, pp. 136-137, Pl. VII, Pl. VIII, figs. 1-5, 9-13.

Test stoutly fusiform with its median part strongly vaulted and umbilical ends pointed. The ratio of axial length to median width of the complete test varies from 6.5 mm : 3.18 mm to 9 mm :3.5 or 1:2.4 to 1:2.5 in our material. More elongated forms probably occur; but so far, I have not found, among our numerous specimens, a single individual attaining the size of 14 mm:4 mm as mentioned by Schwager.

Number of whorls varies from 5 to 7, those possessing $5\frac{1}{2}$ whorls appear to be the predominant type.

Whorls relatively compact in the first one or two volutions but from the second or the third volution onward the chambers become distinctly higher, but their height increases only slightly, up to the last volution.

The following figures show a few measurements (in mm) of the common form:—

Dia. of initial chamber	Widths of successive volution								Specimen
	I	II	III	IV	V	VI	VII	VIII	
.367	.6	1.02	1.7	2.42	3.03				(608)
.344	.59	1.08	1.67	2.4					(903)
.39	.67	1.21	1.87	2.76					(901)
.36	.818	1.51	1.82	2.45					(908)
.39	.61	1.1	1.63	2.27					(2600)
.40	.75	1.127	1.747	2.5	3.383	4.363			Schwager
—	.82	1.20	1.60	2.13	3.0	3.6	4.2	4.4	Deprat

These figures are fairly constant except those in the second row which probably represent a microspheric type. The figure for Schwager's type species are obtained by adding together the "Windungshöhen" and "Wandstärken". If Schwager measured the height of the successive whorls including the thickness of the spirotheca, then the figure must be slightly reduced. At all events they are not incomparable with my measurements.

Axial ratio for the first two volutions fairly constant, 1:1.9 for the first volution and 1:1.7 for the second. These are the results of several measurements. A marked variation is observed from the third volution onward. In the highly inflated variety the axial ratio for the third volution may be as low as 1:1.5 and the fifth 1:1.7, while in one of the elongated forms this value for the third volution reaches 1:2.6 and for the fifth 1:2.

Spirotheca moderately thick, its thickness increases gradually from the first volution up to the fifth or the sixth which varies from 0.08 mm to 0.09 mm.

Antethecæ decidedly thinner than spirotheca being regularly and intensely folded practically throughout their entire height and length. In the axial section the fluted surface is often cut in such a way that a series of highly compressed but regularly arranged arcs appear in the median part of the test, and they usually assume the form of

an inverted U. Towards the umbilical ends the folds become more complicated. In the highly inflated variety the terminal folds are less confusing, but in the elongated variety there is the tendency to develop a network which is however never so intricate as in *Schellwienia richthofeni*.

Number of antethecæ as counted in a few typical specimens are as follows:—

14	22	40	65?
15	22	33	45
15	21	33	44
15	23	42	49 (partially preserved).

These figures obviously arrange themselves in two groups: The one shows a sudden increase from the third volution onward, and the other increases more uniformly. In the absence of correlative data with the axial sections, it seems undersirable to distinguish varieties on this ground, however that may be the logical treatment.

Buccal aperture narrow and low sometimes unobservable. In no case does it reach half the height of the respective chamber.

Anuli absent except on the wall of the initial chamber where they are represented by two black spots often seen in the axial section.

Initial chamber large and spherical with its external diameter usually varying from 0.36 mm to 0.40 mm, sometimes as small as 0.28 mm. The latter either represents a variety closely allied with *Schellwienia richthofeni* or the microspheric generation of *Schell. japonica*.

REMARKS: Among the closest allies of the present species *Schellwienia richthofeni* is naturally the first to be mentioned. These two species do not only possess many of the important structural features in common as will be discussed in connection with the description of *Schellwienia richthofeni*, but they occur in constant association as far as our collection is concerned. The essential difference between the two species lies in the fact that *Schell. japonica* always possesses a large, spherical or nearly spherical initial chamber with its median part more or less strongly vaulted, while *Schell. richthofeni* usually has an irregular-shaped initial chamber and always tends to elongate from the third or fourth volution onward; and further, the latter is characterized by an intricate network of folds in the terminal parts of the test.

If a strict comparison be made between our material and the figures given by Schwager under the designation of the same specific name, one may note, first of all. that our forms are, as a whole, of smaller dimension and possess fewer whorls. These

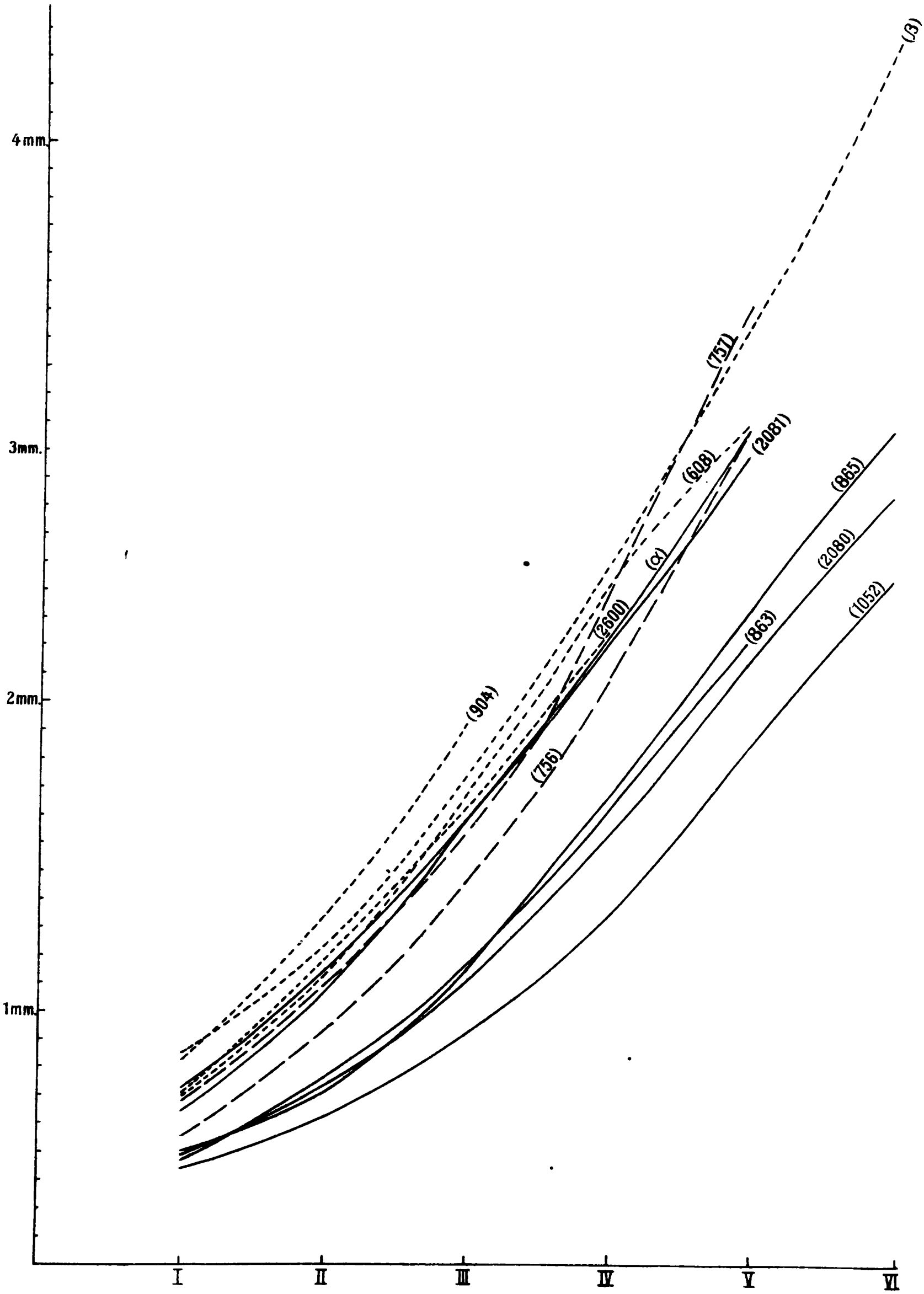

Fig. 14

Width-graphs of *Schellwienia richthofeni* (863, 865, 1052, 2080, 2081, α), *Schell. expansa* (756, 757), *Schell. japonica* (608, 2600, β) and *Schell. japonica* var. *hayasakai* (904), α and β being Schwager's original specimens.

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differences however do not appear to be of persistent nature, for, Schwager himself mentions the fact that many individuals occur in his material that are of considerably smaller size than those shown in his figure. Deprat and Hayasaka have also brought forward examples to illustrate this point. Nevertheless, the fact seems fairly evident, that the majority of the Japanese and Indochinese forms as recently described by Mlle Colani are of larger dimension. and a slightly more compact type of coiling than our specimens. Among the recent finds there are two examples that represent the nearest approach to our specimens. The first one was collected by Deprat from the Cam-man district, Indochina. The widths of this form measure, according to Deprat, as follows:—

I, 0.60; II, 0.95; III, 1.36; IV, 1.98; V, 2.45. mm

The second one was found and described by Dr. Hayasaka, occurring in the limestone of Omi-mura, Echigo, Japan. Dr. Hayasaka's material, though unfortunately somewhat incomplete, recalls strongly in point of its size, shape and type of folds, one of our specimens from the Shanching Limestone of Taichai (Pl. VIII, Fig. 9) which I have described below as var. *hayasakai.*

Under these circumstances, it may appear desirable to distinguish several varieties in this species, especially when it is known that this species has a considerable vertical range. On examining our material closely as well as those dealt with by the above mentioned authors, the minor variations seem to have taken place in all directions that it is difficult to set apart one group of variations without overlapping another. Even in those two varieties distinguished by Deprat, namely var. *akasakensis* and var. *constricta*, it is doubtful whether both of them possess varietal characteristics of persistent nature. Without a more extensive survey of this species it seems useless to consider the problem of its manifold variation.

HORIZON AND LOCALITY: In North China *Schellwienia japonica* has been found in the Fuching, Shanching and Yehching Limestones east of the Taihang Range, and also in the Houshi Limestone of the Pinting Basin, N. E. Shansi. Elsewhere it is reported to occur in association with *Verbeekina verbeeki* and other Permian species. Vertically it probably ranges from Upper Uralian to later Permian.

Schellwienia japonica var. **hayasakai**

Pl. XIII, Figs. 9, 10

1924. *Fusulina* cfr. *japonica* Hayasaka, On the fauna of the Anthracolithic Limestone of Omimura. The Science report of the Tohoku Imperial University, II Ser. Vol. VIII, No. 1, pp. 16-17, Pl. III, fig. 5.

This variety is only distinguished from *Shell. japonica* s. str. by its smaller size, fewer whorls, less compressed type of folding of the antethecæ and a somewhat broader coiling of the whorls but unaccompained by a more vaulted form.

The average widths of the successive volutions and the diameter of initial chamber are indicated by the following two series of measurements:—

Dia. of initial chamber in mm	Widths of successive volution in mm.				Specimen
	I	II	III	VI	
0.39	0.727	1.24	1.94		(904)
0.41	0.41	1.2	1.76	2.5	(611)

Always associated with *Schellwienia japonica* s. str.

Schellwienia complicata (Schellwien)

Pl. XIII, Figs. 11-13, and Pl. XIV, Figs. 1-13

1898. ***Fusulina complicata*** Schellwien, Palæontographica, Vol. XLIV, p. 249, Pl. XX, figs. 1-7.

1910. ***Fusulina complicata*** Staff. Anatomie und Physiologie der Fusulinen, Zoologica, Heft 58, p. 23, fig. 11.

1912. ***Fusulina complicata*** Deprat, Mém. Serv. Géol. Indochine, Vol. I, Fasc. III, pp. 17-19 Pl. VII, figs. 3-6.

1913. ***Fusulina complicata*** Deprat, Mém. Serv. Géol. Indochine, Vol. II, Fasc. I, p. 19, Pl. III, figs. 8-10.

1914. ***Fusulina complicata*** Deprat, Mém. Serv. Géol. Indochine, Vol. III, Fasc. I, p. 19, Pl. I, figs. 10-11.

Test stout and stumpy in the young, but becomes highly elongated in the adult stage. Thus in the second and and third volution the axial ratio rarely exceeds 1:2.2, while for the complete test this value generally rises to 1:3.2, sometimes 1:3.6. The largest individual in our collection is 9.1 mm long and 3 mm broad. The average specimen has a length and width of 8.4 mm : 2.7 mm respectively.

Number of whorls usually $4\frac{1}{2}$, rarely $5\frac{1}{2}$.

Whorls as a whole broadly coiled in the normal specimens. Only in those which develop $5\frac{1}{2}$ volutions, the last part of the outermost whorl becomes decidedly closer owing to the senility of growth. It is therefore evident that $5\frac{1}{2}$ is the highest attainable number of whorls of this species.

Alveolar structure of the osseum moderately coarse, spirotheca fairly thin in the inner volutions, but grows to be thicker towards the outer ones, in the fourth volution its thickness varies between 0.06 mm and 0.08 mm.

Antethecæ relatively thin, so intensely and so irregularly are they folded that it is seldom to find in the axial section a uniserial arrangement of arcs even along the median portion of the test. On the contrary, the truncated folds often appear as

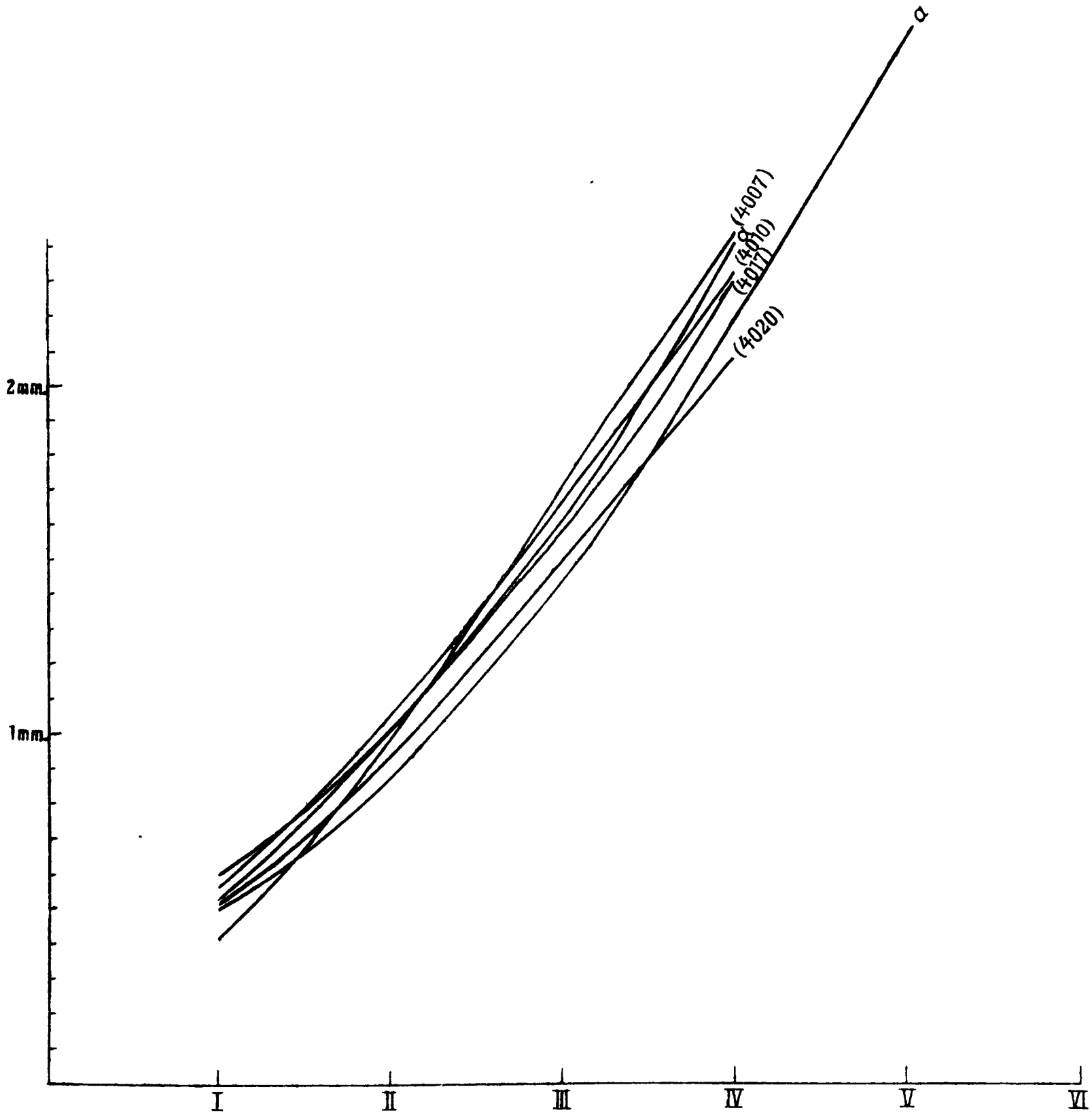

Fig. 15

Width-graphs of *Schellwienia complicata*, α being Schellwien's original specimen.

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aggregating loops which are rapidly transformed into a confused mass of network towards the umbilical ends. No other species of *Schellwienia* can rival the present one in the intensity of antethecal folding.

Numbers of antethecæ are counted from the first to the fourth volution in three typical specimens: They are 10, 23, 34, 42, in one individual, 15, 24, 36, 44, in another and 17, 25, 33, 43 in the third. These figures essentially agree with those given by Schellwien except in the last example which are slightly higher than in the Alpine form.

Buccal aperture very narrow and rather high in the first volution, and broadens out slightly toward the last. In the second volution it occupies about $\frac{1}{8}$ of the length of that whorl, and $\frac{2}{5}$ of the height of the chamber. Similar proportion seems to be maintained from the second volution onward.

Anuli without trace.

Initial chamber spherical having a diameter usually varying from 0.27 mm to 0.3 mm.

Results of measurement:—

	Initial Chamber	Volution					Specimen
		I	II	III	IV	V	
Width in mm	.22	.42	.98	1.72	2.44		(4007)
	.24	.57	1.05	1.66	2.33		(4010)
	.3	.53	1.0	1.56	2.3		(4017)
	.28	.52	1.0	1.58	2.3		(4008)
	.28	.52	.94	1.5	2.08		(4020)
	.27	.56	1.11	1.9	2.66		(4016)
	.32	.5	.867	1.44	2.2	3	
	.35	.6	1.0	1.6	2.4		Schellwien's
Axial ratio			2.1				(4007)
			2.2	2.25	3.2		(4008)
			2	2	2.6		(4016)
			2		4		Schellwien's

REMARKS: This large *Schellwienia* is characterized by broad coiling, relatively few whorls, stumpy form in the young and highly elongated in the adult, and intense

and extraordinarily irregular folding of antetheæ. Even the last named feature alone makes it sufficiently distinctive from any of its allied species. Of the several species from Hsinho, there is only one, namely *Schellwienia richthofeni*, that seems to have some remote relation with our species; for the former is also of a large size, and develops a complicated network of folds in the umbilical regions. It can however be distinguished at once from our species by its closer coiling, more whorls and more regular type of antethecal folds in the median portion of the test.

Among our specimens there are a few closely resembling certain varieties of *Schellwienia alpina* from Indochina as described Mlle. Colani (Op. cit. p. 139, Pl. XI, fig. 13). This raises the question whether certain varieties of *alpina*, for instance, *alpina* var. *antiqua* of the Alpine region may not be, after all, the microspheric type of *Schellwienia complicata;* for, according to Schellwien's measurements, the widths of the successive volutions for each of these forms are nearly equal, and they are both characterized by complicated folding of the antethecæ. Their sizes are also not incomparable. Without a thorough investigation of the respective materials, I would not however attach much importance to this suggestion.

It should also be noted that none of our specimens reaches such a gigantic size as that of the Akasaka district, Japan. There is only one axial section obtained from the Yaoku Limestone of the Pinting Basin that bears a strong resemblance to the Japanese form (see Pl. XIV, fig. 5), though they differ from each other in size.

HORIZON AND LOCALITY: So far, *Schellweenia complicata* is only known in three different localities within North China. It occurs fairly abundantly in the lower layer of "Fusulina Limestone" of Hsinho, Kansu, more rarely in the Yaoku Limestone of the Pinting Basin, N. E. Shansi, and rather frequently in the Miaokou Limestone of Central Shansi. As in the Carnic Alpine region its stratigraphical position is assigned to the Upper Carboniferous.

Schellwenia richthofeni (Schellwien)

Pl. XI, Figs. 6-10; XII, Figs. 1, 2, 4, 5, 7

1883. *Fusulina richthofeni* Schwager, China Vol. IV, p. 124, Pl. XV, figs. 11-17.

1912. *Fusulina richthofeni* Deprat, Étude Géol. du Yunnan Oriental, III partie, pp. 30-31, Pl. VIII, figs. 15, 16.

1925. *Fusulina richthofeni* Ozawa, Journ. Coll. Scien. Tokyo, Vol. XLV, Art. 6, p. 35, pl. V, fig. 1.

This rather large and highly elongated *Schellwienia* is, as a whole, of a spindle-like shape. The median part is seldom vaulted to any extent, but is often cylindrical or even depressed on one side and more or less inflated on the opposite. Towards the

umbilical ends the test gradually tapers to a point assuming the form of a sharp cone with an apical angle from 28° to 34°.

The smallest specimen in our prepared material has an axial length and median width of 7.27 mm : 2.51 mm and the largest 12.1 mm : 2.94 mm. The commonest form usually exceeds 8 mm in length and 2.7 mm in width. The axial ratio therefore may be taken as varying from 1:3 to 1:4.

Number of whorls usually 6, sometimes 5 and rarely 7.

Whorls rather compactly coiled evolving with a slow and uniform rate. This is not only seen in the median sections but may be deduced from the following measurements which represent the widths (in mm) of the successive volutions:—

I	II	III	IV	V	VI	VII	Specimen
·4	·59	1.056	1.667	2.378	3.00		(865)
.467	.667	1.028	1.52	2.067	2.72		(864)
·333	·511	.81	1.22	1.833	2.44		(1052)
·42	·7	1.12	1.7	2.4	3.06		(866)
·333	·511	.8	1.12	1.51	1.9	2.366	(861)
·367	.61	.944	1.42	1.9	2.4		(860)
·424	.88	1.46	2.03				(270)
·44	·79	1.303	2.03				(2079)
·36	·7	1.18	1.76	2.4	3.03		(3111)
·545	·97	1.58	2.21	2.91			(2081)
·394	.636	.985	1.515	2.152	2.73		——
·364	.727	1.242	1.89				(2078)
.622	1.04	1.57	2.262	3.022*			Schwager's

Two of these specimens, namely (270) and (2079), seem to show a tendency to approach *Schellwienia expansa*, and probably represent an intermediate variety between that species and *Schellwienia richthofeni* s. str.

The figures for Schwager's type specimen are obtained by adding his measurements of what he terms "Windungsabstände" and "Semisso-distante Reihe der Schalendurchamesser". All these figures taken in a serial succession, are practically comparable, although in some forms the whorls are a little more closely coiled than others. Here again the phenomenon of "accerlation" or "retardation" is to be observed as in many other

* This value is obtained by assuming the thickness of the spirotheca in the fifth volution to be of the same order as the fourth.

species. Schwager's type specimen, for instance, is obviously one volution advanced as compared with the majority of our forms.

Axial ratio varies from 1:1.7 to 1:2.7 in the first three or four volutions. A sudden increase takes place in the fourth or the fifth. Measurements made on a few selected specimens as indicated below serve to illustrate this remarkable feature, and also define the range of variation:—

I	II	III	IV	V	Specimen
2.5	2.65	2.43	4		(2081)
2.3	2.56	2.74	3.42		(865)
1.67	1.91	2.14	2.3	2.83	(863)

Spirotheca consists of a rather coarsely alveolar osseum and a thin tectum with its aggregate thickness gradually increasing towards the outer whorls. In the fifth volution the thickness varies from 0.056 mm to 0.077 mm. This value does not seem to decrease in the outermost whorl as is usually the case with those forms which show a definite senile stage of development.

Antethecæ are barely supported by inward projection of the osseum at the top. This mechanical weakness is apparently compensated by the thichness of the antetheca itself which usually reaches half the thickness of the adjoining spirotheca.

Each whorl carries a large number of antethecæ which augments enormously especially in the later whorls. The numbers which I have counted in three typical specimens are tabulated below.

I	II	III	IV	V	VI	Specimen
16	28	32	41	51	60	(2080)
18	28	33	42	53		(1052)
15	28	35	45	51		(864)

Schwager writes that in the fifth volution, *Fusulina richthofeni* possesses 25 to 30 antethccæ. This statement however does not seem to agree with his figure (China, Vol. IV, Pl. XV, Fig. 4) in which I have counted from the fifth volution inward: 41, 32, 26, 17, —. These figures practically agree with the values tabulated above, except for the fact that our form is one volution more advanced either through acceleration of development or through its being a macrospheric type which naturally begins with a larger initial chamber and consequently more antethecæ. Otherwise Schwager's section presents exactly the same appearance as ours.

In the median part of the test the antethecæ are intensely and regularly folded. But towards the terminal regions the folding becomes so intricate that a mass of extremely fine network extends to the very umbilical ends. This feature is particularly striking in the last one or two volutions which are always grossly elongated towards the poles.

Buccal aperture extremely small and narrow in the inner volutions, unobservable in the outer ones.

Anuli entirely absent.

Initial chamber spheroidal with an external diameter varying from 0.2 to 0.37 mm, wall of initial chamber fairly thick, usually as thick as, or even thicker than, the spirotheca in the first volution.

REMARK: It is beyond doubt that *Schellwienia richthofeni* is the closest ally of *Schellwienia expansa*, so much so that, at a sight, the one may be regarded as a variety of the other. More careful comparison however reveals that the present species is not only more compactly coiled, but is distinguished by a much more elongated shape and often more whorls. As there is evidence to show that both of these species belong to a group of stable forms (for instance by their long vertical range) these difference ought to be considered as constituting a decisive step of variation which may therefore amount to specific value.

Through gradual vaulting in the median part and the disappearance of the network of folds in the terminal portions, this species is linked, by transitional forms, to *Schellwienia japanica* with which it is no doubt genetically related. Several of the Taichai forms, for instance specimen (866), that are here included in this species are in fact representatives of such intermediate types.

As regards Deprat's *Fusulina richthofeni* from Yunnan I cannot readily identify it either with Schwager's original specimen or with ours, because neither in Deprat's description nor in his microphotographs can we find that characteristic alar prolongation and the network of antethecal folds on which Schwager has rightly laid much emphasis.

Ozawa's identification of a Nagato form with *Schell. richthofeni* is evidently based on limited material. On the single median section published by the said author I am unable to make any definite remark. It may however be noticed that his measurement do not seem to agree either with those given by Schwager or with mine. His figure, too, appears to differ from typical *Fusulina richthofeni*. The doubt is therefore not absent as to whether these Yunnan and Nagato forms actually belong to *Fusulina richthofeni* Schwager.

HORIZON AND LOCALITY: Representatives of this species have been obtained from the Hsiaoching, Fuching and Shanching Limestones in S. Chihli and N. Honan, from the second layer of Fusulina Limestones (counting from below) of the Changchu coalfield, W. Shantung, from Wuhutsui, S. Manchuria, and from the Houshi Limestone in the Pinting Basin, N. E. Shansi. In all these localities it is often associated with *Schellwienia expansa, Schellwienia japonica, Schellwienia nathorsti* etc. Again it occurs in the Chientaokou Limestone together with *Schellwienia vulgaris* var. *minor* and in the Hsinho fauna of N. W. Kansu. While these associated occurrences prove its Uralian age the possibility is not excluded that it may have survived to the Middle Permian period.

Schellwienia richthofeni var. **speciosa**

Pl. XII, Figs. 3, 6, 8

This variety is represented by several individuals among our material. It always associates with the type-species *richthofeni,* and agrees in all its essential properties with that species. In the terminal parts of the test the antethecæ are likewise intricately folded exhibiting the characteristic network. The umbilical prolongation is however more or less of a cylindrical shape instead of being an acute cone. The median portion is slightly more inflated than in *Schellwienia richtnsfeni* s. str. Antethecæ intensely folded; widths of the successive whorls are as follows:

I, 0.41; II, 0.72; III, 1.244; IV, 1.933; V, 2.644; VI, 3.64

These figures are obtained from a typical specimen, and are therefore believed to represent the average. As a senile stage is indicated in this specimen, the maximum number of whorls probably does not exceed 6. Initial chamber rather small with an external diameter of 0.28 mm. Buccal aperture small and narrow, often unobservable. Anuli absent as in the

As to its vertical distribution, the present variety is probably co-extensive with *Schellwienia richthofeni* s. str.

Schellwienia plicata Lee (sp. nov.)

Pl. XV, Figs. 12-16

Of all the sections of this species that I have obtained, none is strictly axial. We can therefore only arrive at some idea of its shape and size by interpreting the several oblique sections. Externally, the test appears to be thick and stout with its median part appreciably vaulted, and umbilical ends usually stumpy, occasionally acute. The width of the complete test varies, in the normal case, from 2.5 mm to 3 mm, and the length of

the larger ones exceeds 6 mm. There is only one section which does not seem to depart to any extent from the axial position. It has a length of 2.6 mm and width 1.2 mm. This extraordinarily small size is obviously due to the immature development as is shown by the absence o a senile stage.

Number of whorls 6 to 7; the first three whorls are highly compact, thence they abruptly become much broader. The last whorl is again distinctly more compactly coiled as compared with the preceeding one. The widths of the successive volutions are as follows:—

I	II	III	IV	V	VI	VII	Specimen
.156	.24	.39	.58	1.06	1.58	2.46	(715)
.156	.24	.38	.61	1.16			(4020)
.18	.29	.44	.69	1.22			(713)
.2	.3	.43	.69	1.19	2.22	2.83	(714)

Spirotheca very thin in the inner, the compacter volutions, reaching about 0.04 mm in the fifth, and 0.09 mm in the last whorl.

Antethecæ extraordinarily thin, intricately folded throughout their length and breadth. In the umbilical regions, they appear as a mass of aggregating loops when seen in the axial section. They are rather crowded in the inner volutions, but less so in the outer ones, numbering 10, 16, 20, 24, 24, 33, from the first to the sixth volution in a typical example.

Buccal aperture exceedingly minute in the inner volutions, altogether disappears in the outer ones. A pair of insignificant anuli is represented in the inner whorls, unobserved in the later stage of development.

Initial chamber extremely small, spherical, having a diameter varying from 0.08 mm to 0.1 mm.

REMARKS: The external form and the type of folding of the antetheæ of this species strongly remind us of *Schellwienia alpina* Schellwien as it occurs in the Alpine region. They are possibly related. The fact that it occurs in the Hsinho fauna accompanied by *Schellwienia complicata*, *Schwagerina fusulinoides*, etc, is also in favour of this suggestion. A remarkable difference is, however, observed in the development of the whorls. The Alpine forms possess, as a rule, only four or five volutions, and they are broadly coiled throughout; while our species often attains seven volutions, and the inner ones are very compact. The complicated type of folding of the antethecæ may suggest some relation with *Schellwienia complicata*, but other features entirely disprove their genetic affinity.

HORIZON AND LOCALITY: This species occurs in the highest layer of the "Fusulina Limestones" of the Shimiao district, S. Chihli, and also in the Hsinho fauna of Kansu. If the latter is equivalent to the Yaoku Limestone of the Pinting Basin as probably is the case, its vertical range must cover the whole of the Taiyuan Formation, for there is reason to correlate the higher layers of the Fusulina Limestone of the Pinting Basin with certain lower layers of Fusulina Limestone of S. Chihli. We cannot however be too dogmatic in this assumption. So far, I have only found a single representative of this species in the Hsinho fauna, and it is decidedly smaller and has fewer whorls than those of the Shimiao district. The possibility cannot therefore be absolutely excluded that this small form may represent a distinct variety. If that be actually the case, we would be quite justified to consider the Hsinho form as a forerunner of *Schellwienia plicata* s. str. and therefore geologically the older, as compared with the Shimiao form.

Schellwienia alpina (Schellwien)

Pl, XV, Figs. 1-11

1898. *Fusulina alpina* Schellwien, Palæontographica, Vol. XLIV, pp. 243-246, Pl. XVII.
1908. *Fusulina alpina* var. *vetusta* Schellwien, Palæontographica, Vol. LV, pp. 170-171, Pl. XV, figs. 1-4.
1912. *Fusulina alpina* var. *antiqua* Deprat, Étude Géol. du Yunnan Oriental, Mém. Serv. Géol. Indochine. Vol. I, Fasc. III, pp. 27-28, Pl. VIII, figs. 1-3.
1925. *Fusulina alpina* var. *vetusta* (?) Colani, Nouvelle contribution à l'Étude des Fusulinidés etc, Mém. Serv. Géol. Indochine, Vol. XI, Fasc. I, pp. 139-140, Pl. XI.

This sickly looking form of *Schellwienia* always appears to have been deformed before it was embedded in the rock. Its variously recurved shape probably does not represent its original form during its life time. Those which seem to have undergone the least morphological changes during or after the process of fossilization are generally cylindrical with the median part sometimes slightly vaulted, and ends always stumpy. The axial length is usually 8 to 9 mm, and median width about 2.5 mm. Individuals having a length of 6.7 mm and width 1.6 mm are also known.

Number of whorls usually 4 to $4\frac{1}{2}$, rarely 5. They are broadly coiled except for the first volution. Sometimes the last whorl is also slightly narrower than the preceeding one.

Spirotheca rather thin, with a finely alveolar osseum, the individual dark lines being often indistinguishable. When seen in the axial section, the spirotheca presents a sinuating outline, and its thickness is rarely uniform for any distance in the lateral direction. Whether this is a characteristic feature of the living organism or one due to subsequent solution of the calcareous material after its death is not known. In the median section it is always to be observed that the spirotheca sets in rather deeply

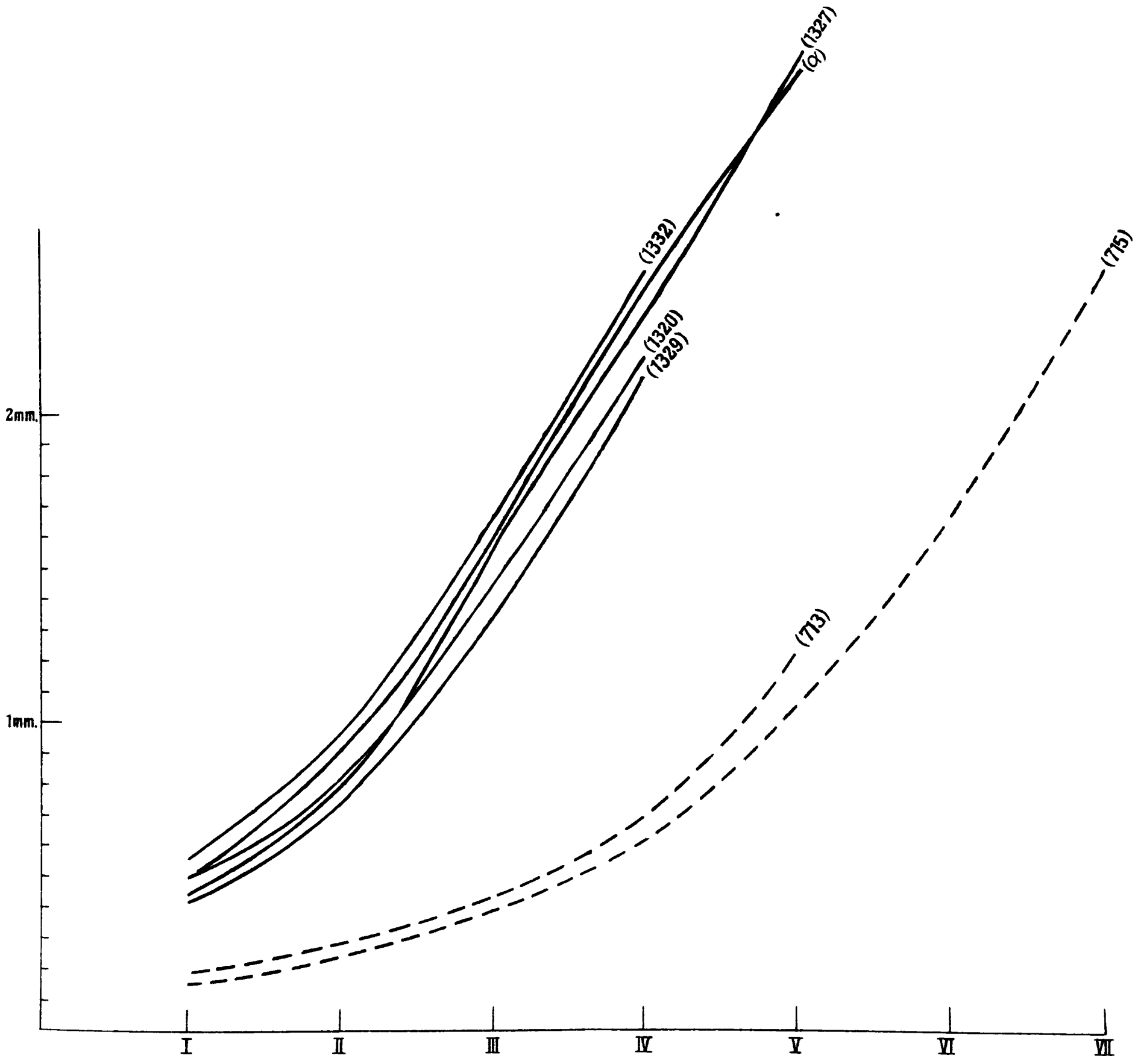

Fig.16

Width-graphs of *Schellwienia alpina* (1320, 1327, 1332, α) and *Schell. plicata* (713, 715); α Schellwien's specimen of *Schell. alpina* var. *antiqua*.

[*To face page 94*]

to meet the antethecæ of the preceding chamber leaving an angular space on the external side of the test so that there appears a sharp groove or furrow along the length of each antetheca.

Antethecæ exceedingly thin, relatively long, and contorted in all sorts of irregular manner in the lateral parts of the test, but become fairly straight in the median region. In the umbilical ends they are sometimes entangled with one another so as to form a complicated network. They are as a whole, rather widely spaced, but never even.

Anuli absent, buccal aperture relatively wide and broad. In the third and fourth volutions it occupies about $\frac{1}{6}$ of the length of the respective whorl, and $\frac{2}{5}$ of the height of the respective chamber.

Initial chamber sometimes spherical, and sometimes irregular in shape. Its diameter usually varies from 0.26 to 0.3 mm, but individuals with an initial chamber as large as 0.46 mm occur in association with the normal type.

Result of measurements:

	Initial chamber	Volutions					Specimen
		I	II	III	IV	V	
Widths in mm	.33	.56	.96	1.67	2.46		(1332)
	.24	.38	.68	1.28	2.03		(1331)
	.29	.5	.83	1.44	2.18		(1330)
	.21	.42	.73	1.33	2.11		(1329)
	.27	.56	1.0	1.72	2.41		(1328)
	.29	.5	.81	1.44	2.2		(1320)
	.31	.5	.89	1.61	2.28		(1319)
	.23	.42	.67	1.22			(1326)
	.26	.44	.78	1.56	2.33	3.17	(1327)
	.29	.45	.73	1.38	2.11		(1318)
	.2	.31	.5	.84	1.53		(1317)
	.26	.5	.9	1.6	2.4	3.1	var. *antiqua* (Schell.)
	.25	.5	.8	1.4	2.1		var. *fraglis* (Schell.)
		.5	.9	1.8	2.7		var. *communis* (Schell.)
	.25	.56	.99	1.61	2.45	3.20	var. *antiqua* (Schell.)
Axial ratio		1.9	2.6	2.7	2.8		(1320)
			3	3.2	3.6		(1317)
			2.7				var. *antiqua*
							var. *communis* (Schell.)
No. of antethecæ		10	20	25	32		(1332)
		10	20	21	31		(1331)
		10	18	25			(1330)
		10	23	25	30		(1328)
		12	20	23			(1326)
		13	21	25	30		var. *antiqua* (Schell.)
		12	20	22			var. *fraglis* (Schell.)
		12	16	20	29		var. *antiqua* (Deprat)
Thickness of Spirotheca in mm		.03	.05	.078	.09		(1319)
			.044	.056			(1326)
		.03	.04	.05	.056	.045	(1327)
		.02	.03	.055	.067	.09	(1318)
		.02	.022	.044	.056	.50	(1317)

REMARKS: The above figures are obtained from a series of selected specimens, and therefore they ought not to deviate to any extent from the normal values. If our figures be compared with those given by Schellwien and Deprat it will be found that they agree fairly well except in the number of antethecæ. This is, however, to be expected when the fact is taken into consideration that their arrangement is usually uneven. As a whole our specimens are practically identical with the Alpine, Yunnan and Indo-Chinese forms. No doubt can possibly exist as to their specific identity.

When we examine closely Schellwien's description and figures of the Alpine species, it will be noticed that there are very few, if any, characteristics in the fossils themselves to justify his establishment of the varieties, *antiqua*, *fraglis* and *communis*. His principal reason is based on the fact that these slightly different forms occur at different horizons; but nothing is said as to whether they are restricted to the several horizons. In the fauna of Yatzetsi, Honan, we have forms occurring side by side that approach severally all of these varieties. I am, therefore, inclined to believe it unnecessary to distinguish the said varieties.

Certain types of the Russian variety *rossica* (e.g. Palæontographica, Bd. LV, Taf, XV, fig. 5) are almost indistinguishable from certain specimens in our material, but the majority of the Russian representatives as described and figured by Schellwien are more or less distinct both from the Alpine type and from our specimens. The Russian varieties are, as a whole, of a stouter shape, and their antethecæ are far more regularly folded. So remarkable are these differences that it appears not unjustifiable to refer them to an independent species.

HORIZON AND LOCALITY: This species has been found in North China only in a single locality, Yatzetsi, Shanhsien, Honan. Associated with it there are *Schwagerina (? princeps)*, *Schellwienia longissima* var. *tenuis* and *Schell. anderssoni*. Thus it is evident that the fauna of which it constitutes an important element, is practically identical with that of the Carnic Alps. Without any hesitation, I would therefore assign it, with Schellwien, to the Upper Carboniferous.

Schellwienia oblonga Ozawa

Pl. XVI, Figs. 1-3.

1925. *Schellwienia oblonga* Ozawa, Journ. Coll. Science Tokyo, Vol. XLV, Art, 6, p. 45, Pl. VIII, figs. 7, .9

This is the largest *Schellwienia* ever found in North China. Its full length is estimated at no less than 11 mm and width 5 mm. Seldom, however, does it attain the full size.

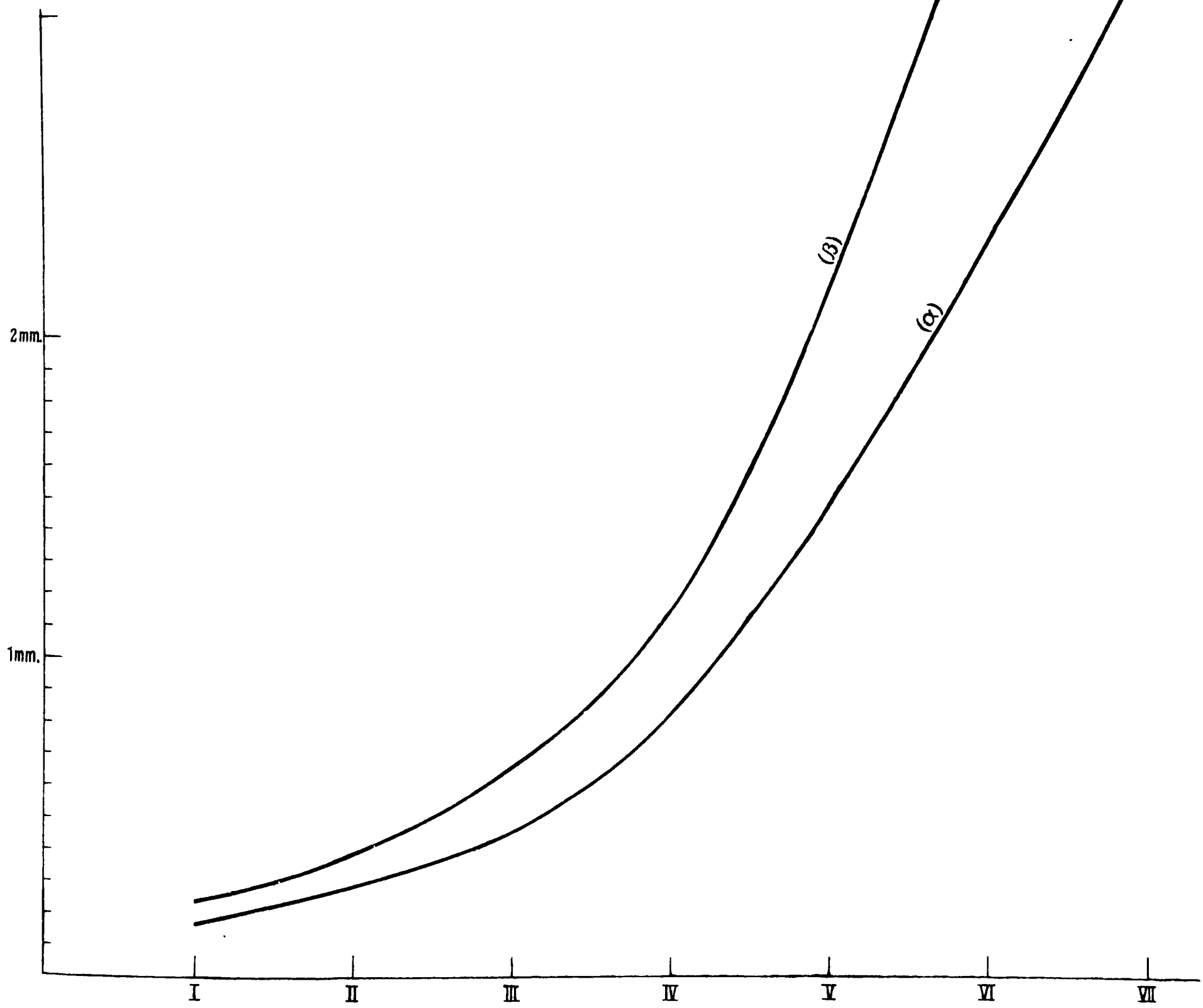

Fig.17

Width-graphs of *Schellwienia oblonga*; (α) a specimen from the Hsinho Limestone, (β) Ozawa's original specimen.

[*To face page 96*]

Test regularly fusiform, highly vaulted in its median portion, tapering rapidly towards the poles which are usually pointed.

In the fully developed individuals there are 9 whorls. These are exceedingly compact from the first to the fourth or fifth volution, then suddenly become much broader. Unfortunately the only axial section which I have obtained is more or less shattered, and therefore admits of no accurate measurement. In one of the median sections the width of the successive whorls measures 0.17, 0.3, 0.44, 0.83, 1.5, 2.33, 2.26 mm from the first to the seventh volution. These figures apparently do not agree with those given by Ozawa, but when they are plotted on a diagram (see Fig. ?) the resulting graphs are essentially of the same type.

The inner whorls are distinctly more elongated than the outer ones. For instance, in the fifth volution the whorl is about 3.16 long and 1.1 mm broad. These give an axial ratio of 1:2.8, while in the fully grown specimens this ratio is only 1:2.2.

Spirotheca relatively thin considering the size of the test. Antethecæ are still thinner. They are rather regularly folded in the inner whorls, but become much more irregular in the outer ones. In one median section I have counted 10 of them in the first volution, 14 in the second, 20 in the third, 25 in the fourth 31 in the fifth, 56 in the sixth. They are as a whole unevenly distributed. It will be noticed that these figures taken in succession are not incomparable with those given by Ozawa.

Initial chamber exceedingly small, spherical, with a diameter varying from 0.09 to 1.11 mm.

A pair of insignificant anuli or pseudo-anuli is developed up to the third or the fourth volution, thence they completely disappear.

Buccal aperture small and narrow in those inner volutions in which anuli are developed. With the disappearance of anuli the aperture also becomes ill-defined or even unobservable.

REMARKS: Although there are several species of *Schellwienia* found in North China that reach the length of the present one, yet, none attains the same width at the same time. From the point of size alone we may compare this species with certain varieties of *Schellwienia japonica*. But the internal structure is thoroughly different. In *japonica* the whorls are more closely and uniformly coiled throughout the successive volutions; initial chamber always much larger; and antethecæ far more regularly folded.

Our species is not only characterized by its shape, so stout and grotesque, but also by its peculiar mode of growth which obviously consists of two stages: In the first,

or the young stage, the whorls are exceedingly compact and the test more or less elongated, whereas in the second, or the adult stage, the whorls are much wider with their antethecæ far more irregularly folded. These features are so striking that they cannot fail to impress the observer with their peculiarity even at a glance. Before Ozawa's paper came into my possession I had founded a new species, *Schellwienia obesa*, for the specimens under consideration. But in looking through Ozawa's microphotographs I had at once recognized this species, and consequently have abandoned my former nomenclature.

HORIZON AND LOCALITY: *Schellwienia oblonga* occurs only sparcely in the Hsinho fauna of Kansu being associated with *Schellwienia complicata*, *Schwagerina fusulinoides* and other Alpine representatives. With these species it may also be safely assigned to the Uralian.

Schellwienia nathorsti Staff et Wedekind

Pl. XVIII, Figs. 14-19, Pl. XIX, Fig. 6

1910. *Schellwienia nathorsti* (Schellwien) Staff-Wedekind, Bull. Geol. Inst. Upsala, Vol. X, No. 19-20, pp. 120-121, Pl. IV, Figs. 1-3.

Test strongly vaulted in the median part tapering at first rapidly then gently towards the umbilical ends which latter are sometimes pointed and sometimes more or less rounded. Between the vaulted median part and each end there often occurs a zone of depression. Size of the test varies over a wide range; one of the slender forms reaches a length of 7.27 mm with a median width of 2.27 mm, while the smallest individual represented in our material is only 4.7 mm long and 1.9 mm broad. The former gives an axial ratio of 1:3.2, and the latter 1:2.5. Again there is a stout variety which has an axial length and median width of 5.3 to 6 mm and 2.3 to 2.7 mm respectively. In these cases the axial ratio only ranges between 1:2.2 and 1:2.3.

Number of whorls usually 6, sometimes 7. The inner whorls are compactly coiled, while the outer ones are relatively broader. Very characteristic is the structure of its spirotheca: In the first two or three volutions the spirotheca is unusually thick and apparently solid showing no trace whatsoever of the alveolar structure. From the third volution a short alveolar osseum begins to make its appearance. The thickness of the osseum increases steadily as the spiral grows, accompanied at the same time by the reduction of the thickness of the tectum. In the third and sometimes the fourth volution these two layers are almost equally thick in the region of the buccal aperture, but the tectum thins down towards the umbilical ends. From the fifth volution onward the tectum becomes very thin, and alveolar osseum distinctly coarser as in the common type of *Schellwienia*.

Antethecæ relatively thick, always crowded, folded rather intensely and more or less irregularly, particularly so in the umbilical regions. Even in the neighbourhood of the buccal aperture the folding seems to affect the entire height of the antethecæ.

Anuli very prominent in the inner whorls. They often appear to be replaced by pseudo-anuli in the outer whorls. In any case, they form a striking feature in this species.

Buccal aperture extremely narrow and minute in the inner volutions, becoming, as a rule, broader and rectangular in cross-section from the fourth volution onward.

Initial chamber thick-walled, usually spherical, rarely deformed probably through an accidental cause. Its diameter ranges from 0.13 to 0.16 mm.

Results of measurement:

(Those marked with * possibly belong to var. *laxa*, † measured from the microphotographs given by Staff).

	Initial chamber	Volution							Specimen
		I	II	III	IV	V	VI	VII	
Width in mm	.156	.28	.456	.74	.99	1.39	1.83?		(1925)
	.13	.267	.42	.67	.92	1.3	1.91		(1878)
	.15	.24	.39	.58	.98	1.47			(1272)
	.15	.267	.456	.78	1.19	1.67			(1271)
	.144	.25	.44	.69	1.02	1.52			(1273)
	.167	.31	.49	.73	1.12	1.71	2.33		(2212)*
	.13	.256	.41	.656	.93	1.31	1.78	2.44	(1883)
	.14	.24	.41	.62	.91	1.38	1.88	2.42	(1884)
		.267	.44	.69	.96	1.33			(1956)*
	.155	.29	.52	.84	1.07	1.72	2.5		(1874)
	.14	.22	.356	.56	.8	1.23	1.7	2.28	(1877)
	.17	.31	.49	.72	1.11	1.61	1.61		(1882)
	.2	.45	.72	1.1	1.62	2.4			Bear Island†
	.3	.3	.54	.8	1.25	1.65			,, †
Axial ratio			1.7	1.8	2.2	3.2			(1925)
				1.7	1.8	2.2	2.5		(1878)
			2.3	2.7	2.7	3.3			(1271)
			1.9	1.7	2.0	2.0	2.2		(1874)
			1.9	1.9	1.9	2.1	2.2	2.3	(1877)
No. of Antethecæ		13	17	25	32	32			(1273)
		11	23	28	35	38	44		(2212)*
		11	21	28	30	36	44	44	(1883)
		11	19	25	29	37	44		(1885)
		12	19	25	34	38	42	43	(1884)
		19	32	35	46				Bear Island
		15	26	34	44				,,
Thickness of Spirotheca in mm		.044	.056	.05	.056	.06	.07		(2212)
		.02	.04	.044	.056	.056	.056	.056	(1883)
		.04	.044	.05	.044	.044	.044	.056	(1884)

REMARK: Of all the *Fusulinæ* so far described by different authors there is only one species, *Fusulina nathorsti*, comparable with the species under consideration, and they may be compared in several respects: for instance, they are both characterized by a peculiarly sharp vaulting in the median region followed by a zone of depression in the lateral parts; by an unusually thick spirotheca in the inner volutions; by a pair of prominent anuli or pseudo-anuli and exceedingly small buccal aperture in the earlier whorls; and by crowded antethecæ. Even the widths of the successive volutions almost completely agree in some cases. The numbers of antethecæ are also of the same order if we take into account the possibility of accelerated development on the part of the Arctic forms.

The apparent difference between *nathorsti* of the Bear Island and our specimens may be noticed in the fact that the former is seemingly less elongated, and that it has a larger initial chamber consequently fewer whorls. Regarding the shape of the test we must note that Staff's only longitudinal section is not axial but distinctly oblique. In a form like the present species which tapers so rapidly towards the poles, a small degree of obliquity would naturally make a great difference to the length of the section. If Staff's longitudinal section were strictly axial, the length would be undoubtedly much greater. Even we assume that the apparent size (4.5 : 2.5 mm) of Staff's prepared specimen does not differ appreciably from the real one, it is not incomparable with some of our stouter varieties whose axial length and median width are 6 mm and 2.7 mm respectively.

Regarding the average size of the initial chamber, the difference is certainly noteworthy. But the type of coiling of the succeeding whorls together with other peculiar features points irresistably to the conclusion that the Arctic forms described by Staff and Wedekind represent the macrospheric and our material the microspheric type of one and the same species, though it is admittedly a strange fact that among the numerous specimens from different parts of North China there is not a single individual possessing so large an initial chamber as that of the average Arctic form.

If, in future, more exhaustive search disproves them to be the macrospheric and microspheric types of the same species, I would still hold that the difference between them amounts no more than a varietal value. Indeed it is already possible to distinguish several varieties among our material. For instance, those which occur in the Hsinan district are generally characterized by smaller size and greater axial elongation; and among the typical forms that occur in the Pinting Basin, N. E. Shansi, there are short and highly inflated ones. It is on account of their intimate association and the presence of numerous transitional types that it is considered useless at present to establish more varieties than is absolutely necessary.

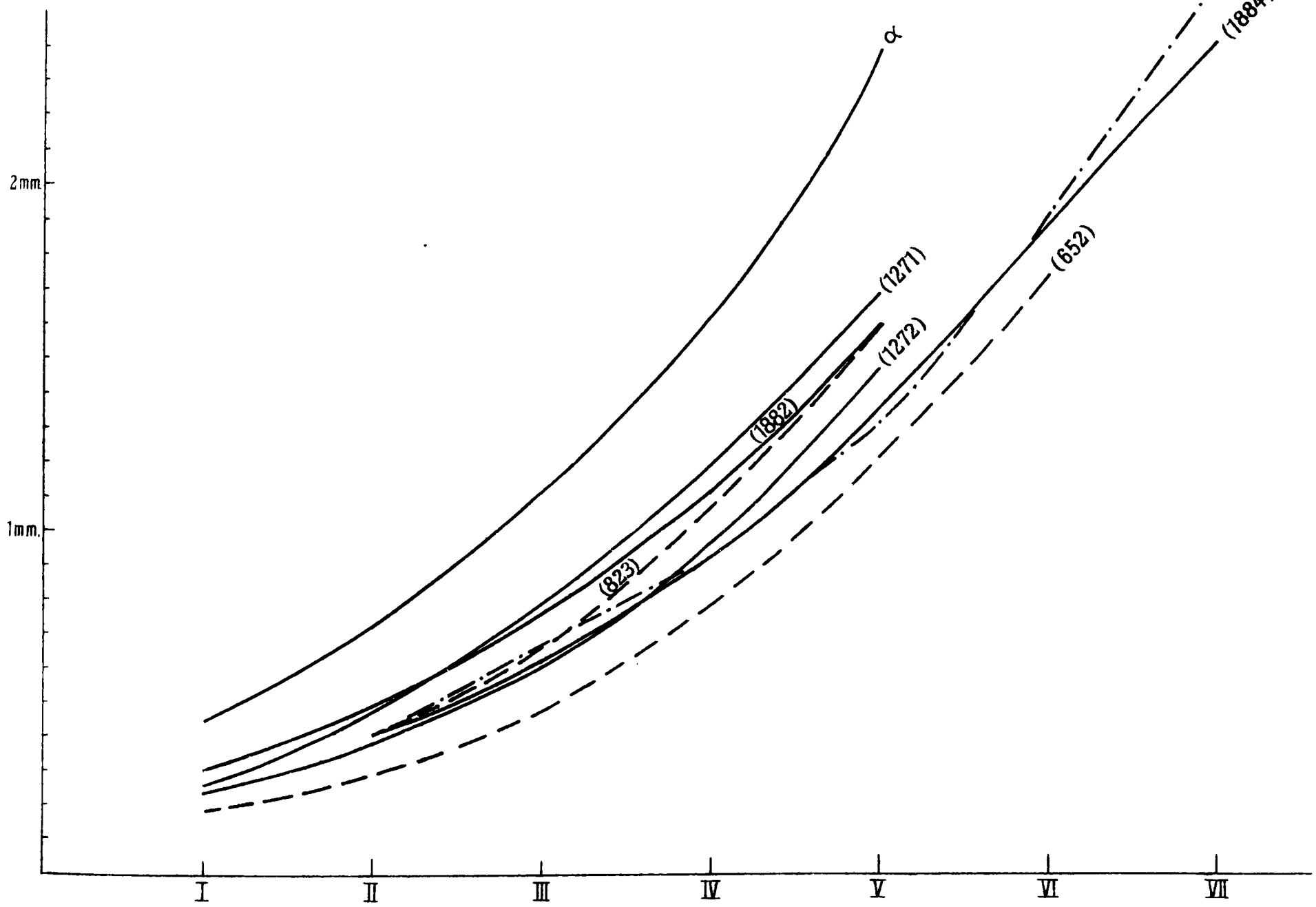

Fig.18

Width-graphs of *Schellwienia nathorsti* and its related species. (1271, 1272, 1882, 1884, α) *Schellwienia nathorsti*; (652, 823) *Schell. subnathorsti*; (2216) *Schell. nathorsti* var. *laxa*; α a macrospheric specimen from the Bear Island.

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with *Schellwienia acuta* the present species suggests some remote affinity by the general shape of the whorls, the nature of the spirotheca and the form of the anuli and buccal aperture. The former, however, is generally of a smaller size, more compactly coiled, and its antethecæ are folded in a different type.

The present species has undoubtedly arisen from its closely associated species, *Schellwienia subnathorsti*, on the one hand, and gave rise to its var. *laxa* on the other.

HORIZON AND LOCALITY: This species is widely distributed in the central part of North China. It occurs in association with *Schellwienia erucaria*, *Schell. pailensis* in the Hsinan district, and abounds in the Suchieh and Kushi Limestones of the Pinting Basin and in the Miaokou Limestone of Central Shansi. In the Chienshi Limestone, namely the fourth layer of Fusulina Limestone above the main coal-seam in the Pinting Basin, scattered individuals of this species appear to occur. But it is not altogether certain whether they are representatives of *Schell. nathorsti* var. *laxa* of immature growth.

Everywhere this species seems to range in the middle part of the series of the "Fusulina Limestones". It undoubtedly represents the Uralian age, probably the middle part of that epoch.

Schellwienia nathorsti var. **laxa** (var. nov.)

Pl. XIX, Figs. 1-5, 7-10

This variety differs from the type-species only in having a larger size (8:2.24 mm) more volutions—usually 7 instead of 6, greater axial elongation, broader coiling of the last two whorls and subcylindrical shape. The structure of its inner whorls perfectly agrees with that of *Schellwienia nathorsti* s. str. It occurs sparcely in the Suchieh Limestone of the Pinting Basin, but abounds in the Chienshi Limestone of the same district. It is also found in the second seam of limestone (counting from below) exposed in Yuehmenkou, west of Taiyuan. The following measurements will show how closely is this variety connected with its type-species:—

	Initial Chamber	Volution							Specimen
		I	II	III	IV	V	VI	VII	
Width in mm	.14	.256	.44	.71	1.04	1.34	1.71	2.24	(1870)
	.13	.23	.37	.6	.86	1.29	1.75		(1960)
	.167	.31	.48	.72	1.05	1.49	2.0		(1962)
	.167	.256	.42	.67	.956	1.37	1.9		(1961)
	.18	.29	.49	.71	1.07	1.5	2.1		(1963)
	.127	.24	.4	.67	.93	1.32	1.92	2.59	(2216)
	.12	.22	.32	.567	.856	1.28	1.93	2.58	(1957)
Axial ratio			1.8	1.8	2.1	3.1	3.3	3.6	(1870)
			1.5	2	2.4	3	3.3		(1960)
				2	2.5	3.2	3.8		(1962)
			1.9	1.9	2.3	2.8			(1961)
Thickness of spirotheca in mm		.033	.033	.05	.067	.04	.044	.056	(2216)
		.03	.03	.044	.044	.04	.05	.056	(1952)

No. of Antethecæ		9	20	27	31	42	44		(2216)
		11	22	28	33	38	46	48	(1871)
			21	29	29	45	49	58	(1957)

Schellwienia subnathorsti Lee (sp. nov.)

Pl. XVIII, Figs. 1-10, 11?

Test rather small, highly vaulted in the median part, tapering rapidly towards the poles. The axial section is almost rhomboid in outline. Sometimes the flanks are slightly depressed as in *Schellwienia nathorsti*. The axial length and median width vary from 4 to 5 mm and 1.85 to 2.1 mm respectively, 4.4 mm: 1.9 mm being the commonest size. Axial ratio of the complete test ranges from 1:2.1 to 1:2.4.

Number of whorls 5 to 6. Inner whorls are rather compactly coiled, from the fourth volution onward the whorls become more broadly wound.

Spirotheca relatively thick in the inner whorls with but a slow increase in thickness towards the outermost one. At any given stage of the spiral growth, the spirotheca is always appreciably thinner in the umbilical region, thickening steadily towards the median part. In the inner whorls it is apparently solid without any visible trace of alveolar structure even in the thinnest section of exceedingly well preserved specimens. A thin layer of distinctly alveolar osseum however begins to appear in the third volution, being no thicker than the tectum in the median region. Thence the tectum becomes thinner, and at the same time the osseum becomes thicker and coarser. In these respects the present species completely agrees with *Schellwienia nathorsti*.

Antethecæ relatively thick and fairly numerous. They are folded throughout their entire length and almost entire height. Even in the median region folds are not absent, though not so compressed and irregular as in the umbilical parts.

Highly characteristic of this species is the fact that the axial ratio for the successive volutions reaches a minimum in the third or the fourth whorls, and this minimum value varies between 1:1.5 and 1:1.8.

Buccal aperture very narrow and rather low at first, becoming broader and higher but ill-defined as the spiral grows. In the fourth and fifth volutions it occupies about $\frac{1}{10}$ of the length of the preceding whorl.

Pseudo-anuli always prominent in the inner volutions, but become less significant and sometimes even disappear in the outer ones.

Initial chamber small, thick-walled, usually spherical with a diameter varying from 0.1 to 0.16 mm.

Result of measurements:

(Those marked with * may be young forms of *Schell. nathorsti*).

	Initial chamber	Volution						Specimen
		I	II	III	IV	V	VI	
Width in mm	.1	.22	.41	.64	1.07	1.6		(823)
	.144	.28	.47	.73	1.09			(819)
	.13	.27	.42	.68	1.01	1.53		(1887)
	.11	.19	.3	.47	.78	1.22	1.74	(652)
	.156	.28	.44	.7	1.02			(817)
	.156	.3	.49	.76	1.11	1.67		(1888)
	.11	.22	.38	.61	.92			(818)
	.1	.18	.29	.47	.73	1.02		(1275)*
	.144	.23	.39	.61	1.00	1.48		(1274)*
Axial ratio		1.6	1.7	1.9	1.77	1.9		(823)
		1.8	1.7	1.5	1.7			(819)
			1.8	1.6	1.8	2.4		(1887)
			2.4	2.4	2.1	2.2	2.4	(652)
			2.15	2.3	3	3.08		(7275)*
			1.8	1.74	1.8			(817)
			1.9	1.8	1.8			(818)
Thickness of spirotheca in mm		.022	.05	.06	.06	.066	.078	(823)
		.03	.033	.04	.044	.05		(1274)*
		.022	.03	.04	.044	.06	.097	(653)
No. of antethecæ		10	19	23	27	34		(827)
		11	19	25	29	35		(828)
		10	21	23	28	38		(821)
		11	22	28	40			(820)
		10	18	23	27	33	34	(653)
		10	19	24	27	36		(824)
		11	18	25	29	32		(1274)*

REMARKS: The general appearance of the sections of the present species and the measurements tabulated above show conclusively that we are dealing here with a form closely related to *Schellwienia nathorsti*. In fact the present species not only occurs side by side with *nathorsti*, but is linked to it by numerous intermediate forms. So close is the relationship that when the varying series is arranged in the proper order, it does not seem unjustifiable to regard the form under consideration as a variety of *nathorsti*. Nevertheless, the majority of them adhere to a definite type being characterized by a set

of peculiar features of their own, such as smaller size, lower axial ratio, rhomboid shape etc. For this reason, I have referred it to an independent species under the name *subnathorsti* from which *nathorsti* had undoubtedly sprung.

Of those which I have made detailed measurements, the several features are not alway true to the typical form. Those from the Hsinan district, Honan, for instance, are distinctly more elongated, and the axial ratios vary in an ascending order without reaching any minimum value. They may be young representatives of *nathorsti*. Again, the only axial section of an individual from the Shanching Limestone of the Shimiao district, S. Chihli, shows a much more regular type of antethecal folds, and closer winding of the inner whorls. It probably belongs to a different variety. But without more material, it cannot as yet be ascertained whether it represents a type. It appears undesirable to establish a variety on account of a single specimen, however such a proposition may appear highly suggestive.

HORIZON AND LOCALITY: This species abounds in the Hsiaoching Limestone of S. Chihli and N. Honan, Suchieh Limestone of N. E. Shansi, and probably also occurs in the Shanching Limestone of the Shimiao district as well as in the Hsinan district, N. Honan. Both in Shansi and Honan it associates with *Schellwienia nathorsti*. The latter species however rises to a higher horizon. In future, a more exhaustive survey may prove this species to be an excellent zoning fossil for the Taiyuan Series as developed in the central part of North China. The fact that its progeny, *Schellwienia nathorsti*, was found in the Bear Island suggests an even higher stratigraphical value.

Schellwienia pusilla (Schellwien)

Pl. XVI, Figs. 4-11

1898. *Fusulina pusilla* Schellwien, Palæontographica, Vol. XLIV, pp. 253-255, Pl. XX, figs. 8-14.

Test cylindrical, or forms a highly elongated ellipsoid. The median portion is in the usual case quite straight, but sometimes gently and broadly depressed. The terminal parts are generally of a hemi-ellipsoidal shape; occasionally, they tend to become somewhat pointed towards the umbilical ends, then they conform more closely with a paraboloid. Length of the complete test varies from 4.4 to 6.7 mm and width from 1.2 to 1.7 mm. The axial ratio ranges between 1:3.3 and 1:4. In one extreme case, the length and width are 7.78 mm and 1.67 mm respectively. These give an axial ratio of about 1:4.7.

Number of whorls usually 5 to 6, sometimes $6\frac{1}{2}$; whorls exceedingly compact throughout.

Antethecæ very thin, widely spaced, particularly so in the outer volutions. Very remarkable is the fact that the antethecæ are all regularly folded even in the terminal parts. The individual folds are rather widely spaced. In the inner volutions the folds reach more than two thirds of the height of the respective chamber. In the outer volutions, however, only the lower rim of the antethecæ are plicated, the upper part—the greater part—being quite straight.

Spirotheca fairly thin in the first three volutions, thence it thickens rapidly. This increase of the thickness of the spirotheca is accompanied by the development of a distinctly coarser osseum and widening of the whorls.

Buccal aperture moderately broad, always low, reaching at most, a little more than one third of the height of the chamber, and one tenth the width of the preceding whorl. Form of the aperture is exceedingly regular, having invariably a flat, bow-shaped cross-section, and its position is always strictly median.

Anuli highly distinct, though not very massive in the specimens from Paoteh, less sharply developed in those from the Hsinan district. They can nevertheless be traced in the inner volutions.

Initial chamber rather small, sometimes spherical and sometimes ellipsoidal. In the latter case, the major axis points towards the poles. Although the diameter of the initial chamber varies from 0.09 to 0.144 mm in the numerous specimens we have obtained, there is no clear evidence to show that they may be attributed severally to the microspheric and macrospheric generations.

Result of measurements:

	Initial chamber	Volution						Specimen
		I	II	III	IV	V	VI	
Width in mm	.12	.18	.3	.49	.72	1.01	1.33	(2854)
	.144	.27	.49	.78	1.11			(2852)
	.09	.144	.23	.78	.65	.98	1.36	(2853)
	.144	.21	.32	.52	.84	1.21		(2855)
	.11	.14	.22	.38	.63	.98		(1257)
	.13	.255	.42	.655	1.0	1.33	1.69	(1269)
	.1	.18	.26	.41	.69	1.0		(1261)
	.13	.21	.32	.52	.8			(1262)
	.11	.22	.32	.48	.73	1.0		(1265)
	.17	.3	.5	.75	1.08	1.42		(1264)
	.18—.2	.35	.54	.81	1.12	1.49		Schellwien's

Axial ratio		3	3.3	3.3	3.4	3.3	(2854)
		2.2	3.3				(2852)
		3	3.4	3.7			(1262)
		2.5	4	4	4.3		(1257)
	2.2	2.5	3	2.8	3.5		(1269)
Thickness of spirotheca		.01	.02	.026	.044	.6	(2857)
			.028	.04	.056	.056	(1269)*
				.04	.06		Schellwien's
No. of antethecæ	11	15	16	19	19		(2853)
		15	17	20	21	23	Schellwien's

*A transitional form between *Schellwienia pusilla* and *Schell. pailensis*.

REMARKS: From the results of extensive measurements as tabulated above, and from Schellwien's careful description, no doubt can possibly exist as to the specific identity of our form with *Fusulina pusilla* Schellwien of the Carnic Alps. It is true that most of our specimens have a smaller initial chamber, consequently the earlier volutions are comparatively narrower. But individual cases are known in the Hsinan fauna, which possess initial chambers nearly equal to that of Schellwien's typical specimen. Numbers of antethecæ in the several volutions of the Alpine and Hsinan specimens are also in striking agreement.

A difficult problem however arises from the close affinity of the present species with the Salt Range forms, namely *Schellwienia kattaensis* and *Schell. pailensis* Schwager. Both of these Indian species and the present one are characterized by highly compressed type of coiling, enormous axial elongation and extremely regular folding in the lowest part of the antethecæ. These Indian species also occur in the Hsinan fauna together with innumerable intermediate forms between them and the species under consideration. There seems little doubt that the latter is the forerunner of the former. Our problem is thus rendered still more difficult.

The only distinction is found in the fact that the Indian species are, as a whole, more extensively stretched, particularly so in the outer volutions; and attain a larger size. Their outer whorls are slightly broader. Only by means of graphs these differences can be detected. A glance at Figure 19 will show that the lower group of curves represents *Schellwienia pusilla*, while the higher ones characterize the Indian species, namely *Schellwienia pailensis* and *Schell. erucaria*. Nevertheless, we must admit that the specific boundary, so to speak, is still an arbitrary one. It is only in the extreme types that the differences become distinct.

HORIZON AND LOCALITY: *Schellwienia pusilla* is abundantly found in the Hsinan district, N. Honan, and in the upper layer of "Fusulina Limestone" of Paoteh, Shansi. In the former case it is associated with *Schell. pailensis* and *Schell. erucaria*. Both of these species are characteristic of the upper part of the Lower Productus Limestone of the Salt Range. In the latter case it occurs alone. Somewhat disconcerting is the fact that in the Alpine region it associates with *Schwagerina fusulinoides* which is the dominant form in the Hsinho fauna in which no trace of this species has yet been detected. From the available data we cannot state beyond the fact that this species belongs to a certain stage of the Uralian.

Schellwienia pailensis (Schwager)

Pl. XVI, Figs. 12, 13; Pl. XVII, Figs. 1-3

1887. *Fusulina pailensis* Schwager, Salt Range Fossils (Productus-Limestone Fossils), Palæontologia Indica, Ser. XIII, p. 987, Pl. CXXVII, figs. 1-7.

Test highly elongated, very broadly and gently vaulted in the median part which slowly tapers towards the paraboloid ends. Now and then the whole body of the test is recurved towards one side, and the points of inflexion often occur at some distance from the median position. Axial length and median width usually about 8.2 mm : 1.8 mm, axial ratio 1:4.6. Among our unprepared material there are individuals which reach even a greater length.

Whorls usually 6, sometimes 7. They are exceedingly compact in the inner volutions, relatively broader in the last two. Spirotheca fairly thin in the inner whorls, but becomes rather thick in the outer ones. Osseum finely alveolar.

Antethecæ very regularly and evenly folded even in the terminal regions. In the inner volutions the folding affects nearly two thirds of their height, but in the outer ones only the lowest rim of the antethecæ is alternately up-turned. The truncated folds therefore appear as a regular series of extremely low arcs in the axial section. In the median region even such diminutive plication often altogether disappears.

Anuli unobservable, they are probably absent.

Buccal aperture relatively narrow, but fairly high. It occupies about $\frac{1}{10}$ of the length of the respective whorl and more than half the height of the respective chamber in the inner whorls, and less than half the height of the chambers in the outer ones.

Initial chamber small, usually spherical, sometimes more or less deformed, having a diameter varying from 0.11 to 0.17 mm.

Result of measurements:

	Initial chamber	Volution						Specimen
		I	II	III	IV	V	VI	
Width in mm	.14	.23	.4	.62	.956	1.37	1.83	(1270)
	.11	.21	.34	.56	.8	1.16	1.67	(1258)
	.17	.29	.42	.71	1.08	1.5		(1268)
Axial ratio		2.4	3	3.2	4.6	4.7	4.5	(1270)
		2.5	3.2	3.9	4.8	4.6		(1268)
Thickness of spirotheca in mm			.02	.022	.033	.056	.06	(1270)

REMARKS: Although none of our specimens of this species reaches such a length as mentioned by Schwager (13 mm), the general shape of the test, the type of coiling and the small initial chamber make it quite certain that we are dealing here with a form practically identical with Schwager's species, *pailensis*, from the Salt Range. In this connection it seems necessary to consider Schwager's guarded remarks that "the species *(pailensis)* cannot as yet be considered as fully established as long as the geological relations to *Fusulina kattaensis* on the one hand and *Fusulina longissima (erucaria)* on the other are not quite distinctly made out". The Hsinan fauna supplies us with some data which seem to throw some light on Schwager's long-stood problem. In the material collected by Dr. J. G. Andersson from the Hsinan district, we find that the species under consideration occurs side by side with *Schellwienia erucaria (= longissima* Schwager*)* as is also the case in the Pail district. Their intimate association in these distantly separated localities and their close resemblance in form and size would seem to suggest that these forms might be, after all, but the macrospheric and microspheric types of one and the same species. One further wonders whether the distinction between *kattaensis* and *pailensis* is really so sharp and definite as is maintained by Schwager. I should not be surprised if the Indian material will ultimately show that the three species described by Schwager belong, in reality, to a single species, though they may cover a considerable vertical range. Before the final settlement of this problem, it appears, however, safer to follow Schwager's original determination.

There is no question that the species under consideration is intimately related to *Schellwienia pusilla*. In fact the two are only separable through the comparison between their size, axial elongation and the type of coiling of the outer whorls. The present

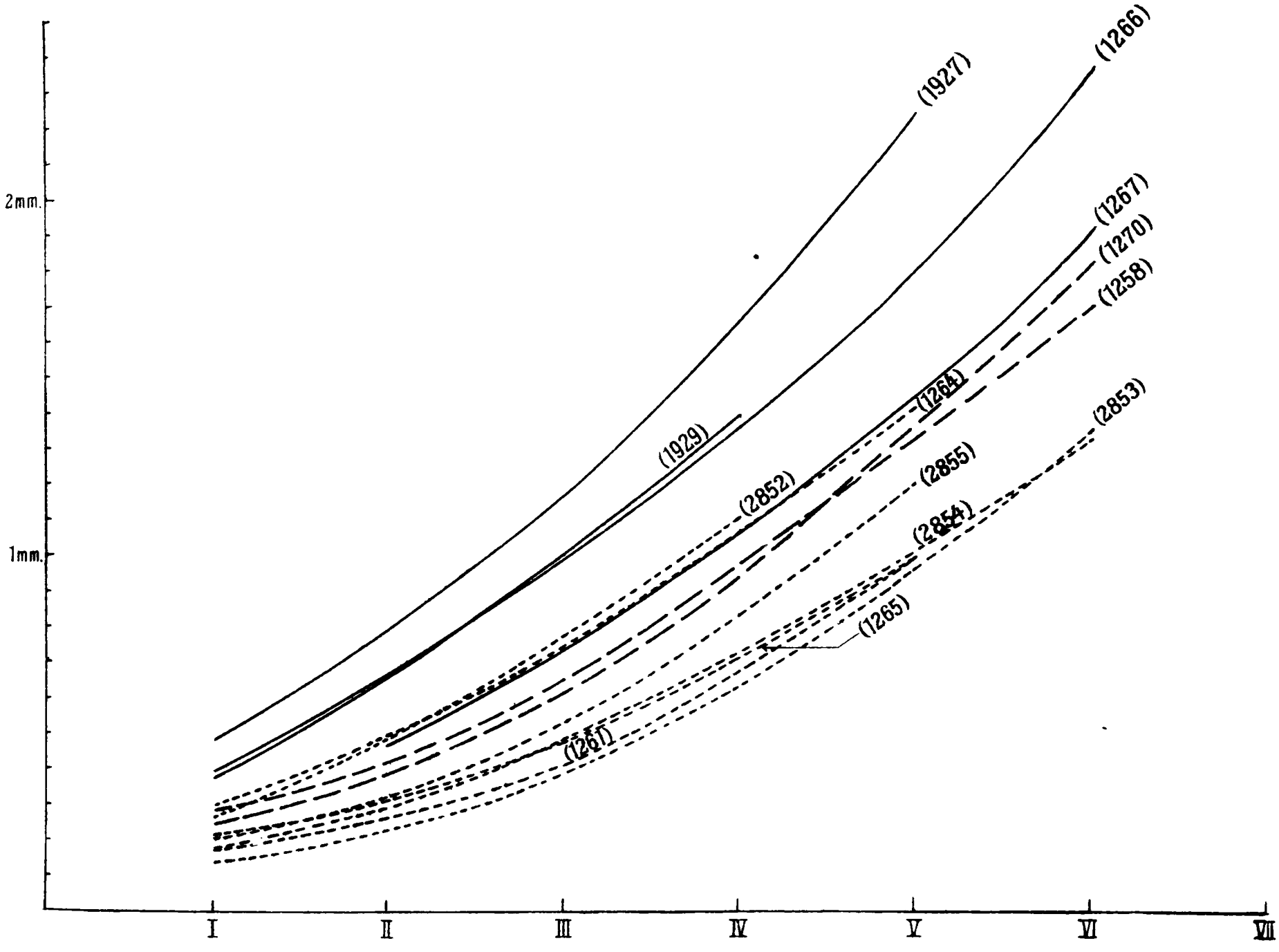

Fig. 19

Width-graphs of *Schellwienia erucaria* (1266, 1267, 1927, 1929), *Schell. pailensis* (1258, 1270) and *Schell. pusilla* (2852, 1264, 2855, 2854, 2853, 1261, 1265).

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species is, as a whole, larger, more extensively elongated and slightly broader in the last one or two volutions. For instance, in the fourth whorl the axial ratio for *pusilla* ranges between 1:3 to 1:4, while for *pailensis* it is over 1:4.6.

In a preliminary examination I have compared certain representatives of this species with *Schellwienia verneuili* var. *sapperi* of North America. The two are certainly alike as regards their general shape, type of coiling, type of folding of the antethecæ etc. More material has however convinced me that there is none in the Hsinho fauna that reaches such an enormous size as that of the American form. Moreover, there are no other American forms found in association. On the other hand, we have splendid examples showing all the peculiarities of the Indian species. If it had any connection with the American fauna, the relationship must be rather remote.

HORIZON AND LOCALITY: This species is crowded in the only layer of "Fusulina Limestone" of the Hsinan district, N. Honan. Whether it also occurs in the Paoteh district, Shansi, is yet uncertain. The limestone carrying this species is undoubtedly equivalent to the Lower Productus Limestone of the Salt Range.

Schellwienia erucaria (Schwager)

Pl. XVII, Figs. 4-8

1887. ***Fusulina longissima*** Schwager, Salt Range Fossils (Productus Limestone Fossils), Palæontologia Indica, Ser. XIII, P. 988, Pl. CXXVII, figs. 7-12, Pl. CXXVIII, figs. 1-3.

Test almost cylindrical, sometimes variously recurved, enormously elongated as in *Schellwienia pailensis* but to a still greater extent; median portion sometimes slightly inflated, more often straight with but a very gentle taper towards the umbilical ends which are, as a rule, blunt or more or less paraboloid. The lateral extension is more striking in the outer volutions than in the inner ones. The largest individual among our material is measured 11.3 mm long and 2.24 mm broad. The average specimen is not much under this dimension.

Number of whorls from 5 to 6. They are exceedingly compact except for the outermost volution. Thickness of spirotheca increases steadily from the first to the last but one whorl. Thus, in a typical specimen it measures 0.023, 0.033, 0.056, 0.07, 0.06 mm from the first to the fifth volution.

Antethecæ evenly folded throughout. In the inner volutions the folding is more intense, affecting more than two thirds of their height, and in the outer volutions only the lowest part of them is plicated. Even in the terminal regions the entangling folds so often present in many other elongated species, are not observed here.

Number of antethecæ from the first to the fifth volution are 11, 25, 28, 35, 42. These appear to represent a typical case.

Anuli unobservable.

Buccal aperture very narrow, considering the axial length of the whorls. It occupies from $\frac{1}{14}$ to $\frac{1}{17}$ of the length of the respective whorl; the height of the aperture usually reaches more than $\frac{2}{3}$ of the height of the respective chamber.

Initial chamber perfectly spherical, usually rather large with a diameter varying from 0.25 to 0.28 mm, sometimes only 0.14 mm.

Width of the successive whorls (in mm) and their axial ratios are as follows:—

	I	II	III	IV	V	VI	Specimen
Width	.48	.79	1.16	1.67	2.24		(1927)
	.39	.68	1.13	1.67	2.24		(1928)
	.38	.66	1.0	1.39			(1929)
	.4	.68	.99	1.37	1.8	2.4	(1266)
	.28	.47	.73	1.06	1.44	1.93	(1267)
Axial ratio			3.8	4.3	5.4	5.2	(1267)
			4	4.5	5		(1927)

Remarks: Because of its gross elongation, Schwager guardedly identified this species with *Schellwienia longissima* Möller. But apart from the external shape there is nothing whatsoever to justify this identification. In *Schell. longissima* the spirotheca is much thinner, the antethecæ much more intensely folded, and the initial chamber generally larger and irregular in shape. To quote Schwager's own words: "The various curving of the shell, a character peculiar to the Indian specimen, gives to these bodies somewhat the appearance of a caterpillar, and if in time, perhaps, a specific distinction of the Indian form should be necessary, the name of *Fusulina erucaria* would be a very appropriate one". And he continues to write: "By far more difficult is the distinction of the not yet full-grown specimens, as a considerable portion of these approaches *Fusulina pailensis* rather nearly". All these remarks are borne out by our material. I have therefore adopted, with Schwager, the name, *erucaria*, instead of *longissima* which latter must in all cases be abandoned. His second remark touches upon the possibility of its being a macrospheric type of *Schellwienia pailensis*. As the fact of dimorphism of fusulinoid Foraminifera was not definitely known in Schwager's time, it is readily understandable that this eminent palæontologist attached much importance to the size of the initial chamber. Therefore he concluded in saying "this latter organ

(inital chamber) is always considerably larger in *Fusulina longissima* (*erucaria*) than it is in *Fus. pailensis*, and thus there is no difficulty in distinguishing them".

While every thing is in favour of the theory that *Schellwienia erucaria* and *Schell. pailensis* are the macrospheric and microspheric types of one and the same species, I have refrained from uniting them at present because I have not yet had the opportunity of examining the Indian materials. Moreover in the Kushi Limestone of the Pinting Basin I have so far only found, after a fairly exhaustive search, the species under consideration but no trace of *pailensis*. Thus it appears still premature to consider them as a single species.

HORIZON AND LOCALITY: In the Hsinan fauna of N. Honan, this species is a common element, though perhaps not so dominant as its associated species such as *Schellwienia pailensis* and *Schell. pusilla*. Further north, in the Kushi Limestone of the Pinting Basin, isolated occurrences of this species are again recorded. As our specimens are unmistakably identical with the peculiar Salt Range form, there cannot be any doubt of its containing rock being equivalent to the Lower Productus-Limestone of India.

Schellwienia longissima (Möller)

Pl. XIX, Figs. 11-14; Pl. XX, Figs. 1-14

1877. *Fusulina longissima* Möller, Die spiral-gewundenen Foraminiferen des russischen Kohlenkalks, pp. 59-61, Pl. I, fig. 4, Pl. II, figs. 1 a-c, and Pl. VII, figs. 1 a-c.

1908. *Fusulina longissima* Schellwien, Monographie der Fusulinen, Palæontographica, Vol. LV, pp. 163-165, Pl. XIII, figs. 14-20.

1924. *Fusulina tenuissima* Colani, Nouvelle Contribution à l'Etude des Fusulinidés etc., Mém. Serv. Géol. Indochine, Vol. XI, Fasc. I, p. 136, Pl. VI, figs. 1-6, and figs. 13-14.

Form of the test generally cylindrical to sub-cylindrical, but individual cases vary over a wide range. In some varieties the test is relatively short and stumpy with rounded ends, and in others it is grotesquely elongated with its ends more or less pointed. Again there are those which show a distinct contraction instead of vaulting in the median part in contrast to the usual form of other species of *Schellwienia*, and also those which are broad and recurved to some extent in the median part rendering the test more or less reniform.

The largest specimens in our collection are 10 mm long and 2 mm wide. That is, they are 1 mm shorter than the longest one observed by Möller, and 2 mm longer than the maximum length mentioned by Schellwien. The average size is, however, much smaller, being 5 to 6 mm long and 1.3 to 1.8 mm broad.

Spirotheca exceedingly thin, measuring about 0.023 mm in the first volution, and gradually increasing to about 0.038 mm in the last. Only in rare cases does it ever reach 0.05 mm in the thickest part.

Osseum distinctly, though rather finely, alveolar, often indistinguishable in the inner volutions.

Number of whorls usually 5 sometimes 6 rarely $6\frac{1}{2}$.

Whorls moderately compact throughout. In some forms the spirotheca evolves with such a slow rate that the heights of the chamber in the successive volutions vary very little from the second volution onward. In others, they show a little more marked increase. From a large number of thin sections, I have selected a relatively few for measuring the widths of their successive volutions. The results of measurement are tabulated below:—

Dia. of initial chamber in mm	Width of successive volutions						Specimen
	I	II	III	VI	V	VI	
0.3	0.355	0.51	0.79	1.05	1.35		(3702)
0.24	0.44	0.68	0.99	1.33	1.66		(3706)
0.29	0.4	0.53	0.76	1.01			(3723)
0.266	0.37	0.566	0.866	1.22	1.6	2.0	(3712)
0.28	0.41	0.60	0.80	1.14	1.50		(3711)
0.34	0.455	0.63	0.966	1.30			(714)
0.22	0.355	0.6	0.855				(715)
0.22	0.32	0.54	0.77				(971)
0.3	0.58	0.82	1.13	1.5			(505)
0.59	0.72	0.92	1.24	1.53	1.93		(717)
0.23	0.355	0.58	0.866				(720)
0.20	0.367	0.54	0.74	1.0			(455)

It may be observed in these figures that the widths of the successive volutions of different individuals are always of the same order, and arrange themselves in a definite succession, though the real value for a particular volution in one individual may not correspond to that of the same volution in another, but may be "accelerated" or "retarded" or even altogether suppressed. As a rule, the first one or two volutions of the normal type are lost in those provided with an extraordinarily large initial chamber.

Antethecæ nearly as thin as the spirotheca. They are intensely and regularly folded even in the median region. The folds reach more than $\frac{2}{3}$ of the height of chamber, and generally of the shape of an inverted U as seen in the axial or para-axial sections.

Number of antethecæ for each volution variable to some extent from individual to individual as shown in the following table:—

Volution						Specimen
I	II	III	IV	V	VI	
11	27	33	32	31 (partially preserved)		(969)
10	27	32	36	38		(3706)
11	21	30	37			(3707)
11	26	32				(970)
10	22	28	31	38		(3713)

Judging from the numbers in the second volution, these specimens seem to fall into two groups: The one possesses 26 to 27 antethecæ in the second volution, and the other 21 to 22. No further regularity is to be observed. These figures also fail to agree with those given by Möller, which are 12, 24, 27 for I, II, III volutions respectively.

The fluctuation of the number of antethecæ may be partly interpreted as a necessary consequence of the fragile nature of the test. For, evidence is not lacking that the test of the present species is often liable to damage, and whenever the test suffers some damage the animal is compelled to go through the complicated process of shell-repair. As a result, the antethecæ tend to crowd in one part, and set distantly apart in another.

A feature of some specific importance regarding the internal structure of this species is the low and broad chamber which is set almost flatly against the initial chamber on the one hand, and marks the beginning of the spiral chambers on the other.

Buccal aperture low, generally less than half the height of the chamber, narrow in the inner volutions, but becomes broader towards the last stage of growth. No trace of anuli has been detected in any of the whorls.

Initial chamber fairly large as may be seen in the foregoing table, sometimes spheroidal, but more often elongated or irregular in shape. When elongated, the direction of elongation generally follows the axis of convolution. Occasionally two initial chambers arrange themselves side by side in one and the same individual.

A thick mass of calcareous matter is always deposited at both ends and along the axis of each volution. In the axial section, this deposit often appears as two lobes

spreading from both ends of the first whorl and terminating in a more or less elliptical shape as the final stage of growth is approached. Sometimes faint, lighter lines are observable interweaving in the black mass. They obviously indicate the intricate folding of the antethecæ in the umbilical regions.

REMARKS: The unusually thin spirotheca and the elongated test of the present species have led Schellwien to assume a close relation between this species and *Girtyina cylindrica*. The latter is however distinguished from the true *Schellwienia* by the presence of a tectorium, and the absence of distinctly alveolar osseum. This, together with the presence of pseudo-anuli and a perfectly round initial chamber in *cylindrica* renders the difference between the two species quite obvious. Their types of coiling also differ from each other: In *cylindrica* and *quasicylindrica* the spiral expands more slowly in the early stage of its growth. When plotted on a suitable base, the width-graphs for *cylindrica* and *quasicylindrica* are more of a logarithmic type, while in *longissima*, this graph is nearly rectilinear.

It must, however, be admitted that the apparent resemblance between *Schellwienia longissima* and *Girtyina cylindrica* and *G. quasicylindrica* is often perplexing. So much so that after a preliminary examination of the material brought back by Mr. Y. T. Chao from the Tzechou and the Liuhokou coalfields, I had tentatively referred a large number of small or young individuals of *longissima* to *cylindrica*. In the same fauna I also labeled several forms of *longissima* as *longissima* var. *fascicula*, *longissima* var. *grandis*, etc. But a more exhaustive survey of the material at my disposal shows that there are among them only two forms, namely var. *compacta* and var. *phaselus*, that may be regarded as more or less distinct varieties, the others being linked to the normal type of *longissima* by numerous intermediate forms.

The apparent resemblance between *Schellwienia longissima* and *Girtyina pankouensis* is even more confusing; for, the latter also carries a thick mass of calcareous deposit in the axial region. Examination with high-powered microscope reveals, however, at once, the presence of an impressive layer of tectorium on the internal side of the spirotheca and a pair of pseudo-anuli in *Girtyina pankouensis*. These features suffice to prove its subgeneric position.

The Indian species designated by Schwager under the name, *longissima*, has in fact nothing to do with *longissima* Möller. I have fortunately found this particular Indian form in North China. The sections show, as do also Schwager's original figures, that this Indian species has fewer whorls, a much thicker spirotheca, coarser alveolar structure of the osseum and even a greater axial elongation as compared with *longissima*

Möller. I feel therefore fully justified to name the Indian species, *erucaria* as was suggested by Schwager himself.

Finally we come to *Fusulina tenuissima* Schellwien. There are few characters that may serve to distinguish *tenuissima* from *longissima* except for the fact that the former possesses 7 to $7\frac{1}{2}$ volutions, greater width and relatively smaller axial ratio. Even these few distinctive characters are by no means definite and absolute. Numerous transitional forms are known which occur side by side in our material. I am therefore inclined to hold that these differences can be no more than of varietal value, and have consequently assigned *Fusulina tenuissima* Schellwien to a variety of *Fus. longissima* Möller under the designation of *Schellwienia longissima* var. *tenuis*.

HORIZON AND LOCALITY: Probably no other species of *Fusulina* is so widely distributed in North China as the present one. Vertically, it appears to range from the lowest to the highest stage of the Taiyuan Series, but is entirely unkown in the Penchi Series. Thus it seems to represent the whole of the upper Carboniferous, and may range into the Permian. Below is a list of names of localities and limestones in which *Schellwienia longissima* has been found:—

Localities	Limestones
Tzechou, Taichai, Liuhokou, S. Chihli and N. Honan.	Abundant in Taching and Shanching Limestones, rare in Hsiaoching, Fuching and Yehching Limestones.
Yaopo, 50 *li* west of Shahohsien, S. Chihli.	Abundant in one of the Fusulina Limestones, probably equivalent to the Taching Limestone.
Hsiuwuhsien, Hsinanhsien, Shenhsien } N. Honan Chienchenghsien, Linfenhsien, Kaihsiuhsien, Yichenghsien } S. Shansi	Common in the only layer of Fusulina Limestone developed in these localities.
Yuehmenkou, west of Taiyuan, Central Shansi	Miaokou Limestone and Maoerhkou Limestone
Chientaokou, south-eaet of Taiyuan, Central Shansi.	Chientaokou Limestone.

Yangchien, Pinting Basin, N. E. Shansi.	Yaoku Limestone, Kushi Limestone, Szechieh Limestone.
Chiangchiu, W. Shantung.	Second and third seams of Fusulina Limestone from below.
Yihsien, S. W. Shantung.	Exact stratigraphical position unknown.
Hungshanyao, N. W. Kansu.	Hungshanyao Limestone, abundant.

Schellwienia longissima var. **compacta** Lee (var. nov.)

Pl. XXI, Figs. 8-11, 13, 14, (5-7, 12, 15)?

This variety is distinguished from *Schell. longissima* s. str. by a closer winding of the whorls, intensely but extraordinarily regular folding of the antethecæ, and sharply pointed umbilical ends. Its mode of coiling suggests some resemblance to *Fusulina cayeuxi* Deprat; the latter differs, however, from this variety in having a smaller axial ratio and stumpy ends.

Schellwienia longissima var. *compacta* is generally associated with *Schell. longissima* s. str. Those impoverished forms with an unusually large and often flattened initial chamber (Pl. XXI, Figs. 5-7, 12, 15.) only appear in the higher horizons of the Taiyuan Series.

Result of Measurements (in mm):—

Dia. of initial chamber	Widths of successive volutions						Specimen
	I	II	III	IV	V	VI	
0.31	0.41	0.53	0.72	0.99	1.28		(3701)
0.24	0.34	0.51	0.72	.99			(3705)
0.255	0.44	0.577	0.8	1.04	1.34	1 67	(501)
—	0.3	0.48	0.744	1.055	1.4	1.68	(716)
0.355	0.53	0.74	1.04	1.38			(703)
0.266	0.42	0.66	0.93	1.23			(502)
	Number of antethecæ						
	11	21	31	33			(3705)

Schellwienia longissima var. **phaselus** Lee (var. nov.)

Pl. XXI, Figs. 1-4

In contradistinction to var. *compacta*, this variety is characterized by a marked increase of the height of the chambers in the successive volutions as may be seen in the following table:—

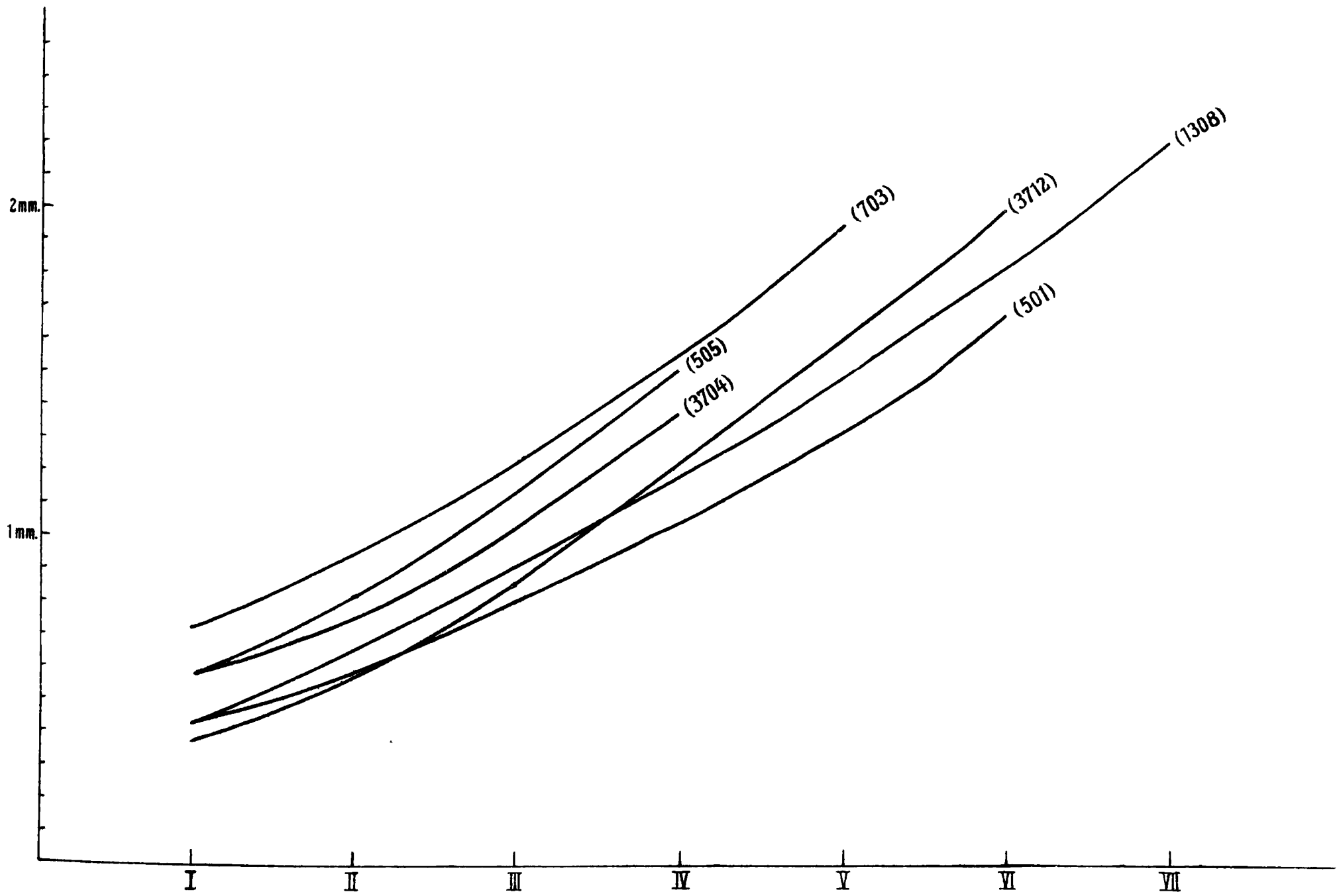


Fig. 20

Width-graphs of *Schellwienia longissima* (505, 3712), *Schell. longissima* var. *compacta* (501, 703), *Schell longissima* var. *phaselus* (3704) and *Schell. longissima* var. *tenuis* (1308).

[*To face page 116*]

Dia. of initial chamber in mm	Widths of the successive volutions						Specimen
	I	II	III	IV	V	VI	
0.3	0.52	0.755	1.03	1.04	1.89		(3704)
—	0.44	0.72	1.11	1.5			(457)

The test is as a whole rather short, broad, and recurved in the median part, so that it assumes the form of a kidney bean, hence its varietal name.

This variety is likewise extensively distributed. Its vertical range is probably co-extensive with *Schell. longissima* s. str.

Schellwienia longissima var. **tenuis** Schellwien em. Lee

Pl. XX, Fig. 15; Pl. XXII, Figs. 1-5

1898. *Fusulina tenuissima* Schellwien, Palæontographica, Vol. XLIV, p. 255, Pl. XIX, Figs. 7-9.

As already remarked, this variety differs from *longissima* s. str. only in possessing one or two more whorls, a comparatively broader test and consequently smaller axial ratio—about 1:3 on the average. The median portion is also somewhat vaulted and often slightly recurved. In this respect, it seems to approach the variety *phaselus*.

It should be noted that the original figure of *tenuissima* given by Schellwien is not exactly axial, but somewhat oblique. Therefore the form of the test appears shorter and more stumpy at the ends than it should appear if a true axial section were made.

The largest specimen among our material measures 7 mm long and 3.2 mm broad.

Number of whorls usually 6 to 7, sometimes as many as 8. The whorls are rather compactly coiled except in the fifth and sixth volutions which are relatively broader. The same phenomenon is observed in the median section given by Schellwien.

A few typical specimens have been measured with the following results:—

Dia. of initial chamber in mm	Width of successive volutions							Specimen
	I	II	III	IV	V	VI	VII	
0.277	0.466	0.71	1.055	1.355	1.766	2.33		(1150)
0.277	0.466	0.67	0.97	1.34	1.73	2.2		(504)
0.26	0.43	0.67	0.92	1.17	1.49	1.8	2.2	(1308)

In a median section of a typical specimen from the Taching Limestone of the Liuhokou coalfield, the antethecæ are counted 10, 25, 28, 34, 39, 39 (partially preserved) from I to VI volution.

Associated with these typical forms, there always occur intermediate types that merge gradually into *Schell. longissima* s. str. on the one hand, and to *Schell. longissima* var. *phaselus* on the other.

Subgenus **SCHWAGERINA** (Möller)

Schwagerina fusulinoides Schellwien

Pl XXII, Figs. 6-17

1898. *Schwagerina fusulinoides* Schellwien, Palæontographica, Vol. XLIV, pp. 259-260, Pl. XXI, figs. 1-4, 8.

Test usually fusiform, moderately vaulted in the median region and slightly rounded at the poles. Sometimes one side of the test is flatter than the opposite; consequently the external appearance of the whole test becomes more kidney-shaped than fusiform, The normal axial length and median width are about 5.4 mm and 2.4 mm respectively, but extreme types vary in size, ranging from 5 mm : 2.3 to 6 mm : 3 mm.

Number of whorls usually 6, sometimes 7. The first two or three whorls are closely coiled; then the coiling rapidly becomes broader. In the last volution the whorl is again closer as compared with the preceding one. Thus the three stages of growth—young, adult and senile—are clearly observable in the axial and median sections as well as in the graphs (see Fig. 21) by the change of the gradient of the curves.

Spirotheca at first very thin; alveolar structure of the osseum hardly observable; but in the later development it steadily grows thicker, at the same time, the osseum becomes coarser. In the thickest part which usually occurs in the last but one volution, its thickness is often no less than 0.09 mm.

Antethecæ short and relatively thin in the young, long and thin in the adult and short and thick in the senile stage. They are gently fluted as a whole, but more intensely folded along the lower edge. Only in the very umbilical ends, the loops and anastomosis usually observed in *Schellwienia*, begins to make their appearance.

Anuli very small and rudimentary in the first two or three volutions, disappearing from the third volution onward. Buccal aperture small and narrow in the inner volutions, becomes broader and larger but ill-defined in the outer ones.

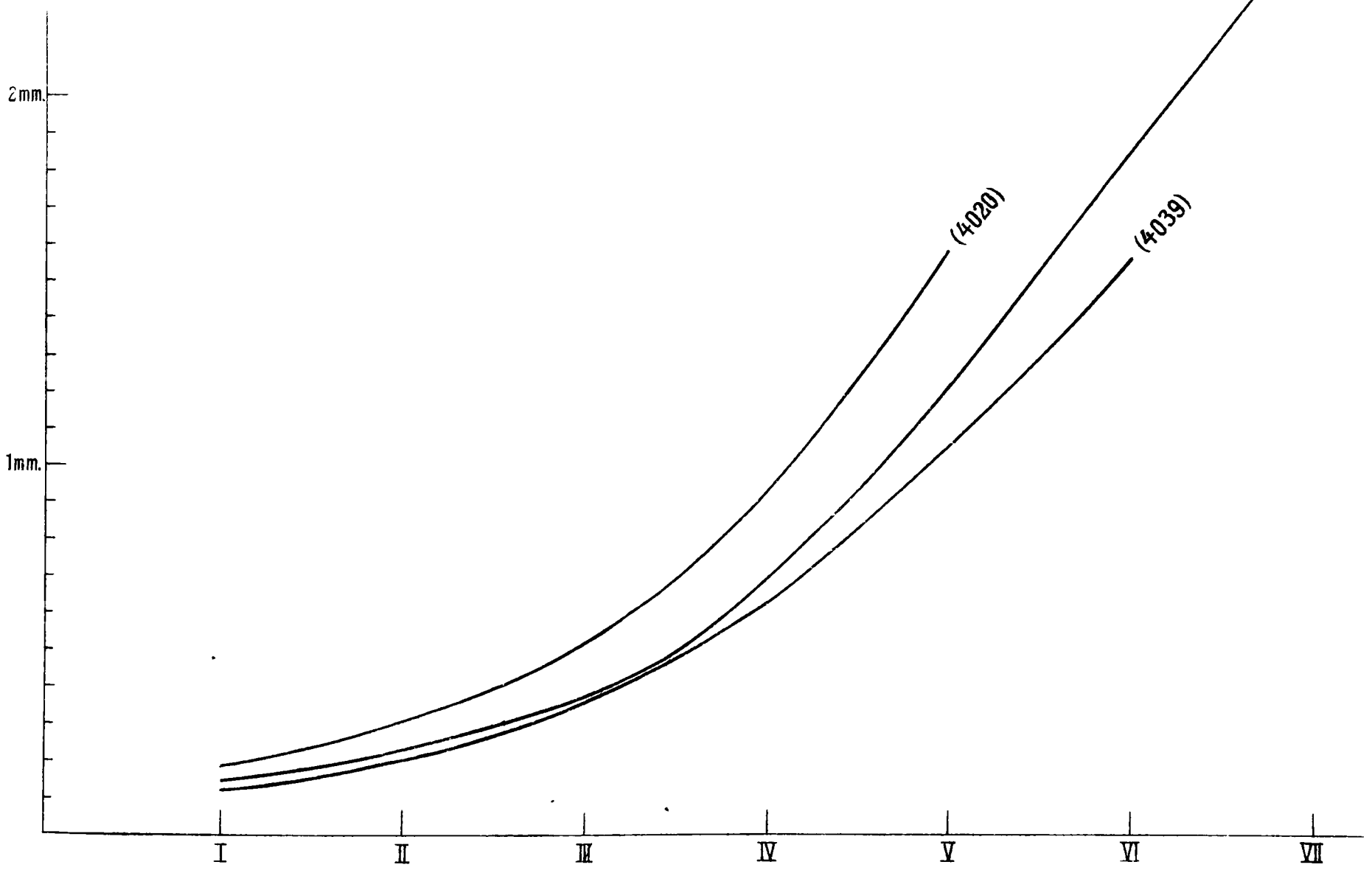


Fig. 21

Width-graphs of *Schwagerina fusulinoides*.

[*To face page 118*]

Initial chamber very small, spherical, having a diameter varying from 0.08 to 0.13 mm.

Result of measurements:

	Initial chamber	Volution I	II	III	IV	V	VI	VII	Specimen
Width in mm	.1	.167	.356	.7	1.25	2.25			(4028)
	.1	.19	.31	.52	.94	1.58			(4020)
	.1	.18	.267	.44	.9	1.35			—
	.08	.167	.256	.39	.61	1.16			—
	.08	.13	.21	.33	.6	.99			(4038)
	.08	.13	.21	.36	.63	1.05	1.56		(4039)
	12	.19	.35	.56	1.06	1.6			(4034)
	1	.167	.28	.48	.84				(4040)
	.077	.13	.21	.33	.57	1.07	1.86?		(4019)
	.9	.156	.23	.38	.71	1.22	1.85	2.46	(4029)
	.11	.19	.32	.6	1.11	1.8	2.44		—
	.13	.26	.39	.7	1.29	2.16			(4032)
Axial ratio			2.4	2.6	2.7				(4040)
			2.3	2.5					(4029)
			2.3	2.46	2.43	2.3			(4032)
No. of antethecæ		10	12	17	20	30	31		—
		8	12	15	17	20	28		—

REMARKS: It is beyond dispute that our form is absolutely identical with the Alpine species described and figured by Schellwien under the name *Schwagerina fusulinoides*, and there is no other species that can be possibly confused with this peculiar one. Highly significant is the fact that it has the dual character of *Schellwienia* and *Schwagerina*. Its form, and to some extent, its antethecal folds, partain the common properties of *Schellwienia*, while its mode of coiling and its shape and size of the inner volutions largely conform with *Schwagerina*. Probably during a certain stage of its development the animal adapted a planktonic habit. Hence it attained a vast extent of distribution without appreciable modification.

We are here undoubtedly dealing with an intermediate form between *Schellwienia* and *Schwagerina*, but to prove that it is a transitional form from *Schellwienia* to *Schwagerina* more evidence is required; namely we must establish the fact that either in itself or in its allied forms, the early stage manifests the essential characters of a common *Schellwienia*, for instance, the presence of a distinctly alveolar osseum, development of

fluted antethecæ etc. before we can admit that view. Such evidence is fortunately forthcoming in the species described below.

HORIZON AND LOCALITY: *Schwagerina fusulinoides* occurs abundantly in the Hsinho fauna, Kansu, and sparcely in the Yaoku Limestone of the Pinting Basin, N. E. Shansi. It probably represents the lowest stage of Uralian, being rapidly replaced in the higher horizons by *Schw. princeps*.

Schwagerina moungthensis Deprat

Pl. XXIII, Figs. 3, 4, 2?

1915. *Fusulina moungthensis* Deprat, Mém. Serv. géol. Indochine, Vol. IV, Fasc. I, pp. 5-6, Pl. II, Figs. 1-6.

1925. *Schwagerina moungthensis* Ozawa, Journ. Coll. Scien. Tokyo, Vol. XLV, Art. 6, pp. 47-48, Pl. VIII, Figs. 1-2.

Test subglobular to ellipsoidal; average size 5.2 mm long and 3.4 mm broad; number of volutions $5\frac{1}{2}$; first three volutions closely coiled, considerably broader in the fourth and fifth, again becoming closer in the last stage; spirotheca rather thick being 0.04, 0.056, 0.078, 0.09 mm, from the second to the fifth volutions; width of the first whorl 0.41 mm, second whorl 0.72 mm, third whorl 1.28 mm, fourth whorl 1.97 mm, and fifth whorl 2.8 mm; antethecæ fairly thin, only plicated in their lower part, and the folds usually arranged more or less in a regular manner; number of antetheæ about 10 in the first volution, 17 in the second, 25 in the third, 20 in the fourth, 23 in the fifth; buccal aperture rather low and narrow in the first three volutions, thence it becomes broader and ill-defined.

There is not much doubt that this species is specifically identical with *Fusulina moungthensis* Deprat of the Chamchit district, Tonkin, and *Schwagerina moungthensis* Ozawa of the Tombstone region, Akiyoshi, Japan. It is however rather difficult to fix its subgeneric position. Structurally it certainly conforms, in all its essential features, with *Schellwienia*, but morphologically it exhibits all the salient properties of *Schwagerina*. Taking all the properties together, this species seems to bear a closer affinity with *Schwagerina princeps* than with *Schwagerina fusulinoides*. If the latter is to be classed in *Schwagerina* as we have done, then obviously we must also refer this species to that subgenus.

This species was procured by Mr. Y. T. Chao from the Wuhutsui coalfield, South Manchuria. He is of the opinion that its containing rock is probably intercalated in the highest part of the coal-bearing series of that district. At all events, the stratigraphical position of this species cannot be lower than Upper Carboniferous, for in Indochina it occurs in association with *Schellwienia alpina*, and in Japan it is again associated with an Alpine species, *Schell. incisa*.

Schwagerina wongwenhaoi Lee (sp. nov.)

Pl. XXIII, Fig. 1; Pl. XXIV, Figs. 1-2

This species is represented in our material only by two incomplete median sections obtained from the Hsiaoching Limestone of Taichai on the Chihli-Honan border and one submedian section from the Hsiaoching Limestone of Heishankou, N. Honan. The full-grown test possesses 7 whorls of which the first four are compactly coiled with relatively thick spirotheca and a large number of antethecæ which are also rather thick and more or less intensely folded. Up to the end of the fourth whorl there is nothing to distinguish it from an ordinary *Schellwienia*. At the commencement of the fifth whorl the spirotheca suddenly broadens out, at the same time, both the spirotheca and the antethecæ become much thinner, and the latter are less crowded, and hardly plicated. In the last volution the spirotheca again becomes thicker and more closely coiled. Thus the development of test is clearly divided into two stages: In the first stage it reveals all the common properties of a *Schellwienia*, and in the second stage it is constructed after the type of a true *Schwagerina*.

Measurement of the width of the successive whorls at the end of each volution gave the following results (in mm.):—

I, 0.32; II, 0.455; III, 0.72; IV, 1.22; V, 2.36; VI, 4.2; VII, 5.45

Number of antethecæ is only counted in the first five volutions. They are : 10, 21, 26, 30, 25. It is to be noted that in spite of a sudden radial expansion of the spiral from the fifth volution, the number of antethecæ in that volution is, on the contrary, much lower, proving that at that stage of its development the animal no longer maintains the character of a *Schellwienia*.

Initial chamber thick-walled, spherical, having a diameter of 0.17 mm.

This species differs from *Schwagerina moungthensis* in that its schwagerinoid (of the *princeps* type) character becomes far more pronounced in its later stage of development. But when compared with *Schwagerina yabei** Staff, obtained from the Sosio Limestone, our form is decidedly more primitive in the sense that it differs more markedly from *Schwagerina princeps*.

Schwagerina tinvenkiangi Lee (sp. nov.)

Pl. XXIII, Figs, 5, 6

Test globular with a subquadrilateral outline in the axial section, length about 6 mm, width 4.1 mm, number of whorls $6\frac{1}{2}$ to 7, spirotheca very thin at the beginning,

*Staff, H. Beiträge zur Kenntnis der Fusuliniden, N. J. F. M. G. P., XXVII, Beilage-Band, p. 463, Pl. VII, figs. 1-3.

thickening gradually outwards: the thickness is measured 0.03 mm in the third volution, 0.033 mm in the fourth, 0.056 mm in the fifth and 0.09 mm in the sixth, becoming again slightly thinner in the very last stage.

In the first two or three volutions the whorls are rather closely coiled and laterally elongated, then the whorls rapidly widen out, and at the same time, the axial ratio continues to decrease: In the third volution the axial ratio is about 1:2.3, 1:1.5 in the fourth, 1:1.5 in fifth and 1:1.24 in the sixth.

A pair of insignificant anuli is present up to the third volution, thence they completely disappear.

Initial chamber exceedingly small, spherical, with a diameter of about 0.1 mm.

All these features practically agree with those of *Schwagerina princeps*. The only difference which serves to distinguish *princeps* from the species in question is the fact that in *princeps* the antethecæ are never folded to any extent, while in *tinvenkiangi* they are all gently and irregularly plicated, so that in the axial section there are always to be observed loops and sinuating lines running through the entire height of all the whorls.

This species stands still nearer to *Schwagerina princeps* than does *Schw. yabei*.

It occurs sparcely in Yatzetsi, Shenhsien, N. Honan. Associated with this species are *Schellwienia alpina*, *Schell. longissima* var. *tenuis*, *Schwagerina princeps*, etc. In all probability it represents a higher, if not the highest, stage of Upper Carboniferous.

Schwagerina princeps Ehrenberg

Pl. XXIV, Figs. 4-6

1877. *Schwagerina princeps* Möller. Die Spiral-gewundenen Foraminiferen etc. pp. 71-74 Pl. V, figs. 1 a-b, et Pl. IX, figs. 1 a-b.

1883. *Schwagerina princeps* Schwager, China, Vol. IV, pp. 132-135, Pl. XVII, figs. 1-8.

1897. *Schwagerina princeps* Schellwien, Palæntographica, Vol. 44, p. 258, Pl. XI, figs. 5-7, 9, et Pl. XXII, figs. 4-7.

1906. *Schwagerina princeps* Yabe, Journ. Coll. Scien. Tokyo, Vol. XXI, Art. 3, pl. I, fig. 2.

1910. ? *Schwagerina* cf. *princeps* Staff-Wedekind, Bull. Geol. Inst. Upsala, Vol. X, No. 19-20, p. 122.

1912. *Schwagerina princeps* Deprat, Mém. Serv. Géol. Indochine, Vol. I, Fasc. III, p. 37, Pl. I, figs. 1-3.

1923. *Schwagerina princeps* Ozawa, Jap. Journ. Geol. Geogr. Vol. II, p. 38.

1725. *Schwagerina princeps* Ozawa, Journ. Coll. Scien. Tokyo, Vol. XIV, Art. 6, p. 47.

This is probably the most widely known and most easily recognizable form among all the species of Fusulinidæ. It is characterized by a globular shape, minute initial chamber, thin and almost straight antethecæ, broad coiling, and a pair of

insignificant anuli which are always present up to the third or fourth volution, and sometimes throughout all the whorls.

Our specimens possess 8 whorls. The first three volutions are uniformly and rather compactly coiled, roughly conforming the Archemedian spiral. But at the commencement of the fourth volution, the spiral abruptly departs from its previous course, and assumes the form of a high exponential type. When measured at the end of each volution, the widths of the successive whorls are as follows (in mm.) :—

I, 0.144; II, 0.244; III, 0.41; IV, 0.956; V, 2.0; VI, 3.3; VII, 4.5; VIII, 5.3

In a specimen from Yihsien, Shantung, the antethecæ are counted 10, 16, 18, 19, 14, 17, 23, 37, from the first to the eighth volution. These figures are not incomparable with those given by Möller, but somewhat higher than those shown by Schwager's specimen. Although one cannot be absolutely certain, in the absence of adequate axial sections, of the specific determination of the materials under consideration, yet, the features presented by the available median sections seem sufficient to warrant the conclusion that they either belong to *Schwagerina princeps* s. str. or to its closely related variety. Moreover, it should be remembered that this planktonic form attains a world-wide distribution and therefore it may be subject to minor variation according to local conditions. Consequently it appears desirable to place its specific characters on the more outstanding features.

Initial chamber minute, spherical with a diameter of no more than 0.08 mm.

In the Yihsien coalfield, Shantung, *Schwagerina princeps* occurs sparcely in association with *Schellwienia vulgaris*, and in Yatzetsi, Shenhsien, Honan, it associates with *Schell. alpina*, *Schell. longissima* var. *tenuis* and *Schwagerina tinvenkiangi*. It probably ranges throughout the whole of the Uralian epoch, and possibly survived to the Middle Permian time.

EXPLANATION OF

PLATE I.

(1) 125

PLATE I.

All figures magnified 55 diameters.

Fig. 1. An axial section of *Fusulinella (Staffella) sphœroidea* Möller, showing its internal structure. Osseum: a whitish layer forming the middle part of the spirotheca; Tectum: a dark lamella indicated by a fine, black line visible here and there on the external side of the osseum; Tectorium: two dark layers, one on each side of the osseum, particularly well exhibited in the lateral part of the test; Anuli: massive, crescentic patches embracing the corners of each whorl. Penchihu, S. Manchuria. 奉天,本溪湖.

Fig. 2. An axial section of *Fusulinella (Neofusulinella) bocki* Möller, showing the presence of the osseum, a whitish layer; the tectum, a thin, opaque lamella visible in the middle part of the spirotheca; two darkish layers of tectorium forming the outermost and innermost layer of the spirotheca; the anuli, a pair of black masses symmetrically arranged with reference to the median plane; and the buccal aperture, a clear space between each pair of anuli. Penchihu. 本溪湖.

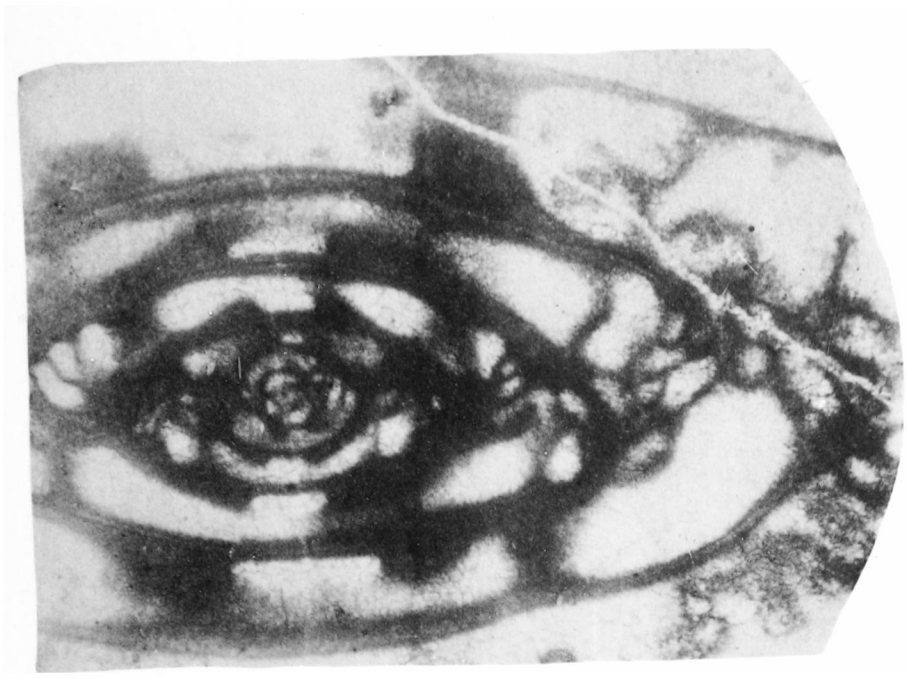
Fig. 3. An axial section of *Fusulina (Girtyina) cylindrica* Fischer, showing the tripartite structure of the spirotheca; alveolar structure of the osseum almost invisible. Tangshan, Kaiping Basin. 唐山.

Fig. 4. A tangential section of the antetheca of *Schellwienia nathorsti* Staff-Wedekind, showing the punctures in the lower part of the antethecæ. Pinting Basin, Shansi. 山西,陽泉.

Fig. 5. An axial section of *Schellwienia secalis* (=*Tricites secalicus* Girty), showing the lamellose or alveolar structure of its anuli. From Mrs. E. R. Applin's collection, Texas, U.S.A.

Fig. 6. A para-axial section of *Neofusulinella bocki* showing clearly the tripartite structure of its theca and faint traces of the alveolar structure of the osseum. Penchihu. 本溪湖.

Fig. 7. Axial section of *Girtyina konnoi* (Ozawa) with its outer layer of tectorium considerably reduced in the outer whorls. Penchihu. 本溪湖.



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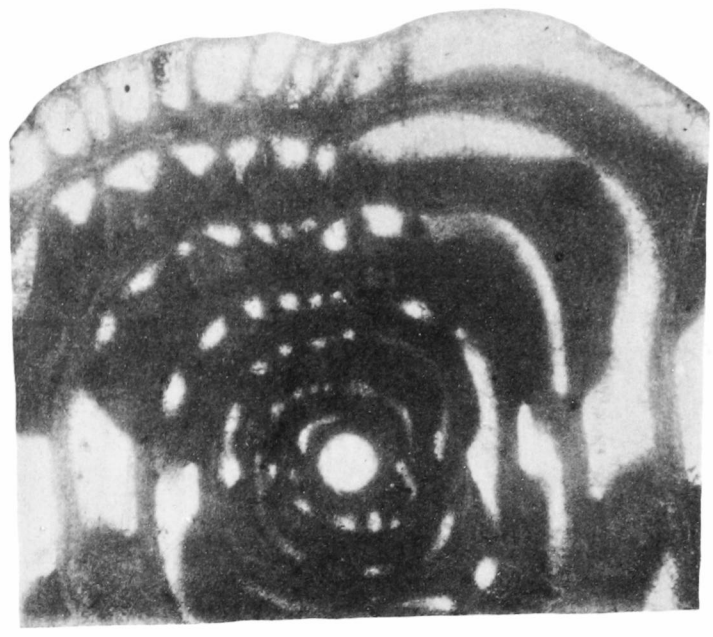

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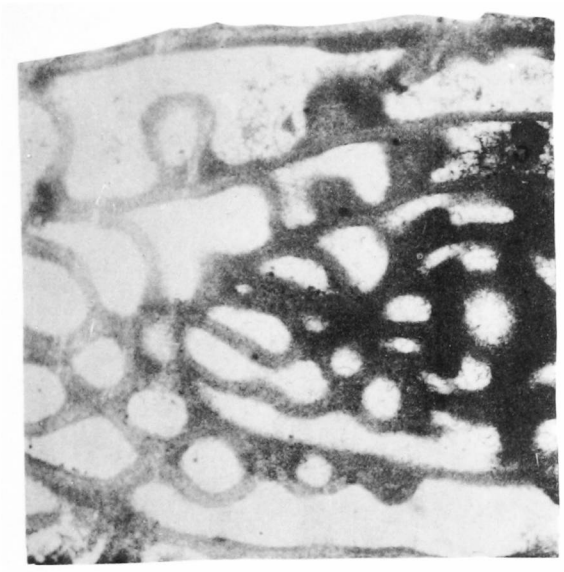

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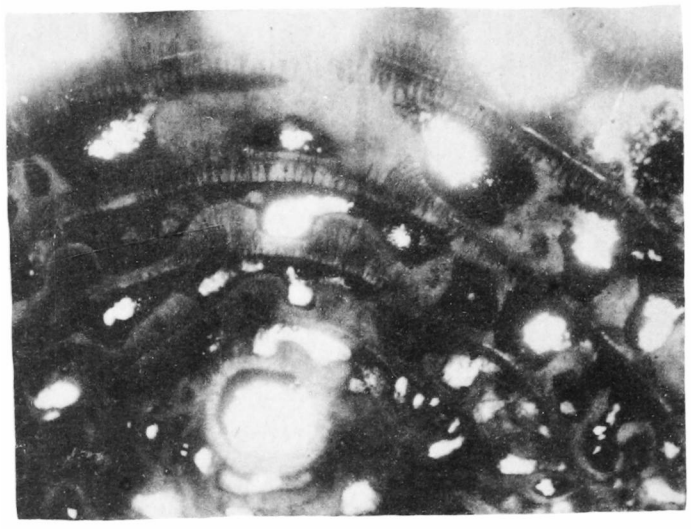

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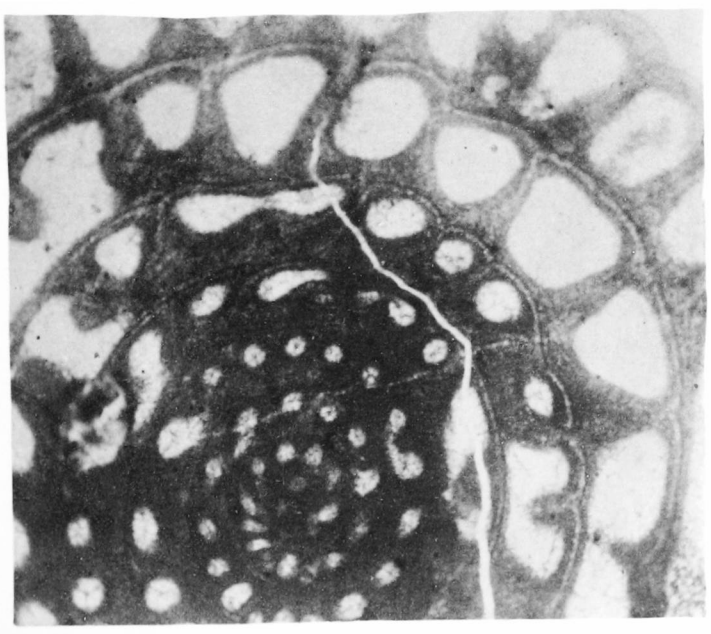

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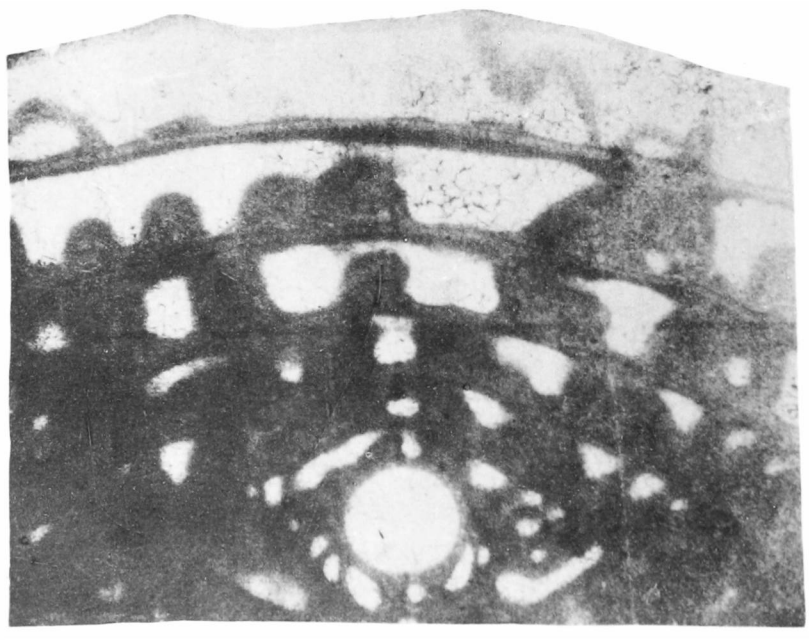

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EXPLANATION OF

PLATE II

PLATE II.

Figs. 1–4. *Boultonia willsi* Lee — p. 10

Fig. 1. Axial section of all the whorls except the first one which is submedian; Wuhutsui, S. Manchuria. 奉天,五湖嘴. ×53.

Fig. 2. Median section of the first whorl, axial section of the rest of the whorls; Wuhutsui, S. Manchuria. 五湖嘴. ×53.

Fig. 3. Submedian section of outer whorls. Wuhutsui. 五湖嘴. ×53.

Fig. 4. Para-axial section of the innermost whorl and submedian section of the outer whorls; Wuhutsui. 五湖嘴. ×53.

Fig. 5. *Boultonia rawi* Lee — p. 11

Axial section, showing the endothyroid shape and the oblique arrangement of the inner whorls; Penchihu, S. Manchuria. 奉天,本溪湖. ×53.

Figs. 6, 7. *Neofusulinella chaoi* Lee — p. 12

Fig. 6. Axial section, ×53.
Fig. 7. do ×15.
} Wuhutsui. 五湖嘴.

Figs. 8-11. *Staffella sphæroidea* Möller — p. 13

Figs. 8, 11. Axial sections, Penchi Lemestone, Penchihu. 本溪湖. ×15.

Fig. 9. Median section, Pankou Limestone, Yuehmenkou, west of Taiyuan, Shansi. 山西畔溝石灰岩. ×15.

Fig. 10. Axial section, Tangshan Limestone, Tangshan. 唐山. ×15.

Figs. 12-17. *Neofusulinella bocki* Möller — p. 16

Figs. 12-14, 16. Specimens from a point 200 km north of Kalgan. 張家口北二百公里. ×15.

Fig. 15. A rather conspicuously vaulted and loosely coiled form showing affinity with *Neofusulinella schwagerinoides* from the Hsiaoyü Limestone, Penchihu. 本溪湖小峪石灰岩. ×15.

Fig. 17. Axial section from Podolsk, near Moscow; for comparison. ×15.

Fig. 18. *Neofusulinella schwagerinoides* Deprat. — p. 19

A para-axial section, Yentai, S. Manchuria. 奉天,煙台. ×15.

Fig. 19. *? Neofusulinella obsoleta* Schellwien — p. 18

A specimen from a point 200 km north of Kalgan. ×15.

Figs. 20-22. *Neofusulinella præsimplex* Lee — p. 20

Figs. 20, 21. Specimens from Yentai. 煙台. ×15.

Fig. 22. A type-specimen from Yanghukou, Kansu. 甘肅,羊虎口. ×15.

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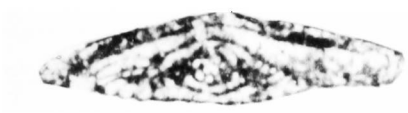

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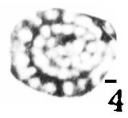

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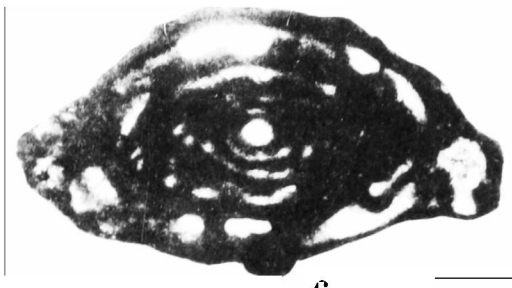

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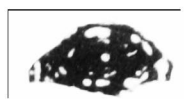

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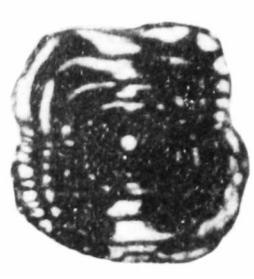

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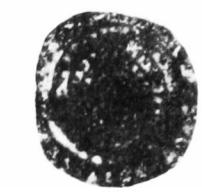

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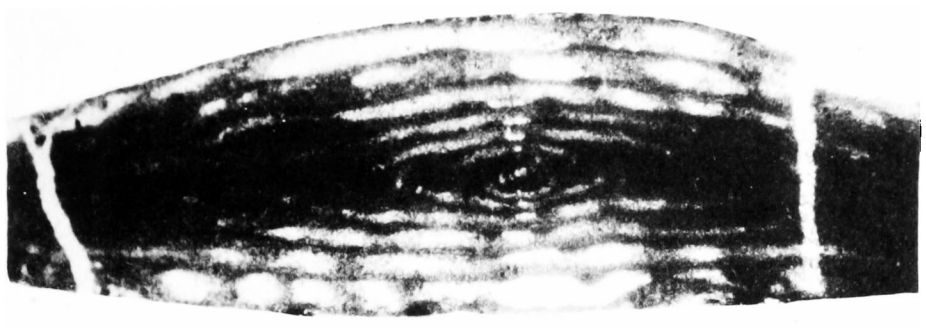

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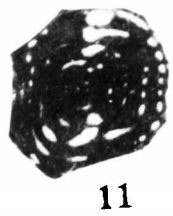

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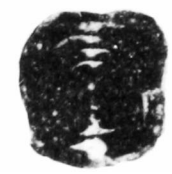

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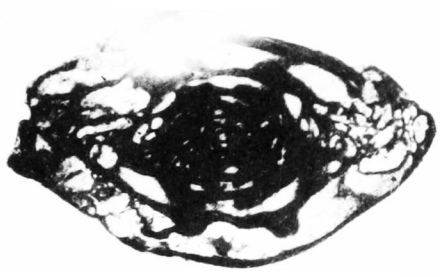

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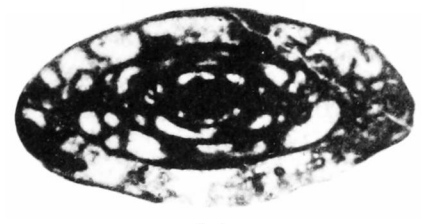

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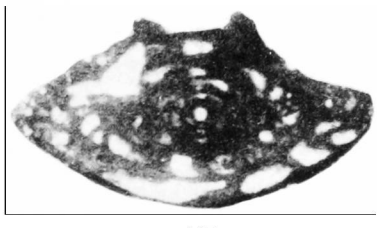

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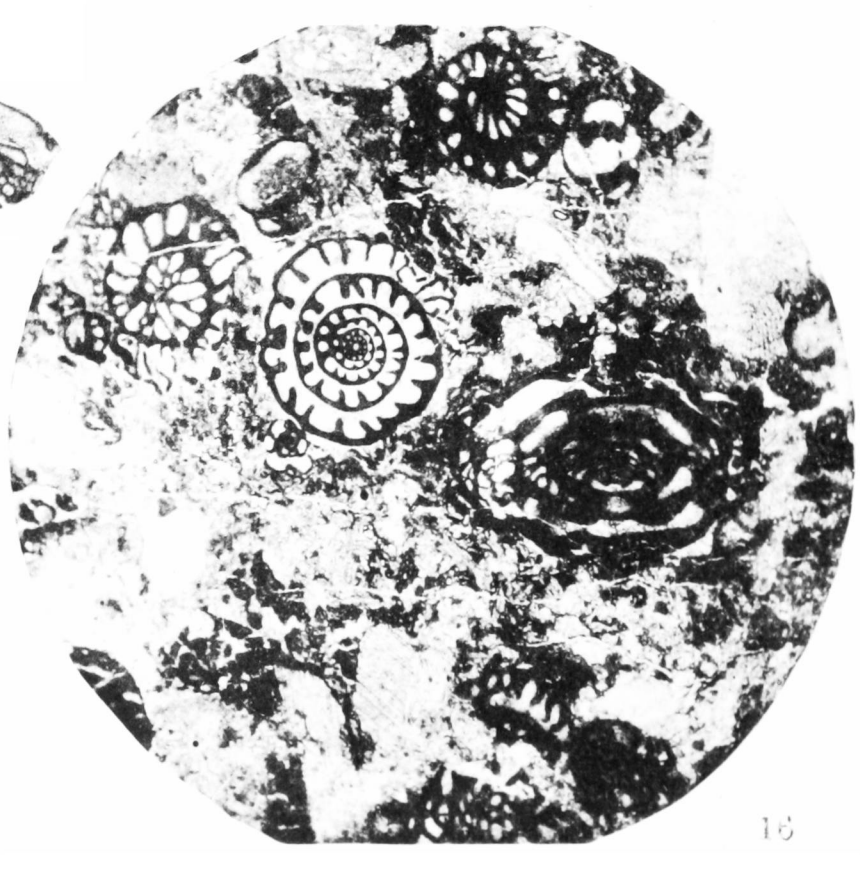

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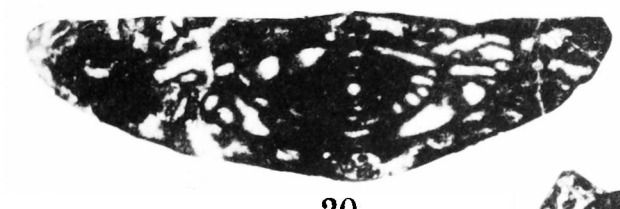

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EXPLANATION OF

PLATE III

PLATE III

All figures magnified about 15 diameters.

Figs. 1-10, 12. *Girtyina konnoi* Ozawa. p. 24

Fig. 1. Axial section, slightly oblique, Penchihu, S. Manchuria. 奉天,本溪湖.

Fig. 2. Median section, Penchihu. 本溪湖.

Fig. 3. Axial section, Tangshan Limestone, Tangshan. 唐山.

Fig. 4. A large variety from Yentai, S. Manchuria. 奉天,煙台.

Fig. 5. Median section, Tangshan. 唐山.

Fig. 6. Axial section, Pankou Limestone, Central Shansi. 山西畔溝石灰岩.

Fig. 7. Median section, slightly deformed, Tangshan. 唐山.

Fig. 8. An individual with an unusually large initial chamber, Penchihu. 本溪湖.

Fig. 9. A variety roundishly vaulted in the median part, from a point 200 km north of Kalgan. 察哈爾.

Fig. 10. An unusualy cylindrical form from a point 200 km north of Kalgan. 察哈爾.

Fig. 12. A large variety from the same locality. 察哈爾.

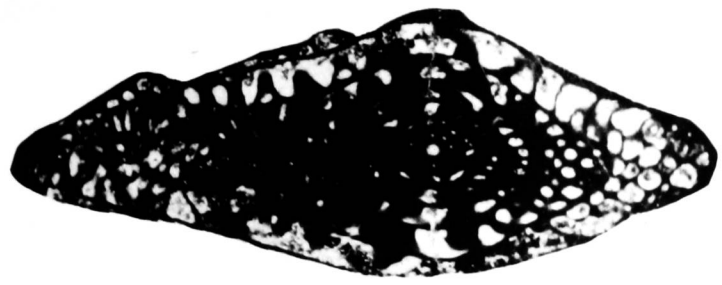
Figs. 11, 13, 14. *Girtyina Schellwieni* Staff p. 27

Figs. 11, 13. Median section, Mayi Limestone, Penchihu. 本溪湖螞蟻石灰岩.

Fig. 14. An intermediate form between *G. Schellwieni* and *G. konnoi*, Pankou Limestone, Shansi. 山西畔溝石灰岩.

Figs. 15-21. *Girtyina teilhardi* Lee p. 28

Figs. 15, 17-19, 21. Axial sections.
Figs. 16, 20. Median sections.
} from a point 200 km north of Kalgan. 察哈爾.



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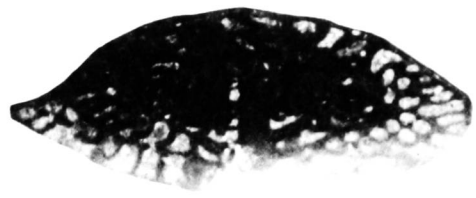

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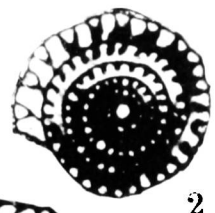

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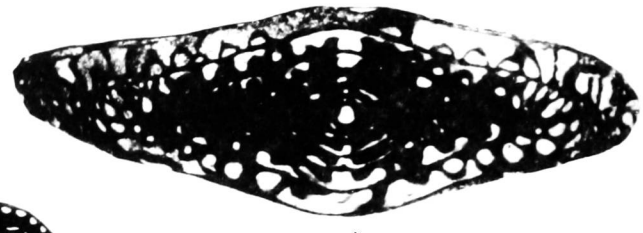

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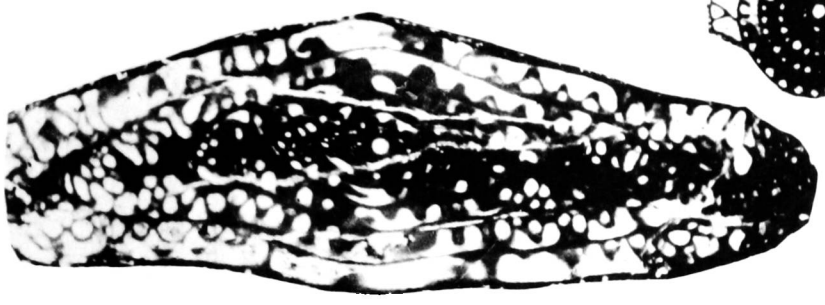

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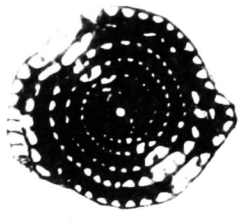

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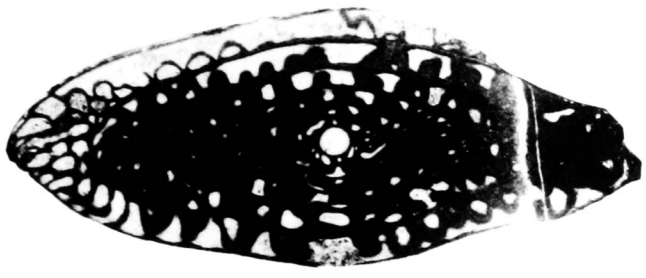

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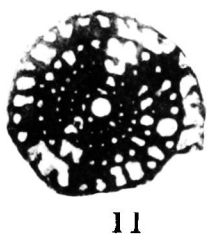

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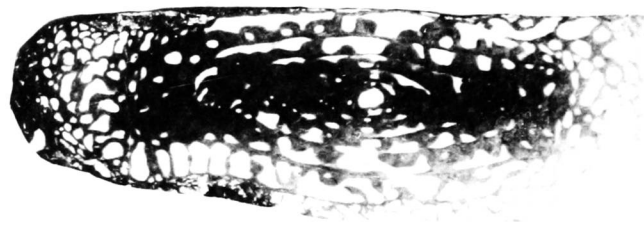

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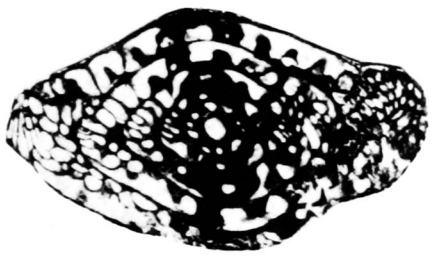

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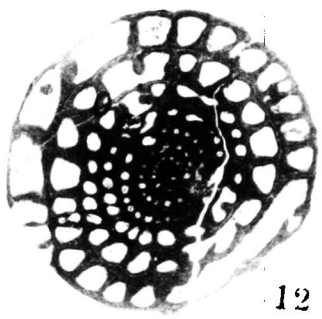

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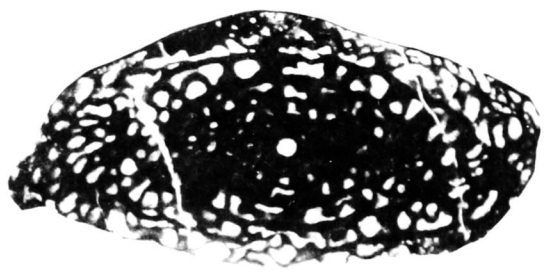

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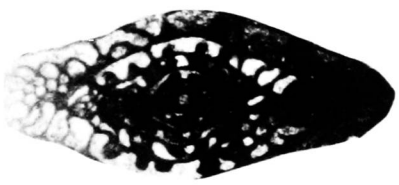

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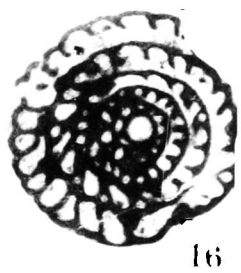

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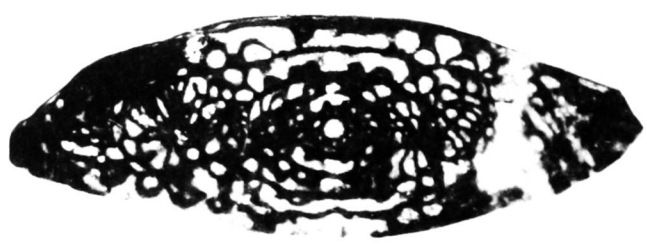

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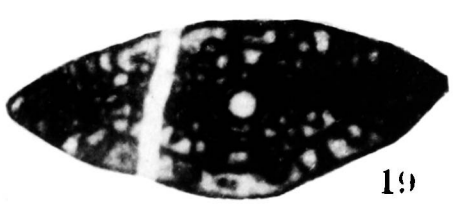

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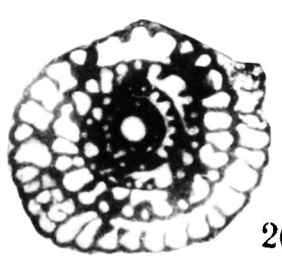

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EXPLANATION OF

PLATE IV

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PLATE IV.

All figures magnified about 15 diameters.

Figs. 1-9. *Girtyina cylindrica* (Fischer). p. 32

Figs. 1, 5. Axial sections, Penchi Limestone, Penchihu, S. Manchuria. 奉天,本溪湖, 本溪石灰岩.

Fig. 2. A form having more whorls than the usual type. Tangshan. 唐山.

Fig. 3. Median section of a normal form, Tangshan. 唐山.

Figs. 4, 9. A variety approaching *G. quasicylindrica*. Fig. 4. a specimen from the Penchi Limestone, Fig. 9 from the Yanghukou Limestone.

Figs. 6, 7. Typical specimens from the Tangshan Limestone, Tangshan Basin. 唐山.

Fig. 8. A specimen from the Miatschkovo Limestone, Environs of Moscow.

Figs. 10-19. *Girtyina quasicylindrica* Lee p. 35.

Figs. 10, 12, 13, 15-19, specimens from the Yanghukou Limestone, Kansu. 甘肅永昌縣西八十餘里羊虎口.

Fig. 18. An abnormal individual.

Fig. 11. A form more vaulted than the usual type, from the Pankou Limestone, Shansi. 山西畔溝石灰岩.

Fig. 14. A highly elongated variety from the Hsükiachuan Limestone, Chiang-chiu, Shantung. 山東章邱徐家莊石灰岩.

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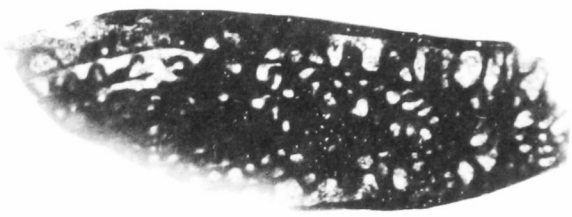

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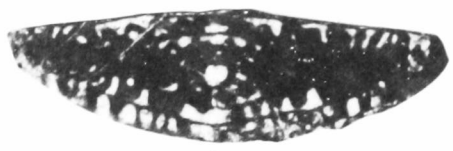

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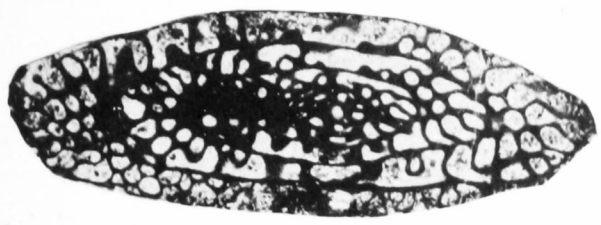

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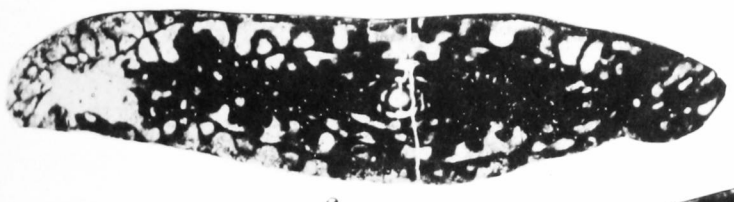

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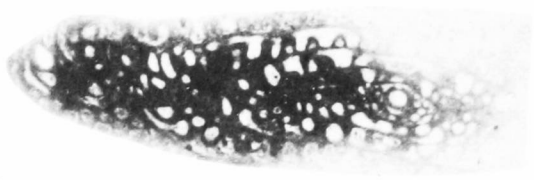

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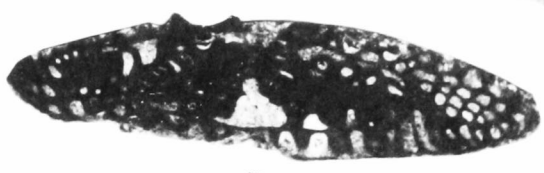

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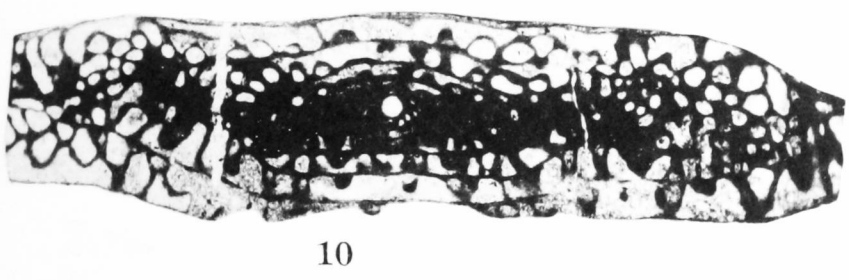

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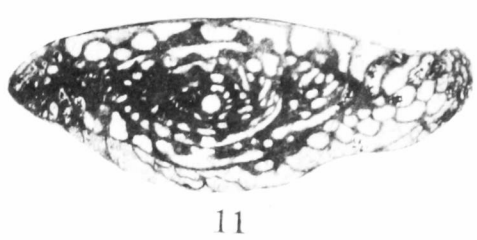

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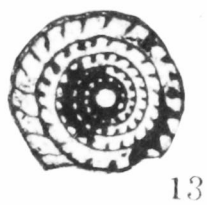

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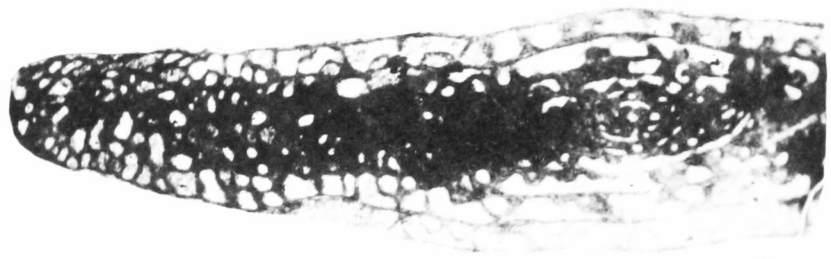

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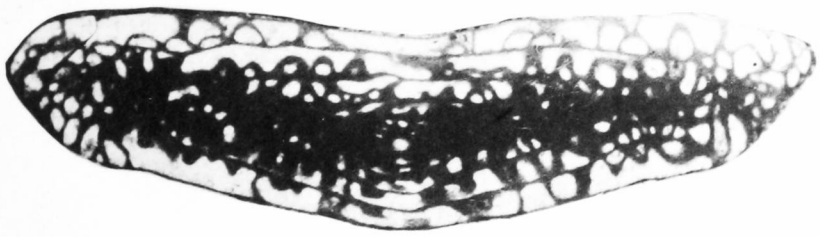

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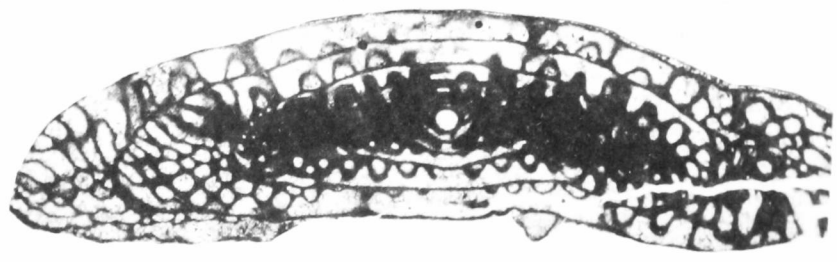

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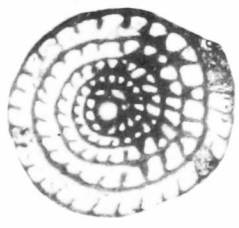

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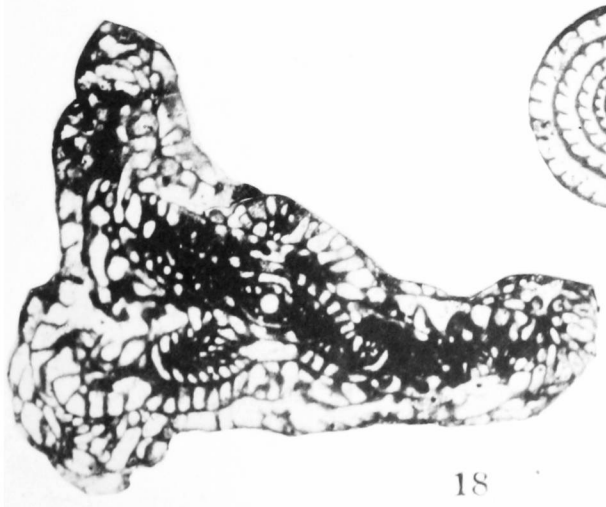

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EXPLANATION OF

PLATE V

(1) 133

PLATE V.

All figures magnified about 15 diameters.

Figs. 1-2. *Girtyina quasicylindrica* var. *brevis* Lee p. 39.

Fig. 1. A typical form from the Yanghukou Limestone. 羊虎口.

Fig. 2. A stumpy form from a point 200 km north of Kalgan.

Figs. 3-5. *Girtyina pankouensis* Lee p. 30.

Figs. 3, 4, two axial sections showing the heavy calcareous deposit; Fig. 3 from the Hsiaoyü Limestone, Penchihu, (本溪湖小峪石灰岩), Fig. 4 from the Pankou Limestone, Central Shansi. (山西畔溝石灰岩).

Fig. 5. Median section, Hsiaoyü Limestone. 本溪,小峪石灰岩.

Figs. 6-11. *Schellwienia simplex* Schellwien p. 40.

From the Yaokou Limestone, 60 *li* south of Kaotaihsien, Kansu. 甘肅高台縣南六十里窯溝窯溝石灰岩.

Fig. 13. Showing the crowded occurrence of *Schellwienia simplex* in the Yaokou Limestone in association with its variety *minuta*. 窯溝.

Figs. 12, 14-19. *Schellwienia simplex* var. *minuta* Lee p. 42

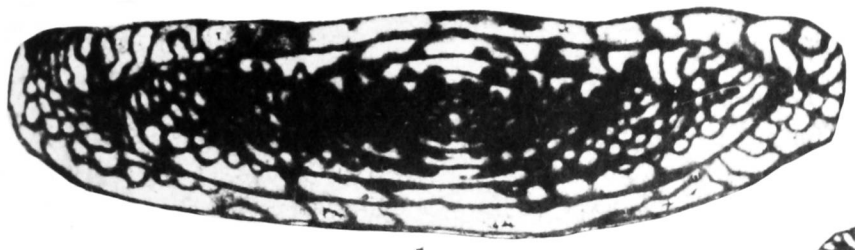
Fig. 12. A form approaching *Schellwienia simplex* s. str. Yaokou Limestone, Kansu. 窯溝.

Figs. 14, 16, from Yaoku Limestone, Pinting Basin, Shansi, 山西,陽泉,水泉溝,腰固石.

Figs. 15, 17-19. From Yaokou Limestone, Kansu. 窯溝.

Figs. 20, 21. *Schellwienia incisa* Schellwien. p. 46

Hsinho, Kansu, 甘肅,山丹縣西四十里新河.



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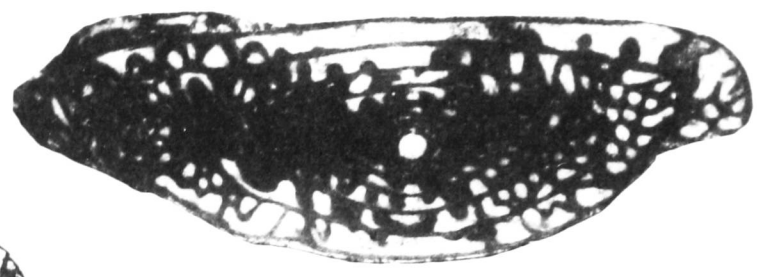

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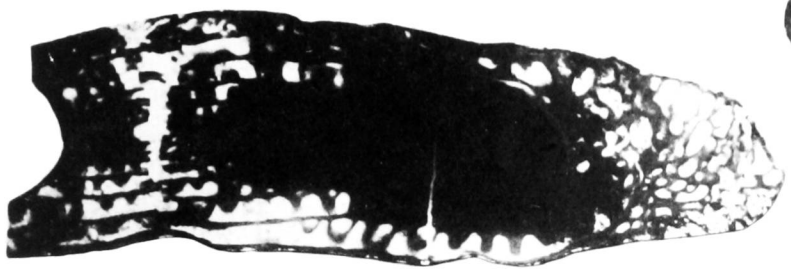

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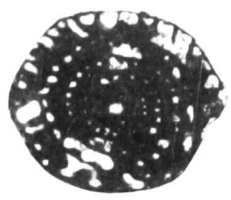

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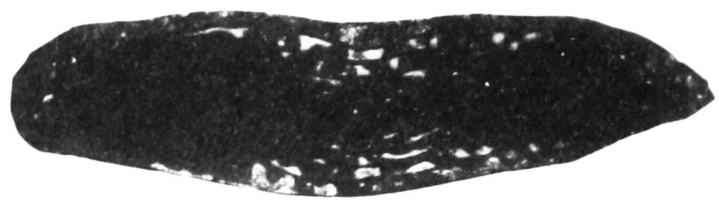

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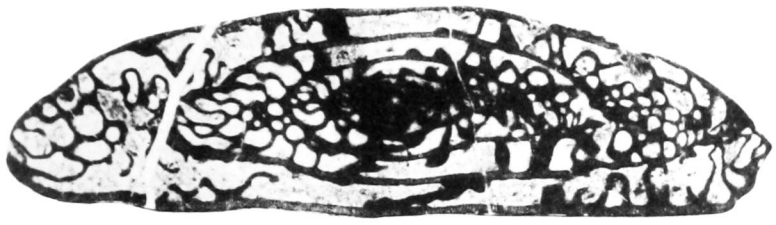

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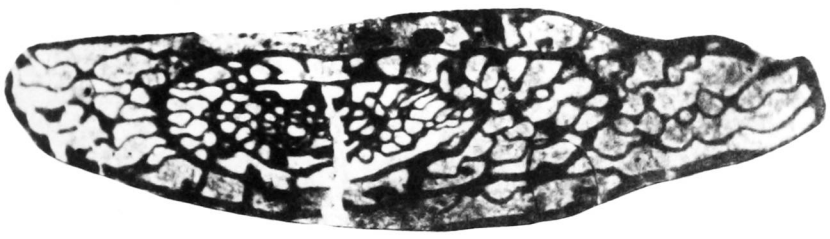

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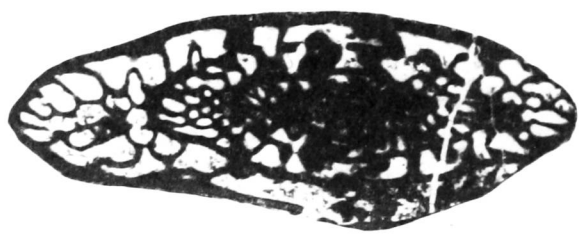

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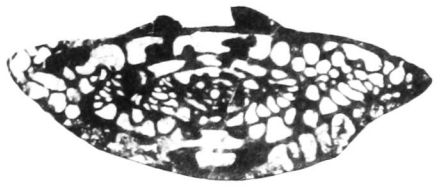

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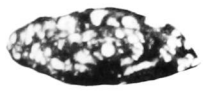

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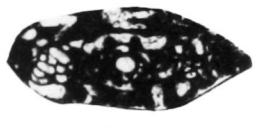

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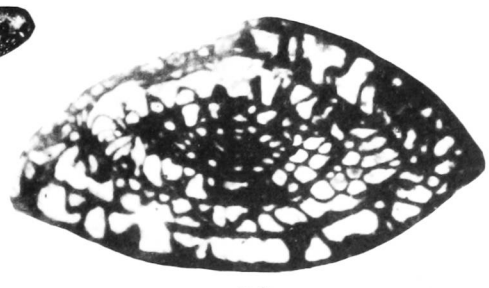

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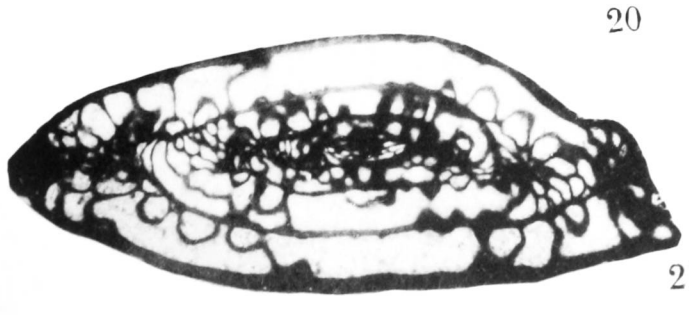

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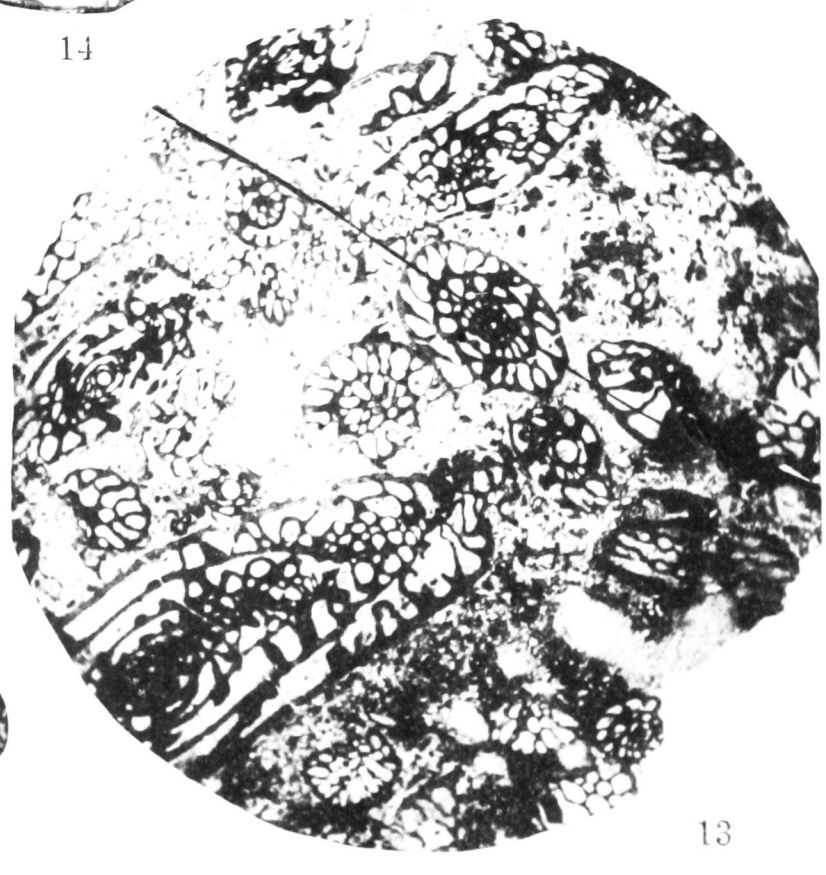

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EXPLANATION OF

PLATE VI

PLATE VI.

All figures magnified about 15 diameters.

Figs. 1-4, 6, 9? *Schellwienia parvula* Schellwien p. 43

Figs. 1, 6. Axial sections from Hsinho, Kansu. 甘肅,山丹縣西四十里新河.

Figs. 2-4, 9. Specimens from the Yaoku Limestone, Pinting Basin, Shansi. 山西,陽泉,腰固石. Fig. 9 possibly belongs to *Schellwienia prisca*.

Figs. 5, 7, 8, 10-23. *Schellwienia prisca* (Ehrenberg). p. 47.

Figs. 5, 7. Possibly belong to *Schellwienia parvula*, from the Yaoku Limestone, Pinting Basin, Shansi. 山西陽泉腰固石.

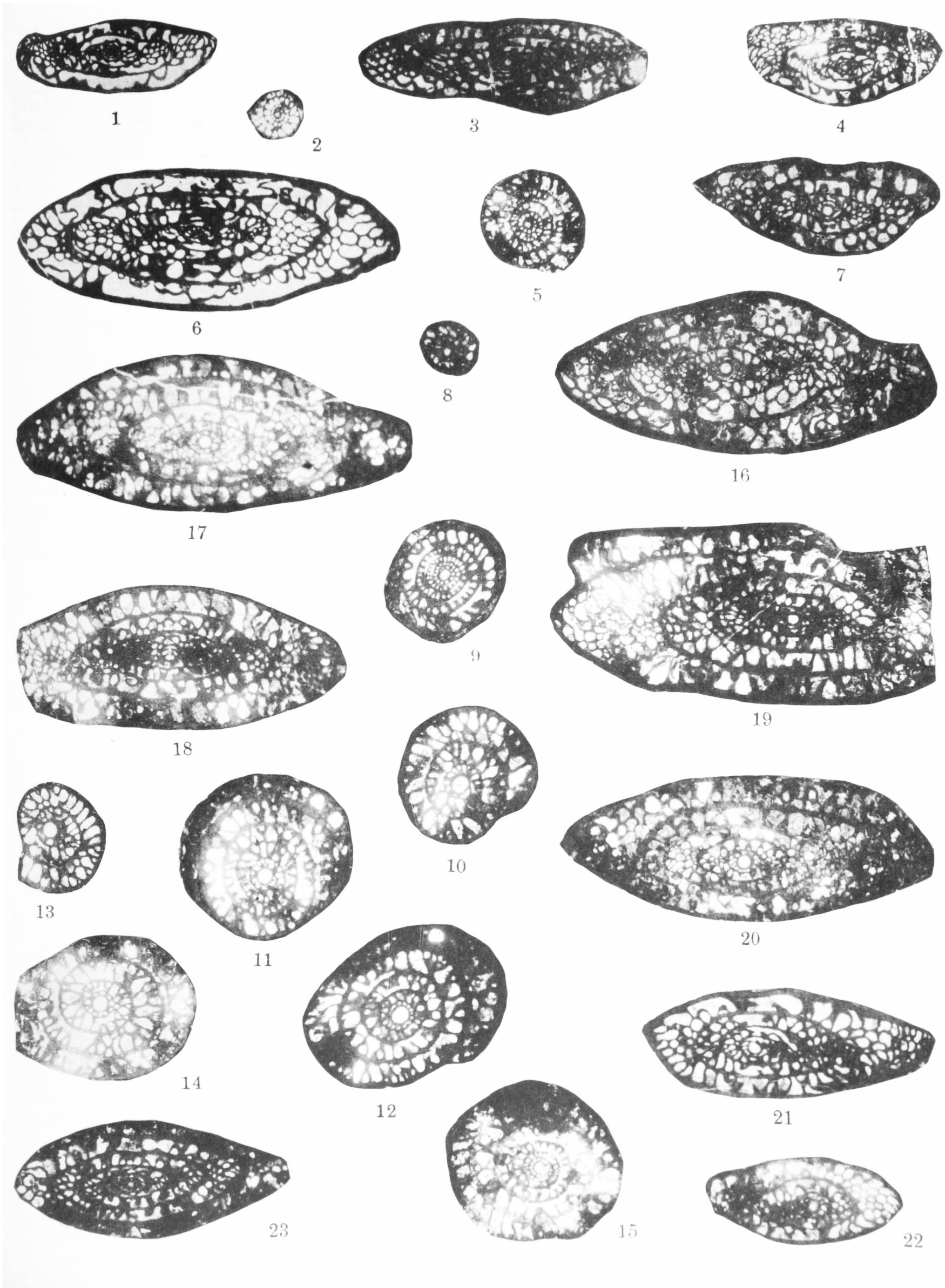
Fig. 8. Median section of a young individual from the Yaoku Limestone, Pinting Basin. 山西陽泉腰固石.

Figs. 10-18, 20, 22. Typical specimens from the Yaoku Limestone, Pinting Basin, Shansi. 山西,陽泉,腰固石.

Fig. 19. A variety approaching *Schellwienia complicata*, Yaoku Limestone, Pinting Basin. 陽泉腰固石.

Fig. 21. A specimen from the Hsinho Limestone, Hsinho, Kansu. 甘肅,新河.

Fig. 23. A variety approaching *Schellwienia regularis*, Yaoku Limestone, Pinting Basin. 山西陽泉固腰石.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EXPLANATION OF
PLATE VII

PLATE VII.

All figures magnified about 15 diameters.

Figs. 1-7. *Schellwienia arctica* Schellwien. p. 52.

Figs. 1-3. Typical specimens from the Kushi Limestone, Pinting Basin, Shansi. 山西,陽泉,固石.

Fig. 4. A form possibly represents the microspheric type of *Schellwienia arctica*, from the Yaoku Limestone, Shansi. 山西,陽泉,腰固石.

Fig. 5. Tentatively referred to *Schellwienia arctica*, Kushi Limestone. 陽泉,固石.

Figs. 6, 7. Specimens from Spitzbergen for comparison.

Figs. 8-10. *Schellwienia regularis* Schellwien p. 50

Figs. 8, 9. Typical specimens from the Hsinho Limestone, Hsinho, Kansu. 甘肅, 山丹縣西四十里新河.

Fig. 10. A young individual from the Yaoku Limestone, Pinting Basin, Shansi. 陽泉,腰固石.

Figs. 11-13. *Schellwienia anderssoni* Schellwien p. 57.

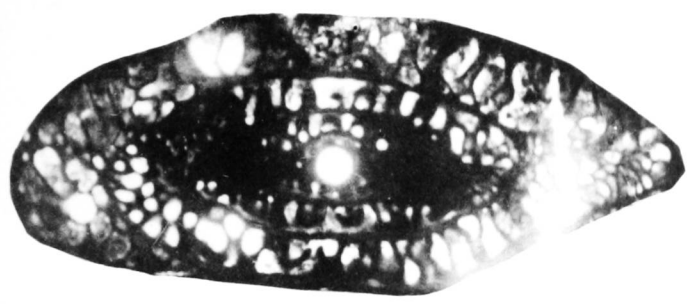
Figs. 11-12. Individuals of fully-grown size. Yatzetsi, Shenhsien, Honan. 河南陝縣 鴨子嘴.

Fig. 13. A young individual. Yatzetsi, Shenhsien, Honan. 河南,陝縣,鴨子嘴.

Figs. 14-18. *Schellwienia nobilis* Lee p. 55

Figs. 14, 15. From Wuhutsui, S. Manchuria. 奉天,五湖嘴.

Figs. 16-18. From the Yehching Limestone, Taichai, S. Chihli. 直隸,磁縣,台寨,野青石灰.



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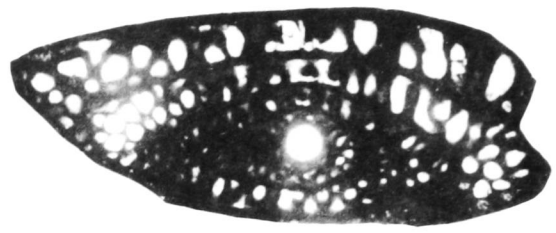

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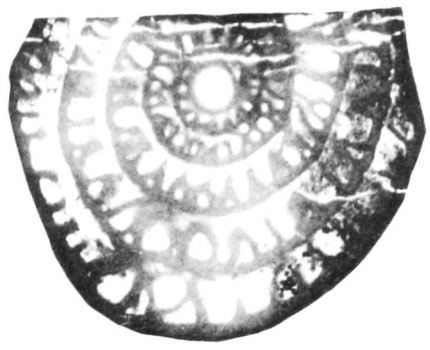

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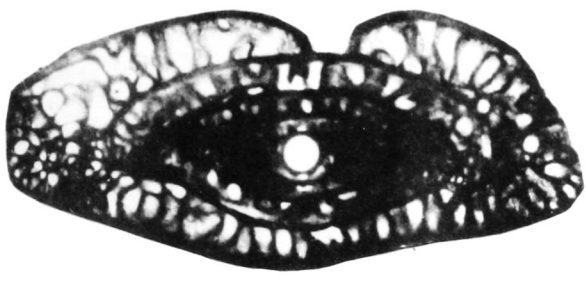

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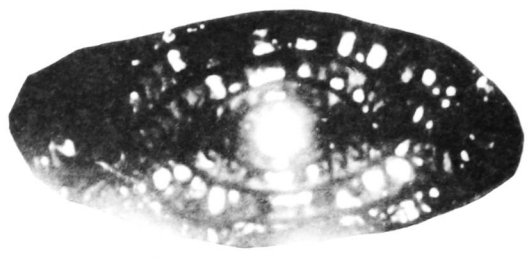

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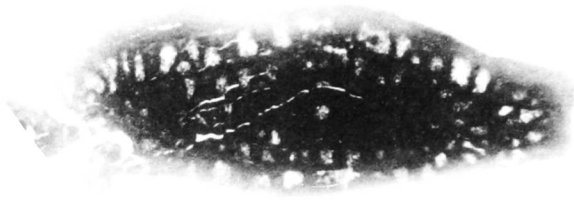

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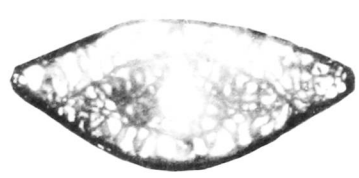

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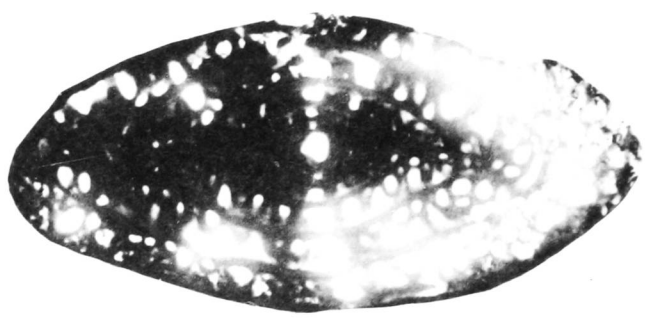

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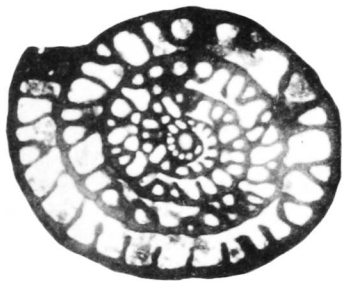

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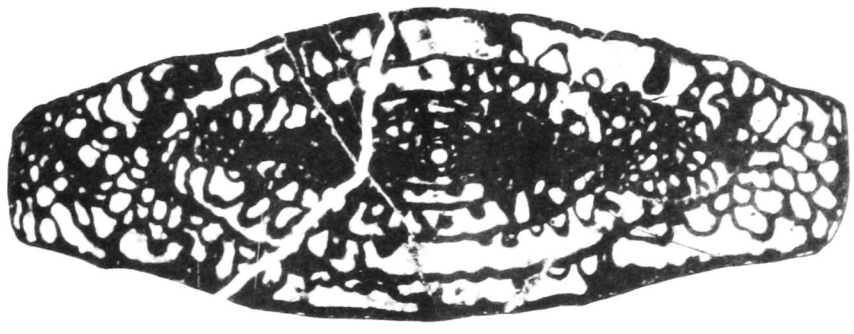

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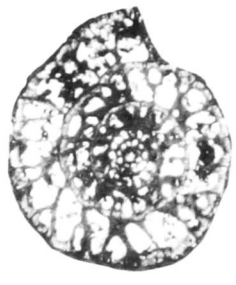

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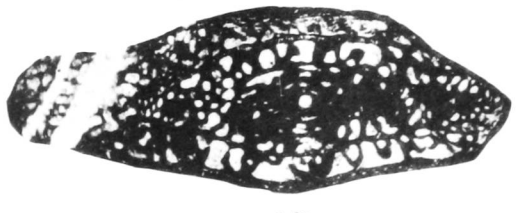

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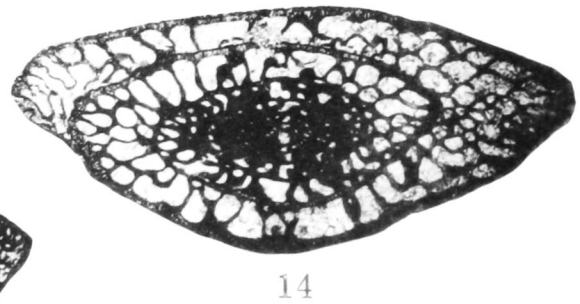

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EXPLANATION OF

PLATE VIII

PLATE VIII.

Figs. 1-3, 10. *Schellwienia valida* Lee. p. 69.

Figs. 1, 2, 10. Macrospheric type, Yihsien, Shantung. 山東,嶧縣. Magnification: Fig. 1, ×15.8; Fig. 2, ×16.7; Fig. 10, ×16.5 dia.

Fig. 3. Microspheric type, Yihsien, Shantung. 山東,嶧縣, ×16.

Figs. 4, 5. *Schellwienia valida* var. *exigua* (Schellwien) p. 70.

Fig. 4. Axial section, from Yihsien, Shantung. 山東,嶧縣. ×16.4.

Fig. 5. A form showing some affinity with *Schellwienia prisca*, from Hsinho, Kansu. 甘肅,新河. ×15.

Figs. 6-9, 11, 12. *Schellwienia vulgaris* Schellwien p. 59.

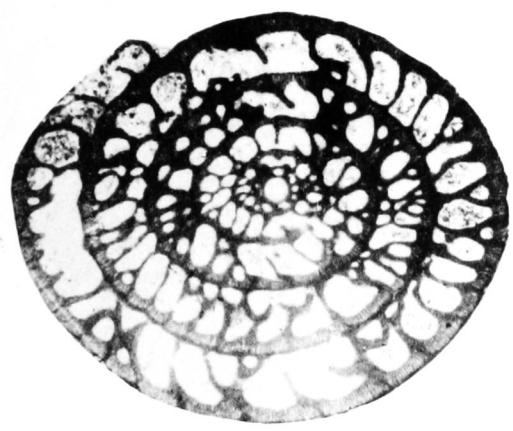
Figs. 6, 7. Typical specimens from the Taching Limestone, Taichai, S. Chihli. 直隸磁縣台寨,大青石灰岩. ×15.

Fig. 8. Microspheric type from Yaopo, Shahohsien, S. Chihli. 直隸沙河縣窯坡. ×15.

Fig. 9. A microspheric form, almost completely shattered, from the Taching Limestone, Shimiao, S. Chihli. 直隸磁縣彭城東南十五里石廟大青石灰岩. ×15.

Fig. 11. A young individual of the macrospheric type, from Yihsien, Shantung. 山東,嶧縣. ×16.7.

Fig. 12. A microspheric specimen from the Taching Limestone, Taichai, S Chihli. 台寨大青石灰岩. ×15.



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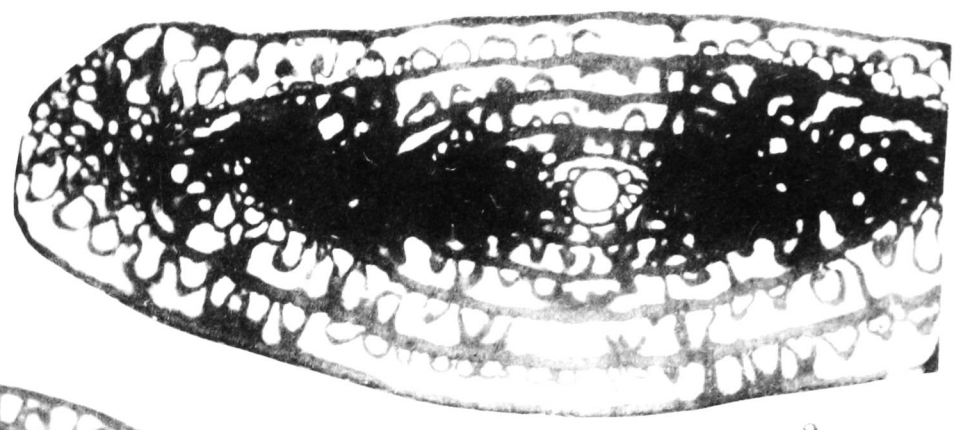

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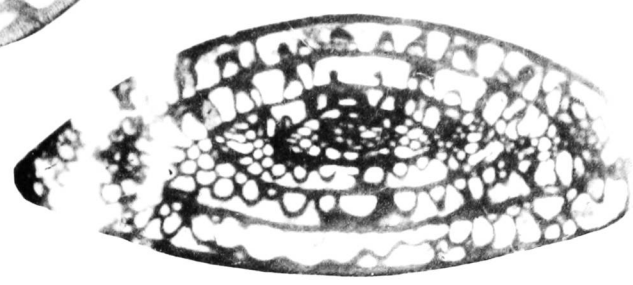

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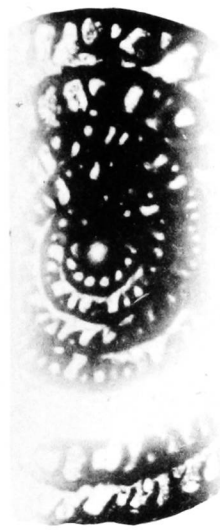

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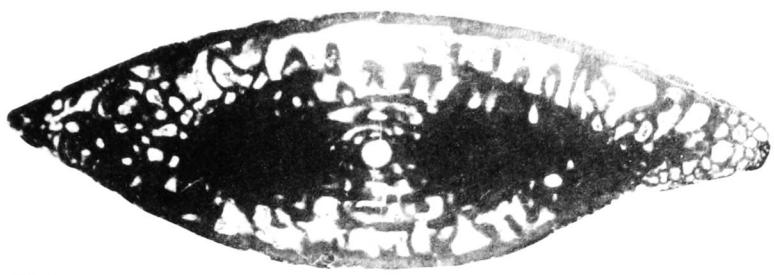

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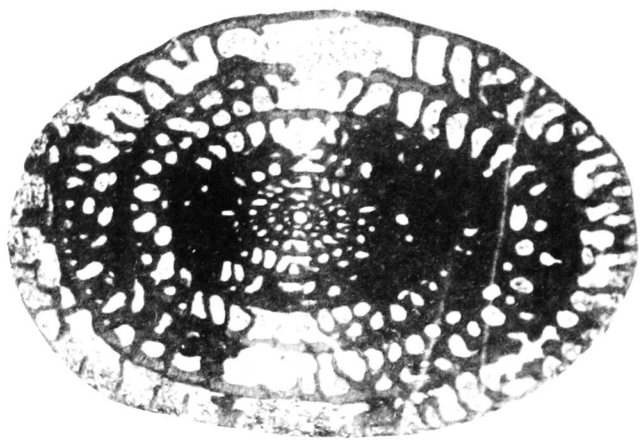

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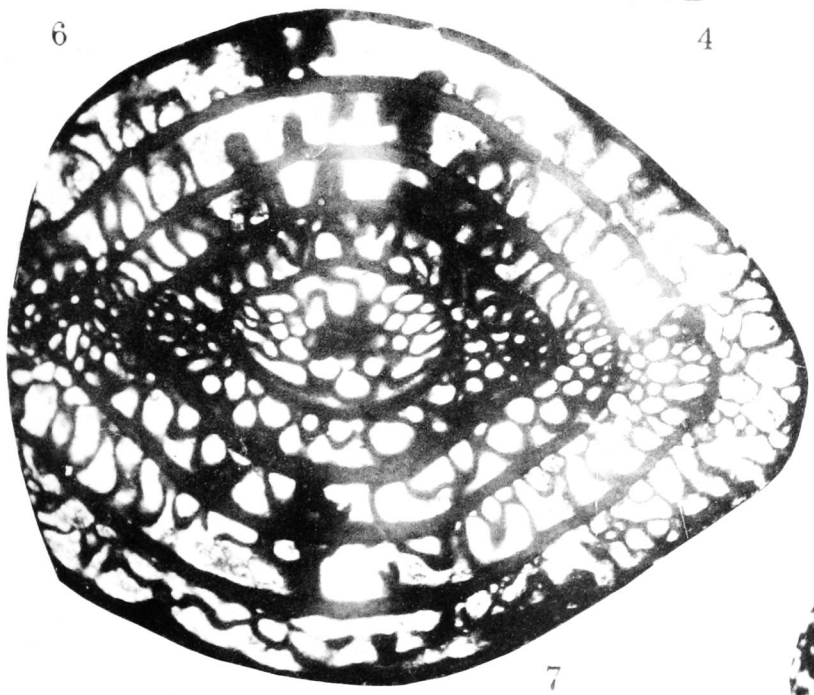

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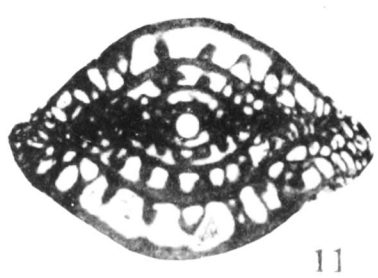

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EXPLANATION OF

PLATE IX

(1) 141

PLATE IX.

Figs. 1, 2. *Schellwienia verneuili* var *obtusa* Lee (var. nov.) p. 71.
From Yuehmenkou, 30 *li* west of Taiyuan. 山西太原西山月門溝廟溝石灰岩. ×15.

Figs. 3, 5. *Schellwienia vulgaris* var. *fusiformis* Schallwien em. Lee p. 67.
Fig. 3, a specimen from Yihsien, Shantung. 山東嶧縣. ×16.
Fig. 5, a specimen from Yaopo, Shahohsien, Chihli. 直隸沙河窰坡. ×15.

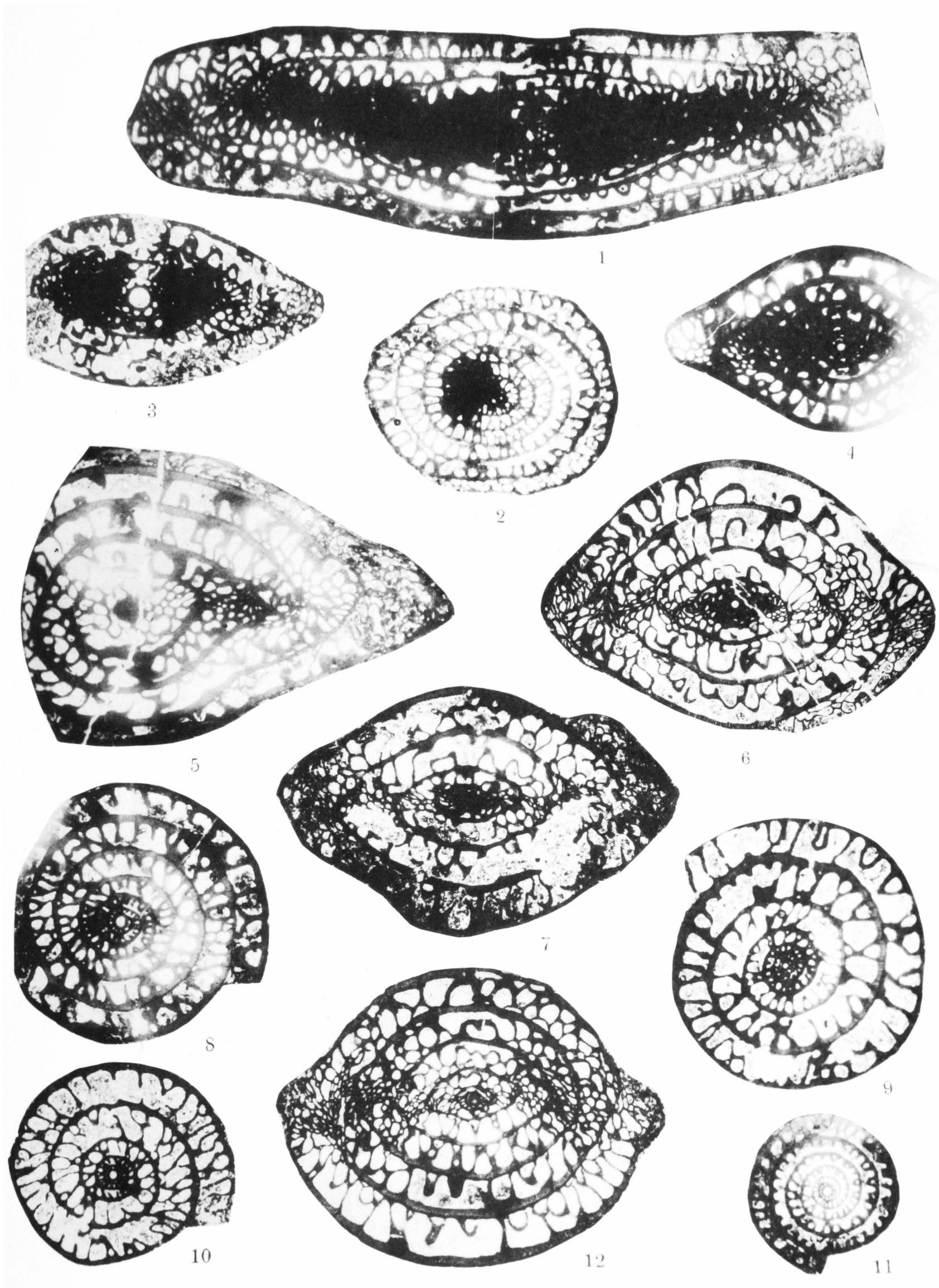
Figs. 4, 8. *Schellwienia vulgaris* var. *watanabei* Lee p. 64.
Hungshanyao, Kansu. 甘肅,永昌縣西五十里紅山窰. ×15.

Figs. 6, 7, 10. *Schellwienia vulgaris* var. (cf. *kozui*) p. 68.
Yihsien, Shantung. 山東嶧縣 ×15.

Fig. 11. *Schellwienia vulgaris* var. *minor* Lee (var. nov.) p. 66.
Hungshanyao, Kansu. 甘肅,紅山窰. ×15.

Fig. 12. *Schellwienia vulgaris* var. *globosa* Schellwien. p. 67.
Yihsien, Shantung. 山東嶧縣. ×16.

Fig. 9. *Schellwienia vulgaris* Schellwien p. 59.
A microspheric individual from Yihsien, Shantung. 山東嶧縣. ×16



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EXPLANATION OF

PLATE X

(1) 143

PLATE X.

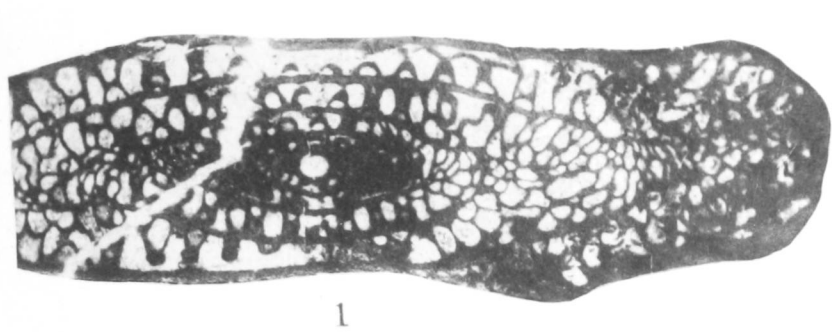
All figures magnified about 15 diameters.

Figs. 1-4. *Schellwienia verneuili* var. *levidensis* Lee (var. nov.) p. 72.
Fuching Limestone, Liuhokou, Honan. 河南六河溝復青石灰岩.

Figs. 5, 6. *Schellwienia* cf. *lutugini* Schellwien p. 76.
Yaoku Limestone, Pinting Basin, Shansi. 山西陽泉腰固石.

Figs. 7-12. *Schellwienia acuta* Lee p. 79.
Fig. 7, a diagonal section, Fig. 8, an axial section of specimens from the Fuching Limestone, Taichai, S. Chihli. 直隸南部台寨復青石灰岩.
Figs. 9, 10, 11. Specimens from the Fuching Limestone, Liuhokou, Honan. 河南六河溝復青石灰岩.
Fig. 12. A young individual from the Fuching Limestone, Liuhokou. 六河溝復青石灰岩.

Figs. 13-17 *Schellwienia cervicalis* Lee p. 77.
Fig. 13. Axial section of a typical specimen (macrospheric type?) from the Shanching Limestone, Liuhokou, Honan. 六河溝山青石灰岩.
Figs. 14, 15, an axial and a diagonal section of ?microspheric individuals from the Fuching Limestone, Shimiao. 直隸磁縣彭城東南十五里石廟復青石灰岩.
Fig. 16. A median section, slightly oblique, Fuching Limestone, Shimiao. 石廟復青石灰岩.
Fig. 17. A submedian section showing deeply furrowed spirotheca, Shanching Limestone, Liuhokou, Honan. 河南六河溝山青石灰岩.



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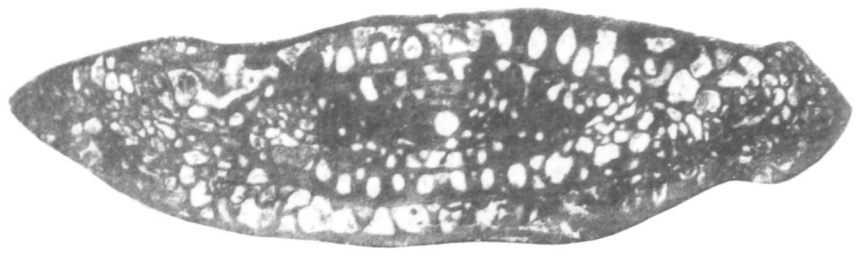

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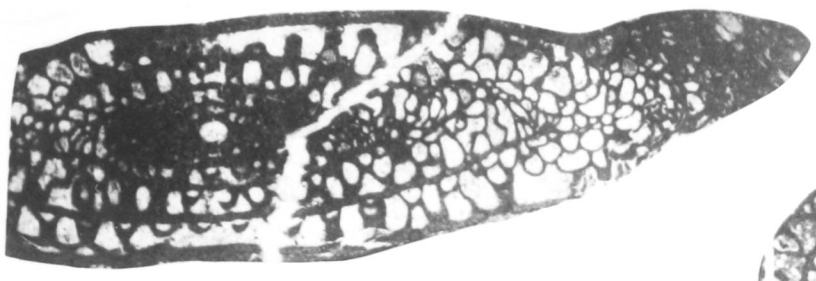

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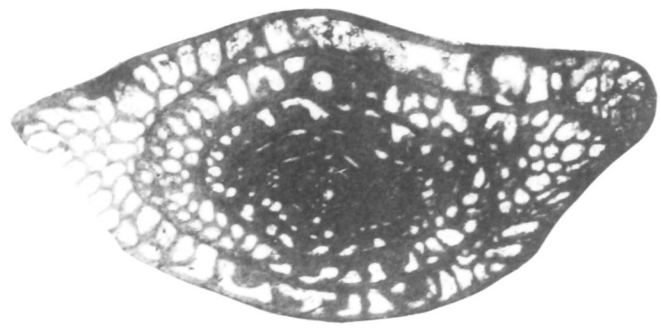

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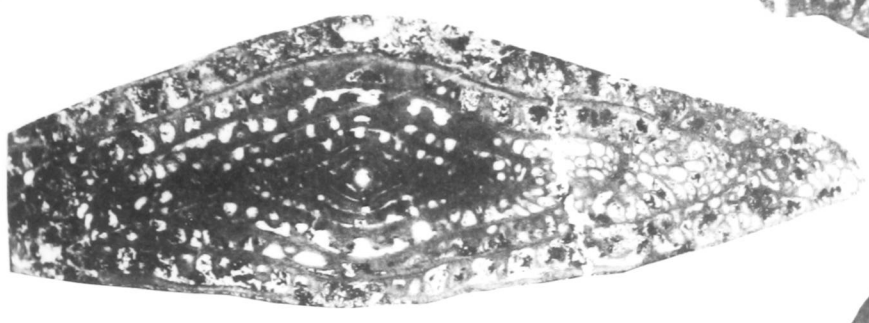

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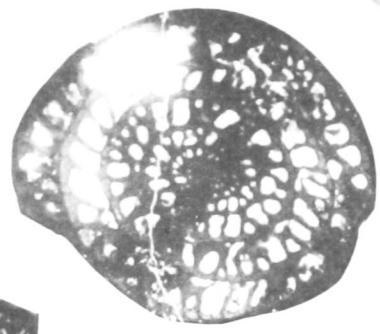

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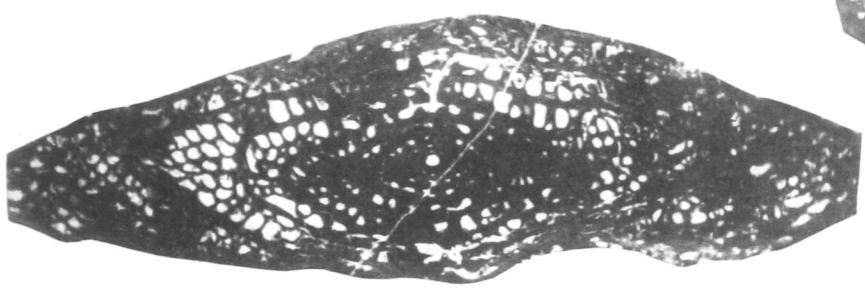

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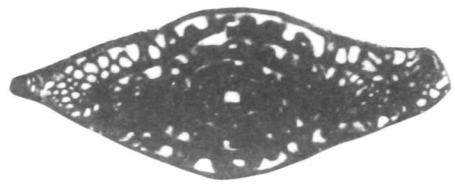

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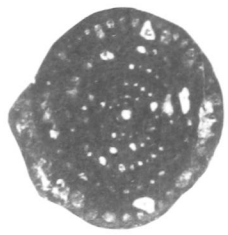

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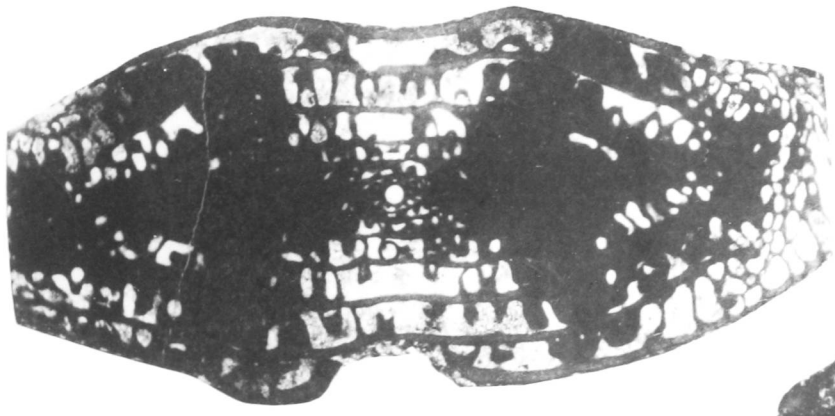

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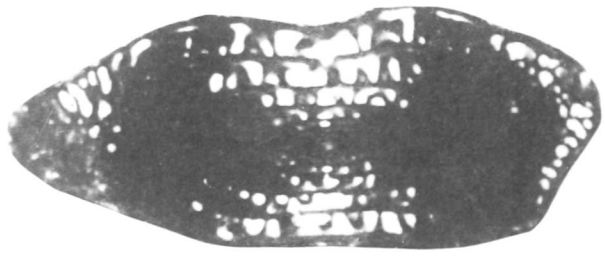

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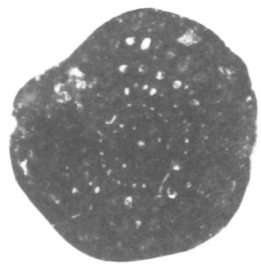

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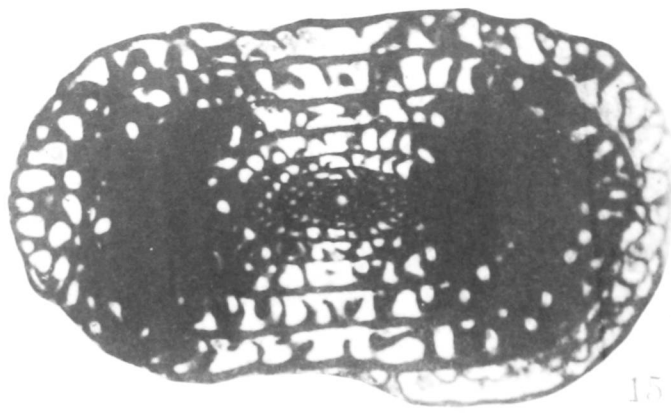

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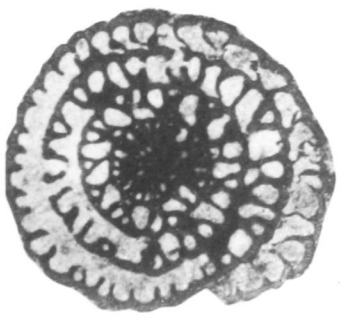

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16

EXPLANATION OF

PLATE XI

PLATE XI.

All figures magnified about 15 diameters.

Figs. 1-5. *Schellwienia expansa* Lee p. 80.

Fig. 1. Axial section of a typical specimen from the Taching Limestone, Taichai, S. Chihli. 直隸磁縣台寨大青石灰岩.

Fig. 2. An individual with a slight median depression, Houshi Limestone, Pinting Basin, Shansi. 山西陽泉猴石.

Fig. 3. An elongated and recurved form showing a close affinity with *Schellwienia richthofeni*. Miaokou Limestone, Shansi. 山西廟溝石灰岩.

Figs. 4, 5. Two median section; Fig. 4, a specimen from the Houshi Limestone (陽泉,猴石), and Fig. 5, from the Hsiaoching Limestone, Liuhokou. (河南六河溝小青石灰岩).

Figs. 6-10. *Schellwienia richthofeni* Schwager p. 88.

Fig. 6. A form closely related to *Schellwienia expansa* Yangshukou Limestone, Wuhutsui, S. Manchuria. 奉天,五湖嘴楊樹溝石灰岩.

Fig. 7. A young individual from the Houshi Limestone, Pinting Basin, Shansi. 山西陽泉猴石.

Fig. 8. A slender form from the Hsinho Limestone, Hsinho, Kansu. 甘肅山丹縣西四十里新河.

Fig. 9. A form approaching *Schellwienia complicata*, Chientaokou Limestone, east of Taiyuan. 山西太原東南十五里澗道溝石灰岩.

Fig. 10. A specimen with its outermost whorl removed, Shanching Limestone, Taichai, S. Chihli. 直隸台寨青石灰岩.

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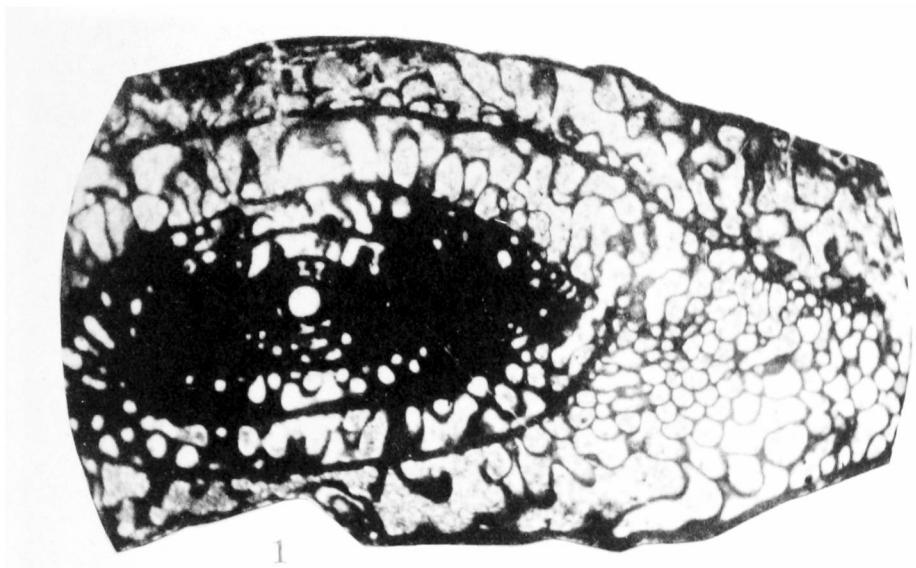

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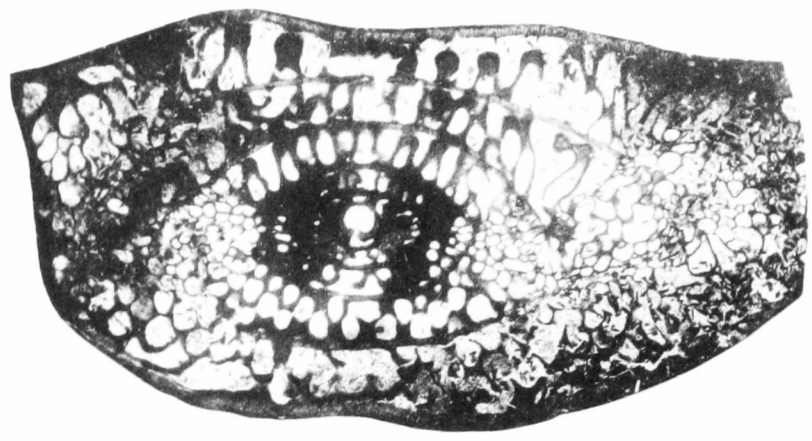

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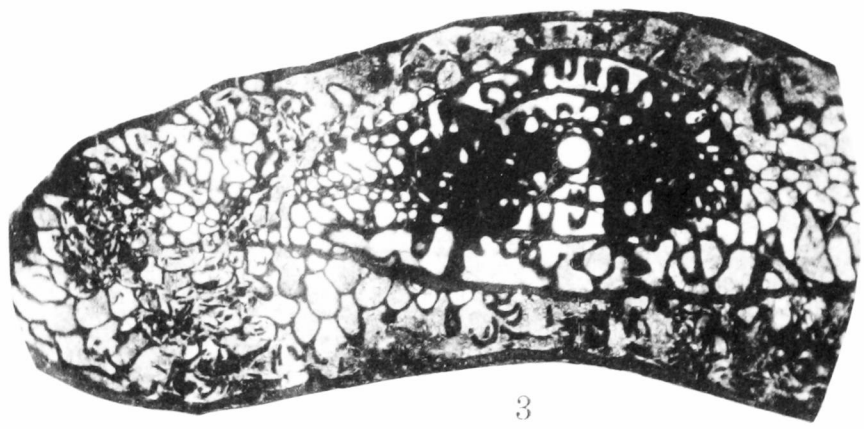

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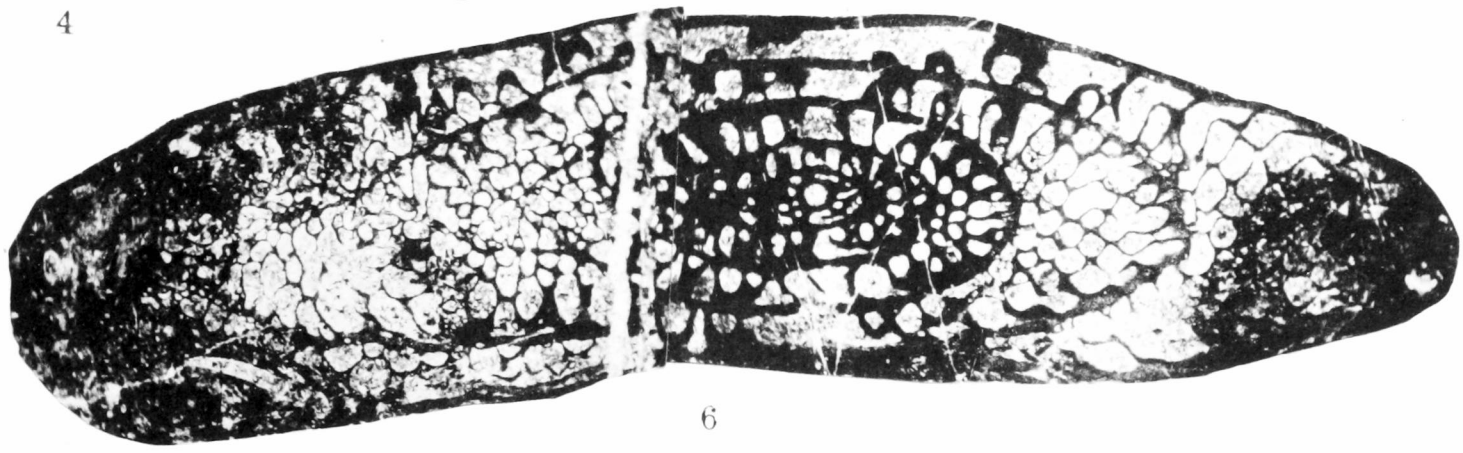

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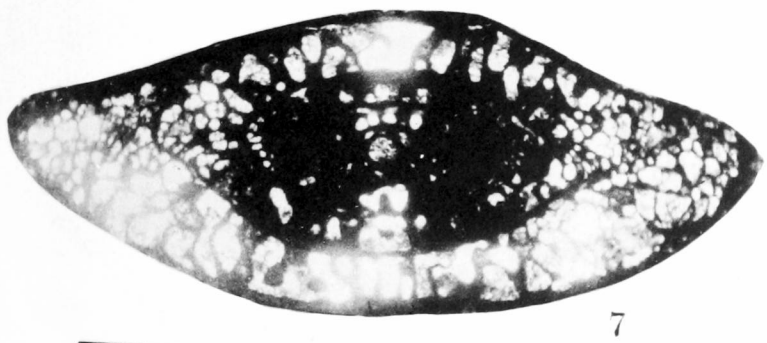

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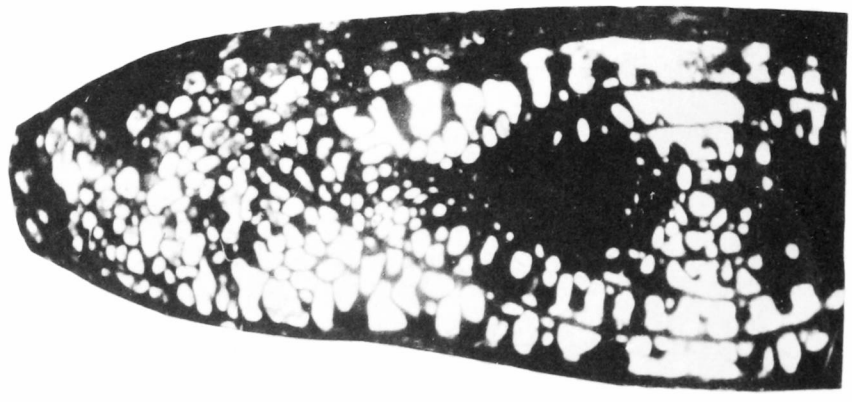

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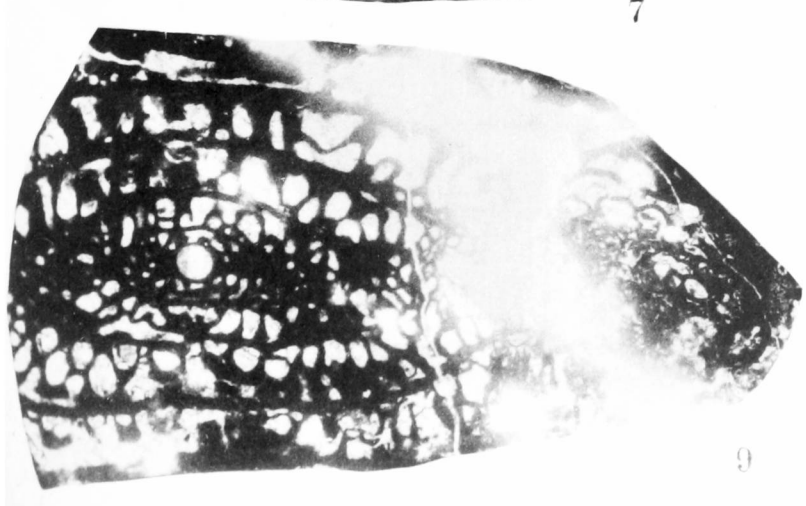

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EXPLANATION OF

PLATE XII

(1) 147

PLATE XII.

All figures magnified about 15 diameters.

Fig. 1, 2, 4, 5, 7. *Schellwienia richthofeni* Schwager p. 88.

Fig. 1. Axial section of a typical specimen showing the conical shape of the umbilical ends and the complicated folds of the antethecæ in the umbilical regions. Fuching Limestone, Taichai, S. Chihli. 直隸南部台寨復青石灰岩.

Fig. 2, 7. Two typical median sections; Fig. 2, a specimen from the Houshi Limestone, Pinting Basin, Shansi, (陽泉,猴石), Fig. 7, from the Fuching Limestone, Taichai. (台寨復青石灰岩).

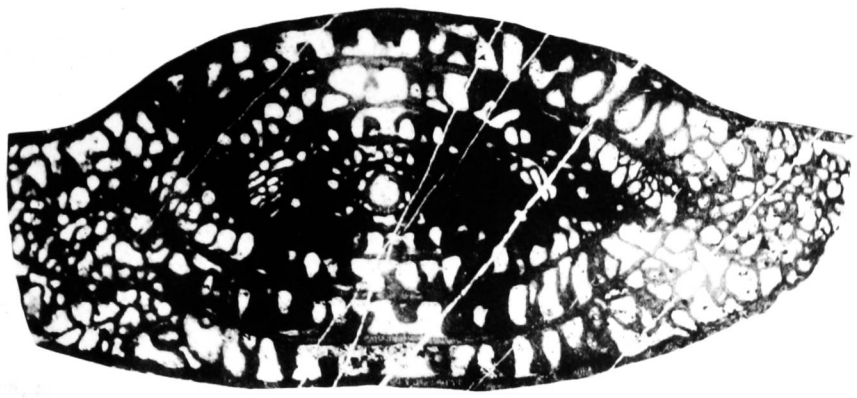
Fig. 4. Para-axial section of a young individual, Yaoku Limestone, Pinting Basin, Shansi. 山西陽泉腰固石.

Fig. 5. A form approaching *Schellwienia complicata*, Chientaokou Limestone, Eastern Hills of Taiyuan. 山西太原東山澗道溝石灰岩.

Figs. 3, 6, 8. *Schellwienia richthofeni* var. *speciosa* Lee (var. nov.) p. 92.

Fig. 3. Hsiaoching Limestone, Liuhokou. 河南六河溝小青石灰岩.

Fig. 6, 8. Two axial sections showing the median vaulting and stumpy ends, from the Fuching Limestone, Taichai, Chihli. 直隸台寨復青石灰岩.



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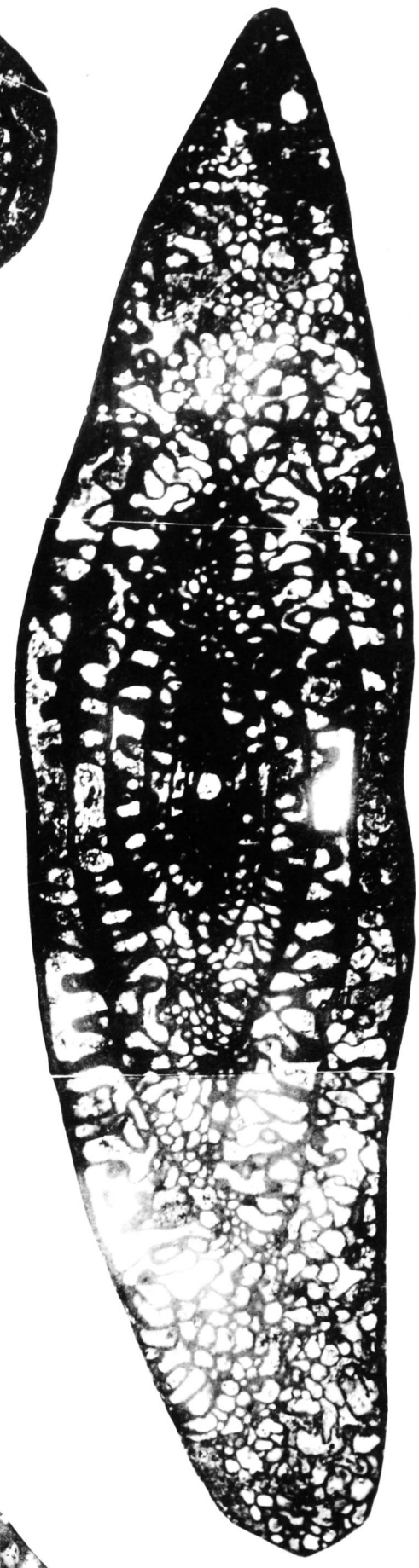

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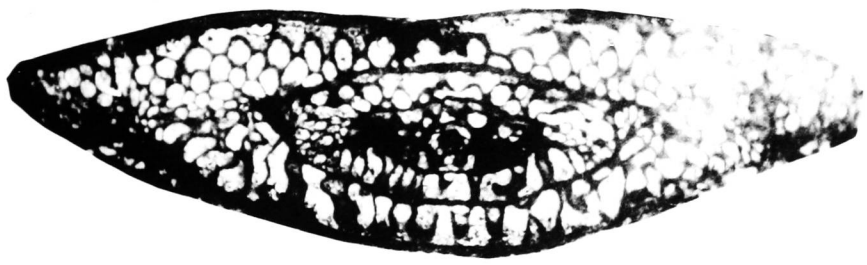

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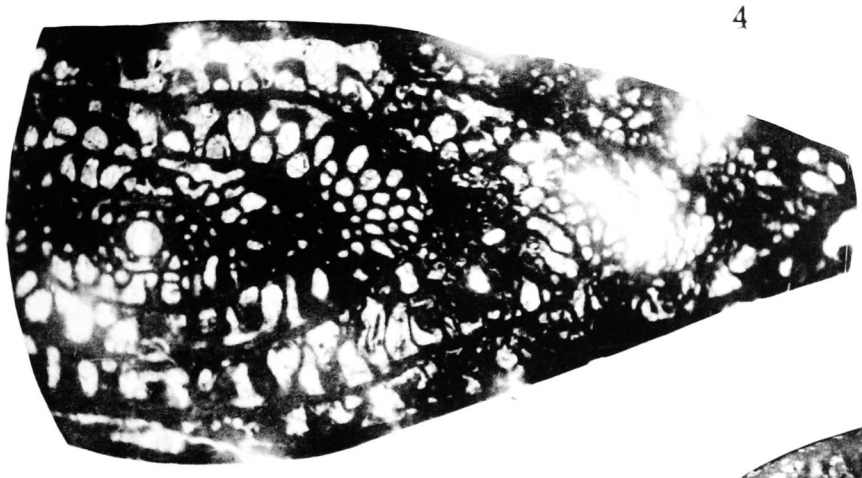

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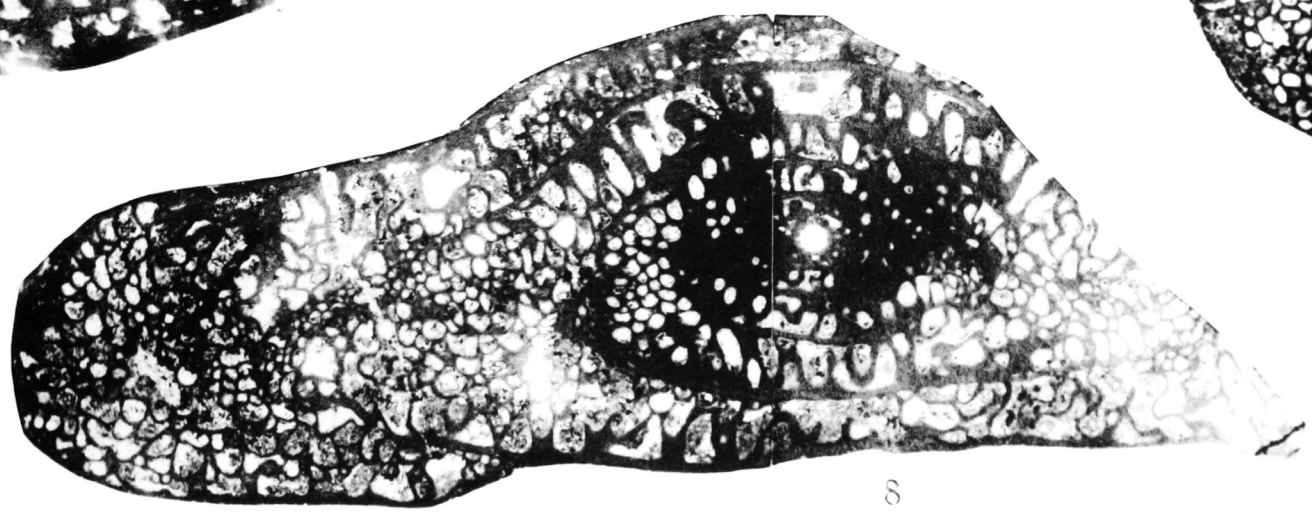

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EXPLANATION OF
PLATE XIII

(1) 149

PLATE XIII.

All figures magnified about 15 diameters.

Figs. 1-8. *Schellwienia japonica* Gümbel p. 82.

Figs. 1, 2. Highly vaulted forms from the Fuching Limestone, Shimiao, S. Chihli.

Fig. 3. A typical specimen from the Fuching Limestone, Taichai, S. Chihli. 直隸南部台寨復青石灰岩.

Fig. 4. A specimen from the Shanching Limestone, Taichai. 台寨山青石灰岩.

Figs. 5, 6. Axial sections, Fuching Limestone, Shimiao, Chihli. 直隸磁縣石廟復青石灰岩.

Figs. 7, 8. Axial sections, Shanching Limestone, Taichai, Chihli. 台寨山青石灰岩.

Figs. 9, 10. *Schellwienia japonica* var. *hayasakai* Lee (var. nov.) p. 85.

Shanching Limestone, Taichai. 台寨山青石灰岩.

Figs. 11-13. *Schellwienia complicata* Schellwien p. 86.

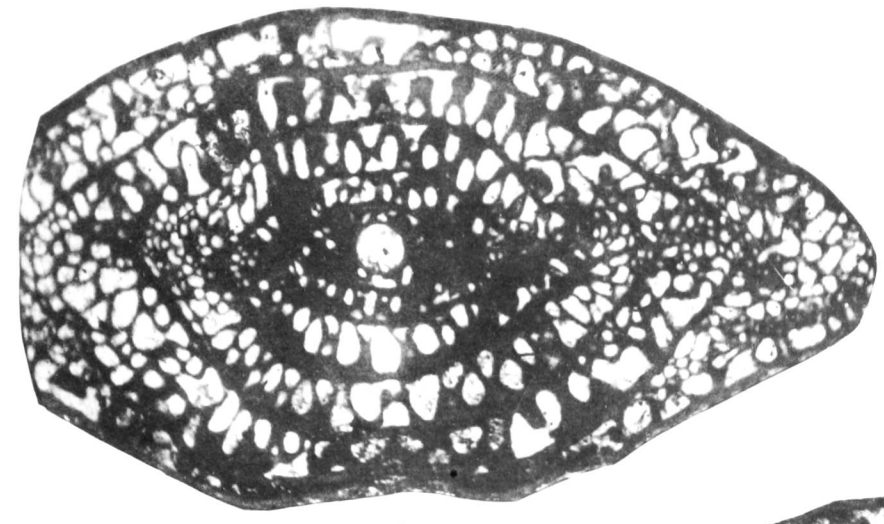
Fig. 11. A young individual from Hsinho, Kansu. 甘肅新河.

Fig. 12. Axial section of a fairly common form in the Hsinho fauna, Hsinho, Kansu. 甘肅新河.

Fig. 13. Median section of an individual showing some Affinity with *Schellwienia prisca* and *Schell. regularis*, Hsinho, Kansu. 甘肅新河.

J. S. Lee: Fusulinidæ of North China

Pl. XIII.



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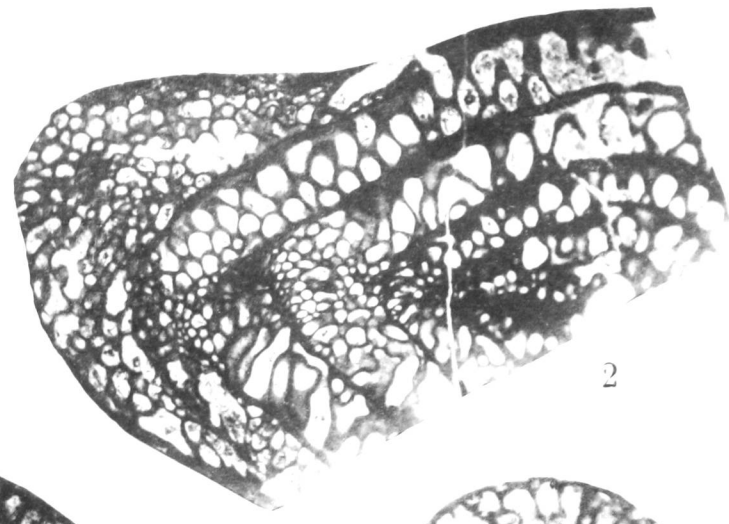

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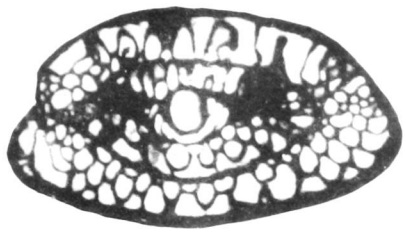

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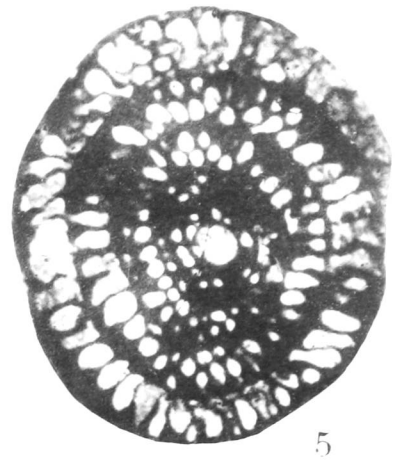

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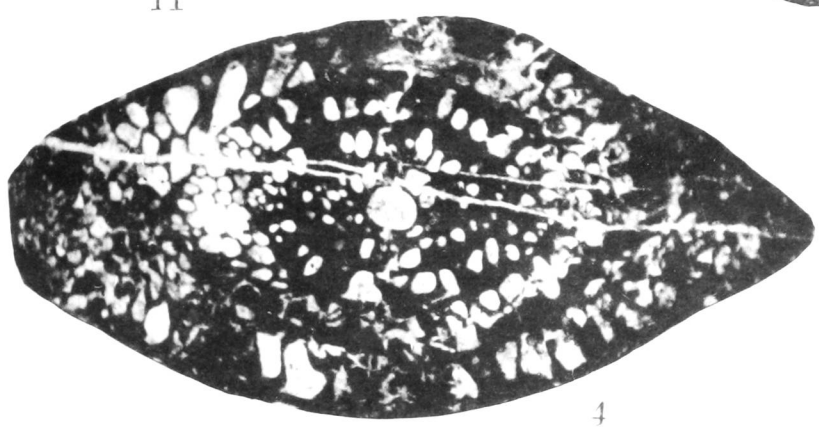

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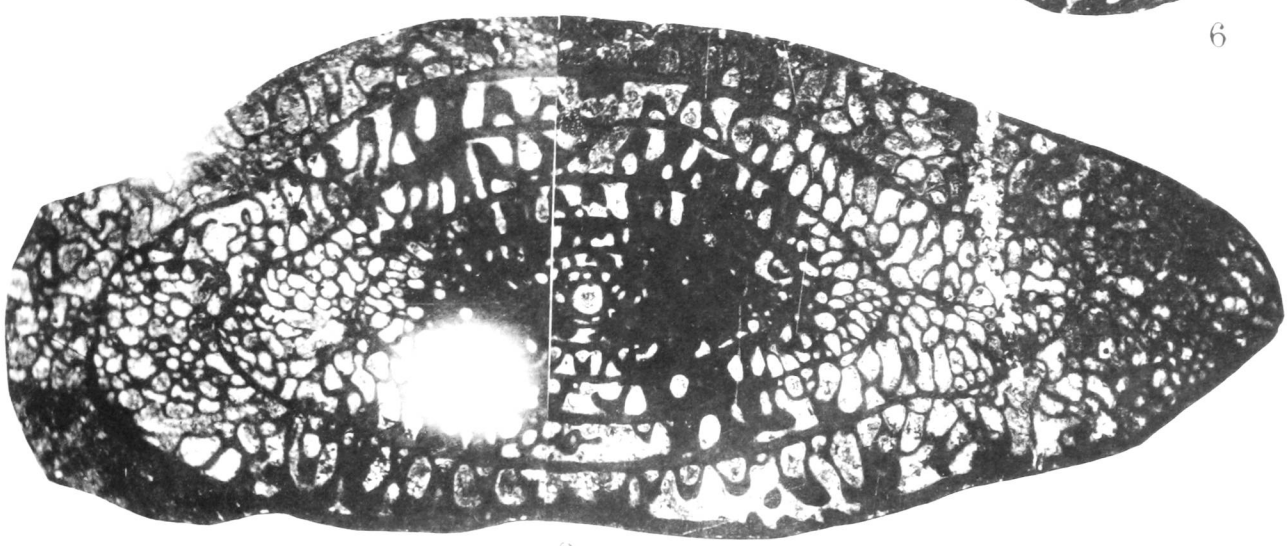

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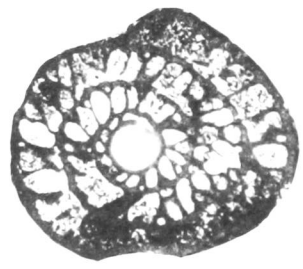

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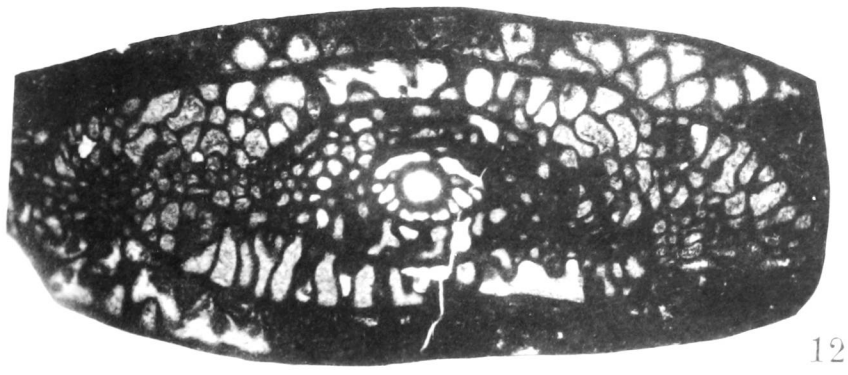

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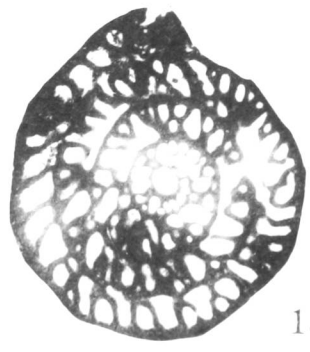

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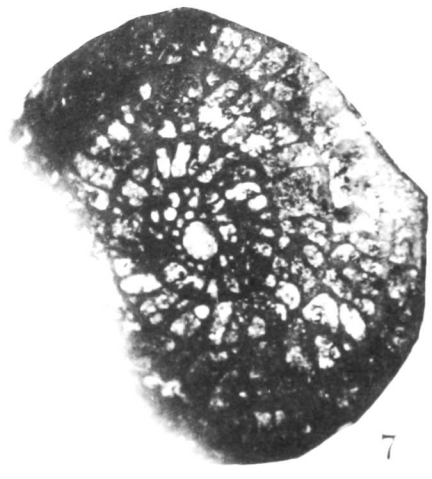


7

EXPLANATION OF

PLATE XIV

PLATE XIV.

All figures magnified about 15 diameters.

Figs. 1-12. *Schellwienia complicata* Schellwien p. 86.

Fig. 1. A typical median section from the Houshi Limestone, Pinting Basin, Shansi. 山西陽泉猴石.

Figs. 2-4, 10-12. Typical specimens from the Hsinho Limestone, Hsinho, Kansu. 甘肅新河.

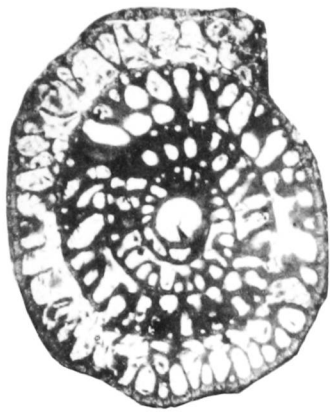
Fig. 7. A specimen singularly recalling Schellwien's type-form figured in Palæontographica Bd. XLIV, Taf. XX, Fig. 3. Yaoku Limestone, Pinting Basin, Shansi. 山西陽泉腰固石.

Fig. 5. A fairly common form in the Yaoku Limestone, Pinting Basin, Shansi. 山西陽泉腰固石.

Fig. 6. A variety showing some affinity with *Schellwienia prisca*, Hsinho Limestone, Kansu. 甘肅新河.

Fig. 8. A variety showing some affinity with *Schellwienia alpina*, Hsinho Limestone, Kansu. 甘肅新河.

Fig. 9. A young individual from the Hsinho Limestone, Kansu. 甘肅新河.



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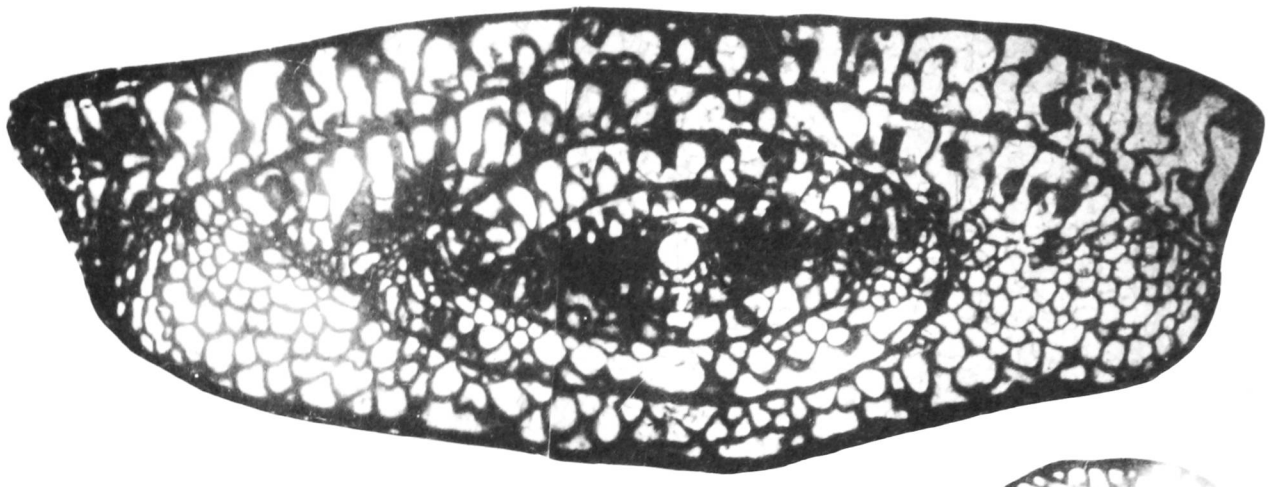

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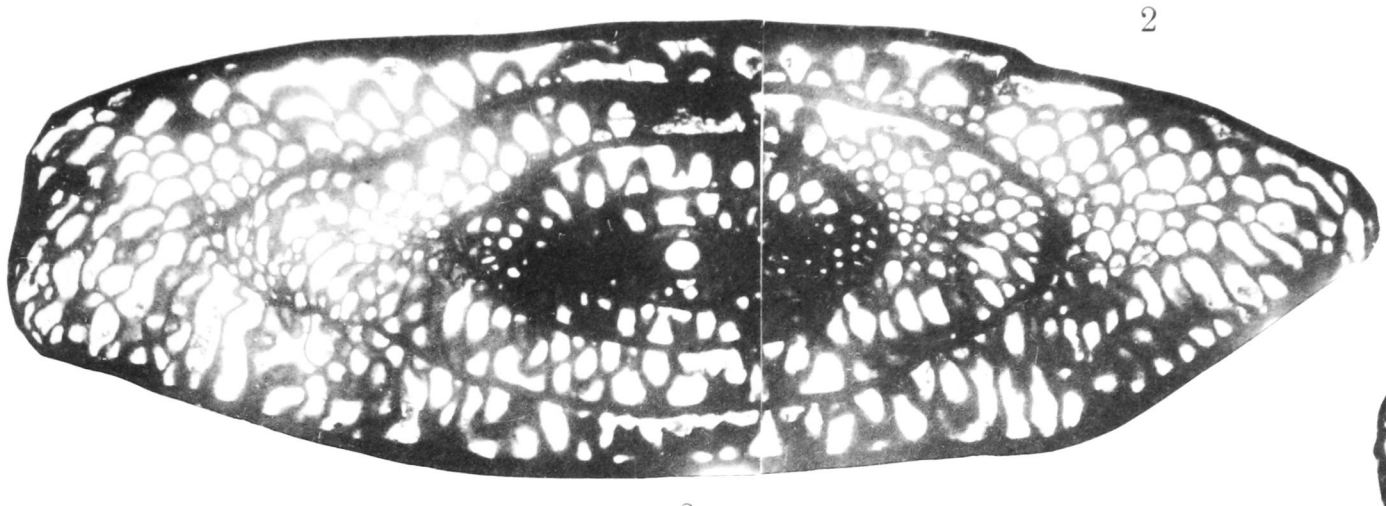

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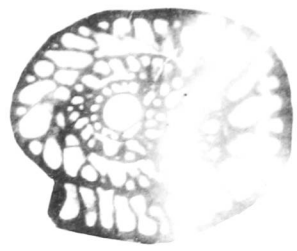

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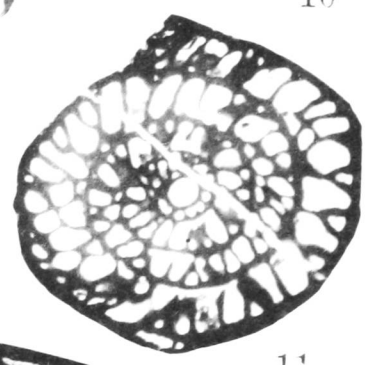

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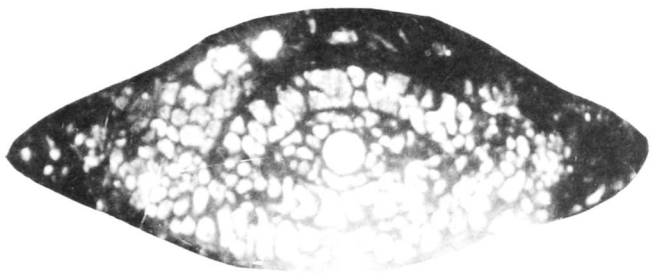

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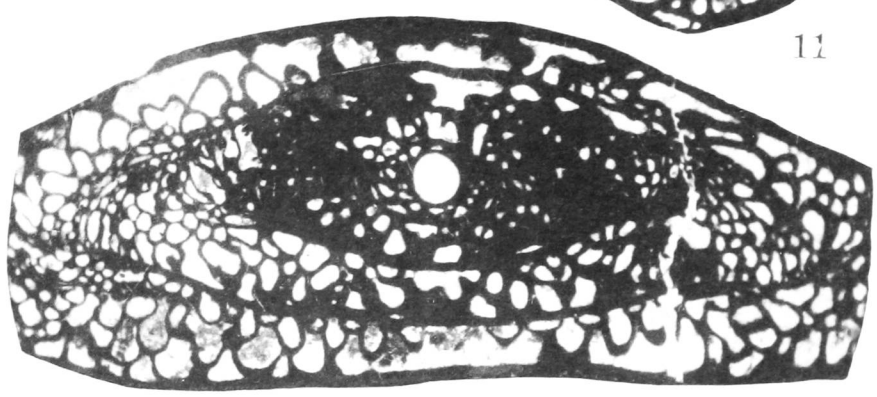

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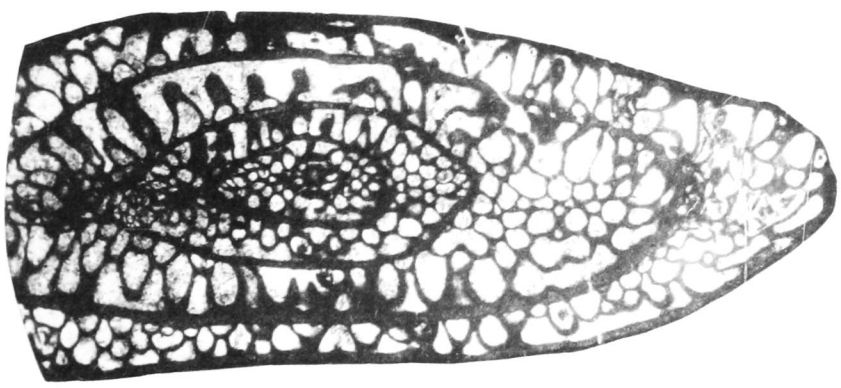

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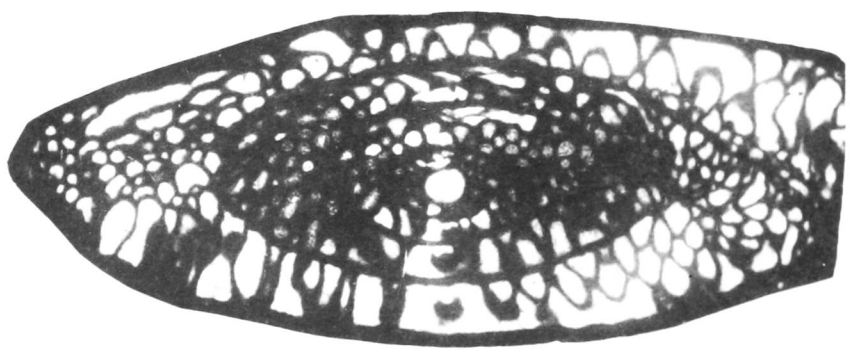

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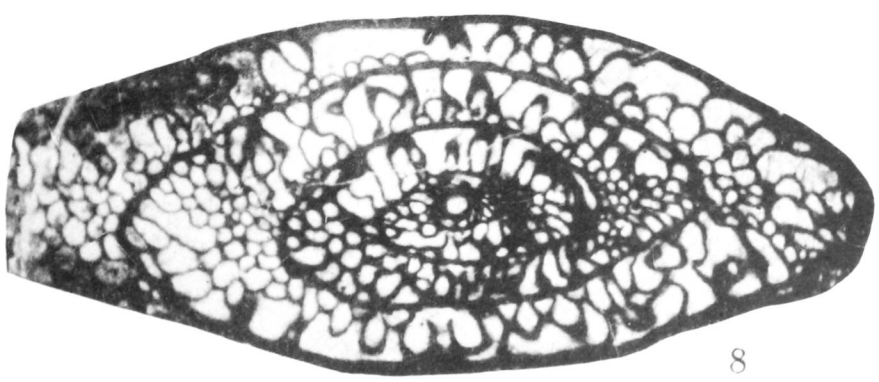

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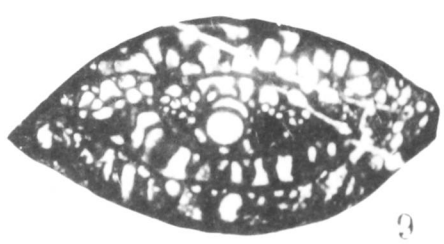

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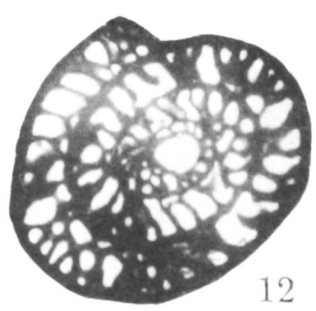

12

EXPLANATION OF

PLATE XV

(1) 153

PLATE XV.

All figures magnified about 15 diameters.

Figs. 1-11. *Schellwienia alpina* Schellwien p. 94.

Typical specimens showing the extraordinarily irregular folding of the antethecæ and variously contorted and deeply furrowed test. Yatzetsi, Shenhsien, Honan. 河南陝縣鴨子嘴.

Figs. 12-16. *Schellwienia plicata* Lee p. 92.

Figs. 12, 13. Diagonal sections from the Yehching Limestone, Shimiao, S. Chihli. 直隸南部石廟野青石灰岩.

Figs. 15, 16. Median sections of specimens from the same limestone and the same locality as indicated above.

Fig. 14. A nearly axial section of a small (young?) individual from the Hsinho Limestone, Kansu, found in association with *Schellwienia alpina*. 甘肅新河.

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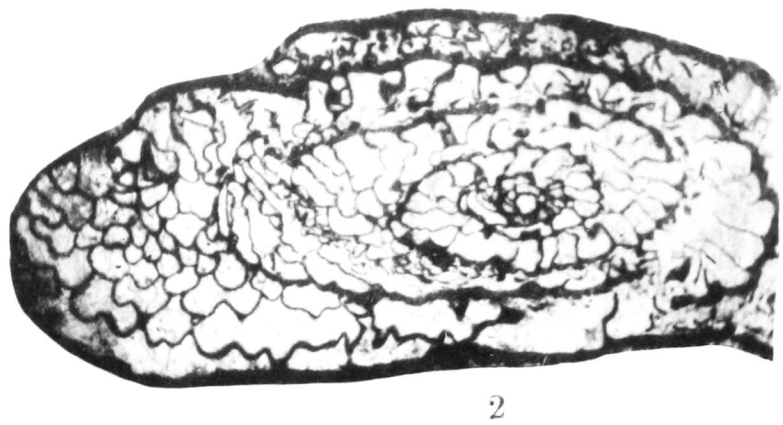

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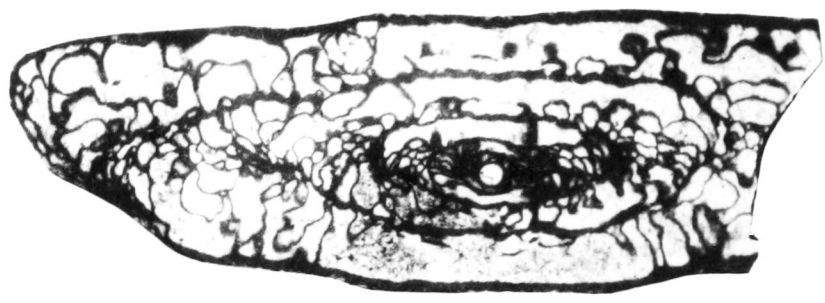

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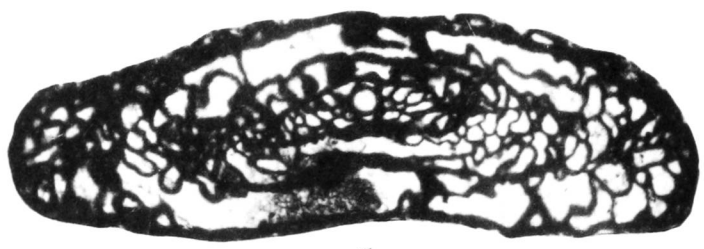

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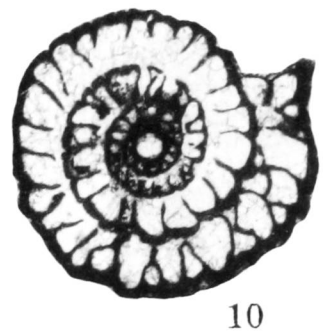

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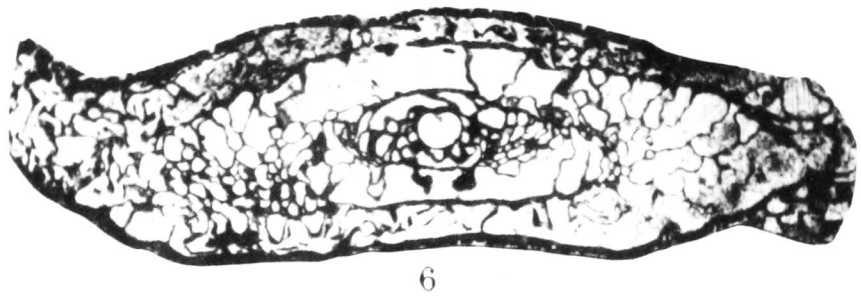

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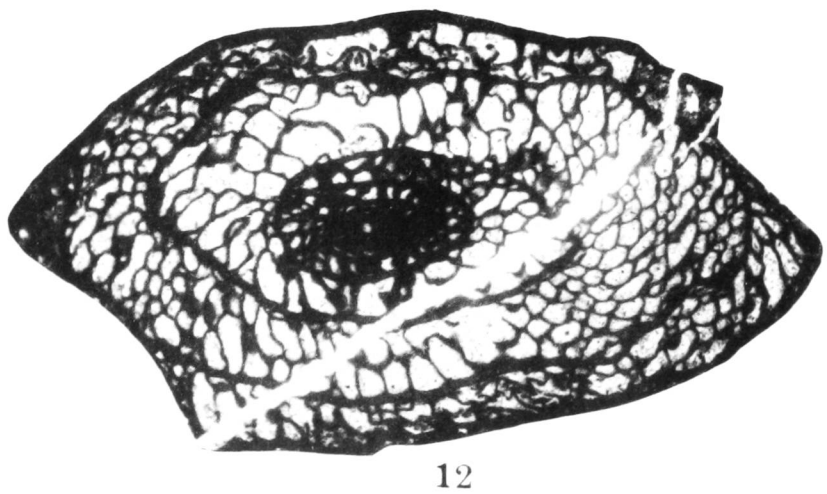

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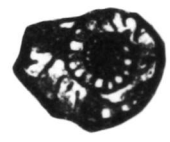

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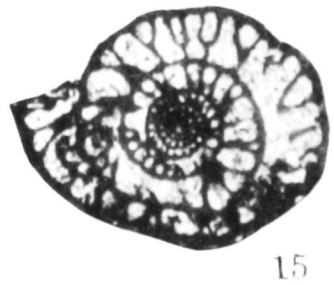

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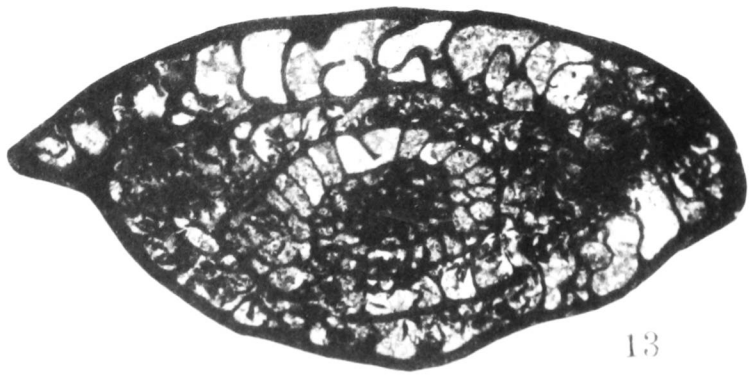

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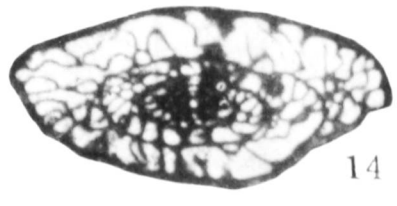


14

EXPLANATION OF

PLATE XVI

PLATE XVI.

All figures magnified about 15 diameters.

Fig. 1-3. *Schellwienia oblonga* Ozawa — p. 96.

Fig. 1. A nearly axial section.
Figs. 2, 3. Median sections.
Hsinho, Kansu. 甘肅新河.

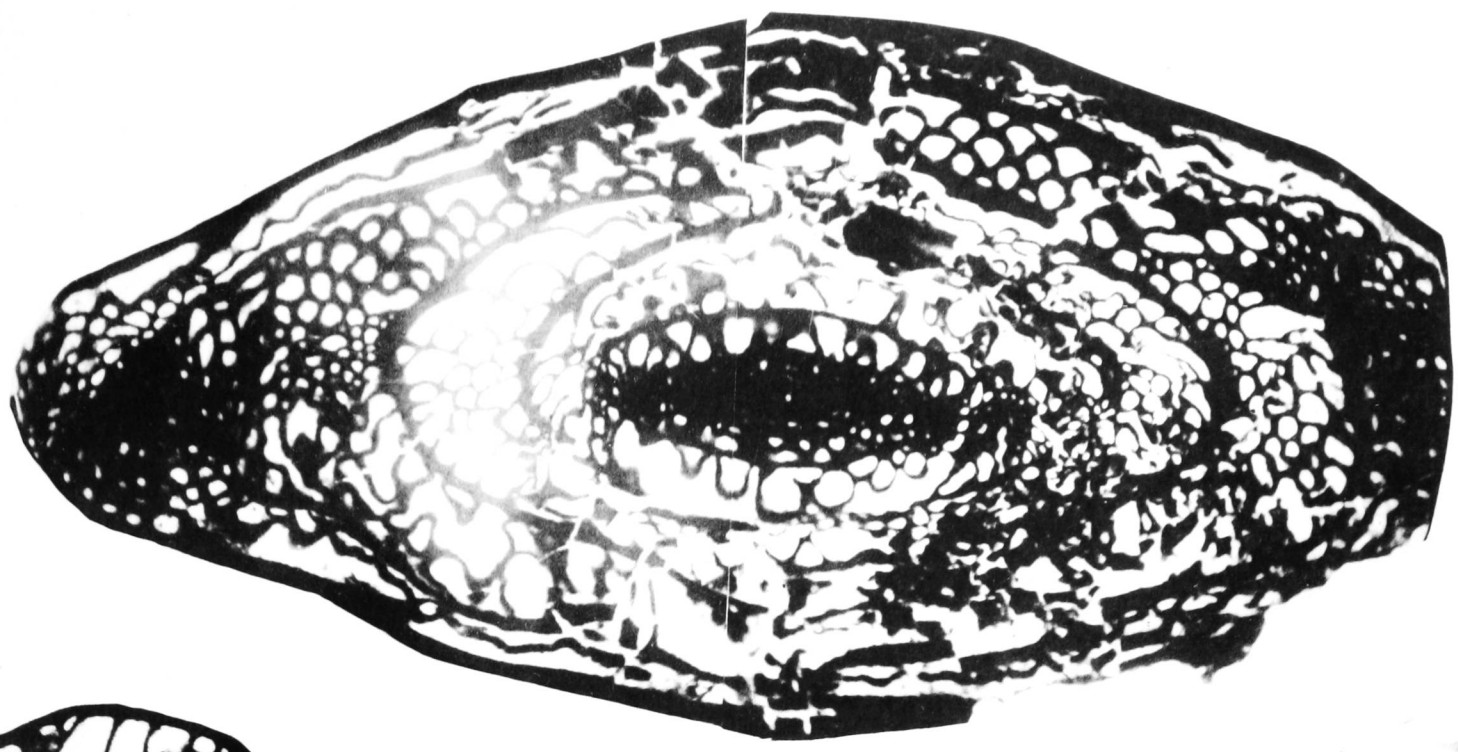
Figs. 4-11. *Schellwienia pusilla* Schellwien — p. 104.

Figs. 4, 7, 8. Specimens from a point 60 *li* north of Hsinanhsien, N. Honan. 河南新安縣北六十里.

Figs. 5, 6, 9-11. Specimens from the Paoteh Limestone, Paotehchou, Shansi. 山西保德保德石灰岩.

Figs. 12, 13. *Schellwienia pailensis* Schwager — p. 107.

Forms showing a strong affinity with *Schellwienia pusilla*, Hsinanhsien, N. Honan. 河南新安縣北六十里.



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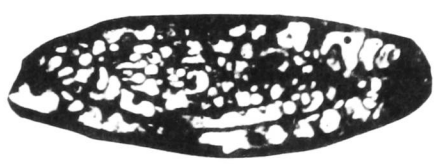

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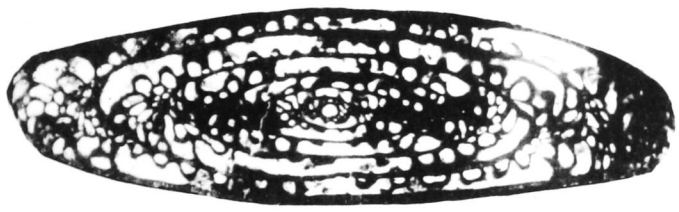

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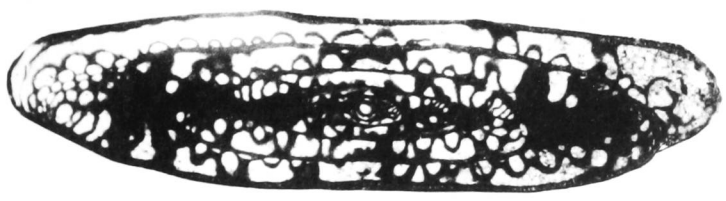

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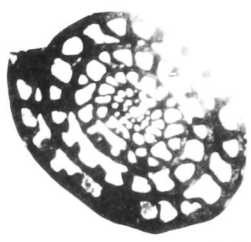

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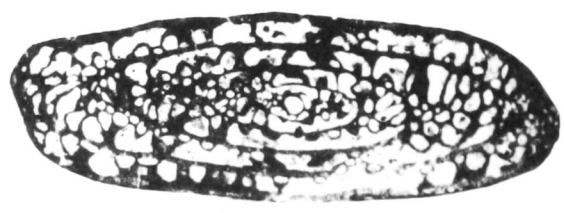

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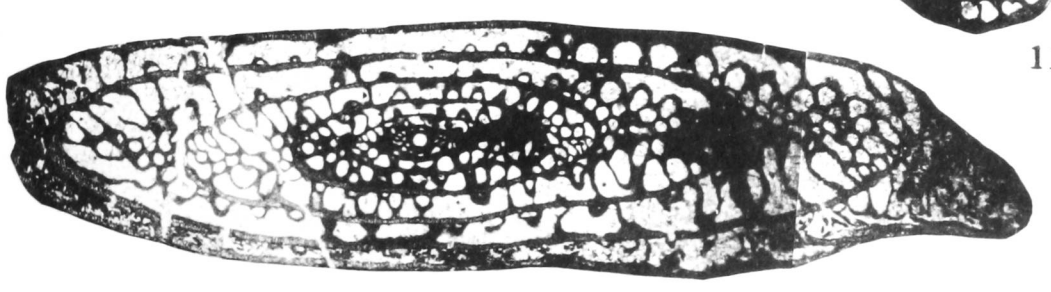

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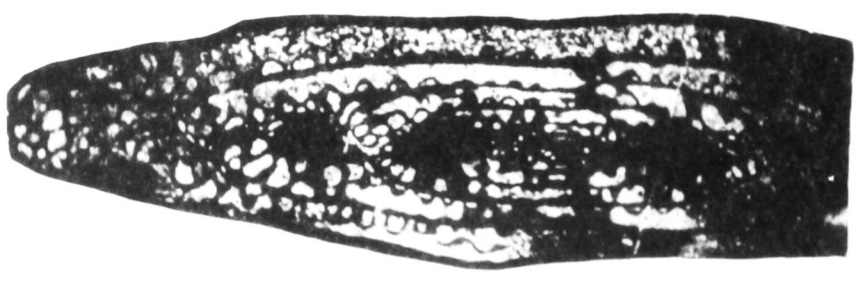

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10

EXPLANATION OF

PLATE XVII

PLATE XVII.

All figures magnified about 15 diameters.

Figs. 1-3. *Schellwienia pailensis* Schwager. p. 107.

Typical specimens from a point 60 *li* north of Hsinanhsien, N. Honan. 河南新安.

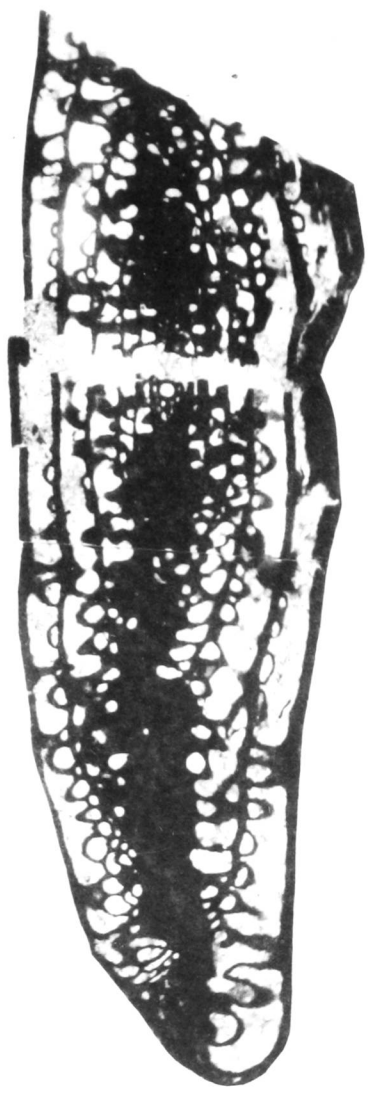
Figs. 4-8. *Schellwienia erucaria* Schwager. p. 109.

Figs 4, 7. Typical specimens from the Kushi Limestone, Pinting Basin, Shansi. 山西陽泉固石.

Fig. 5. An axial section parallel to the plane of axial curvature. Hsinan, N. Honan. 河南新安.

Fig. 6. An axial section perpendicular to the plane of axial curvature. Hsinan, N. Honan. 河南新安.

Fig. 8. An abnormal specimen with a large and irregularly shaped initial chamber. 河南新安.



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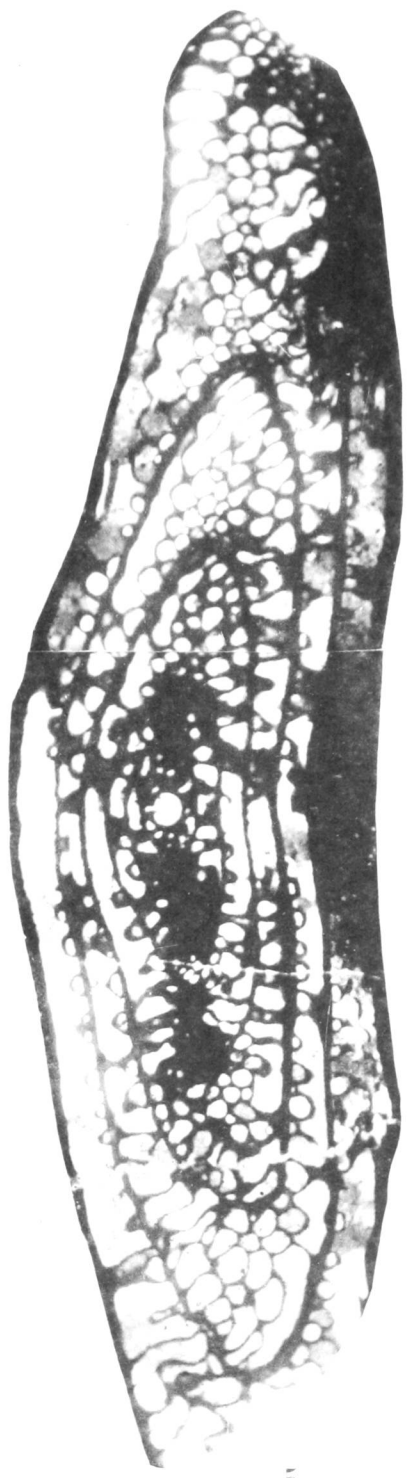

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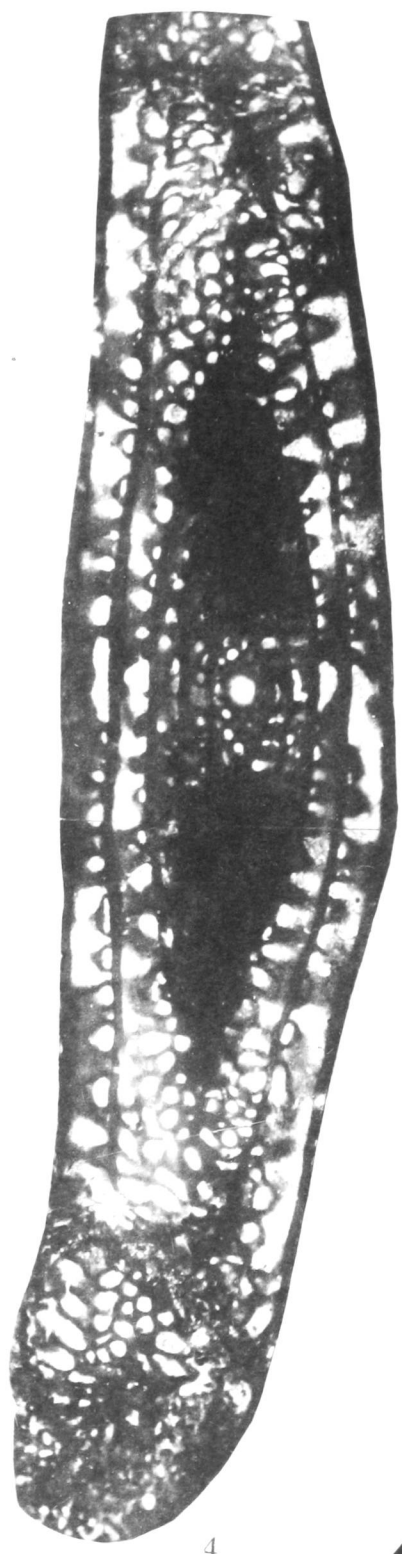

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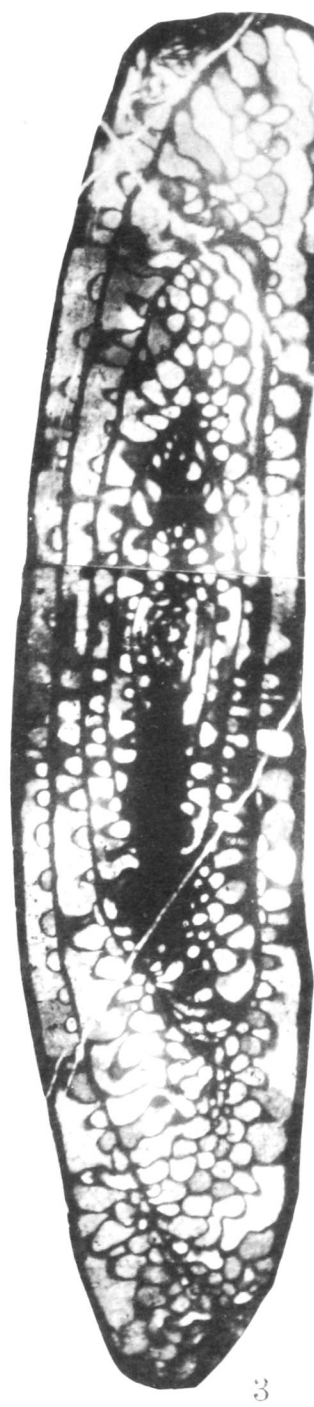

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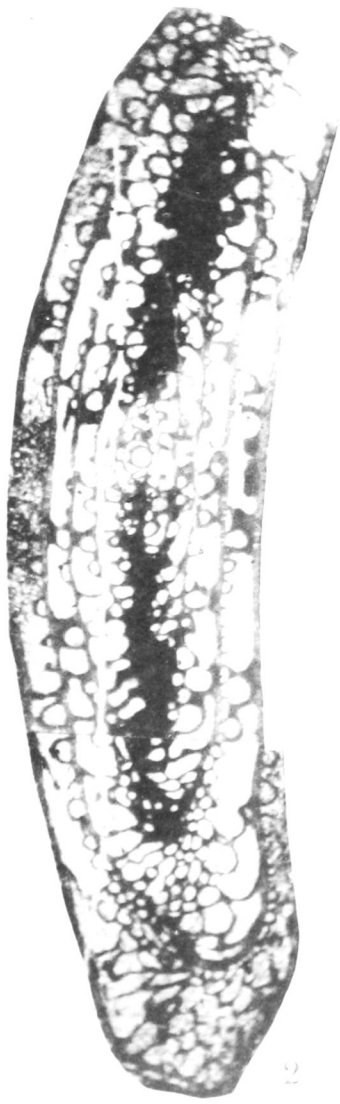

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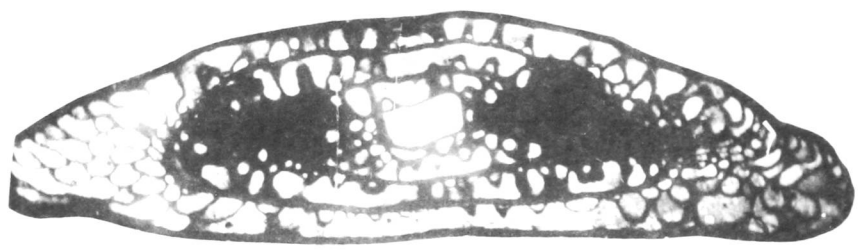

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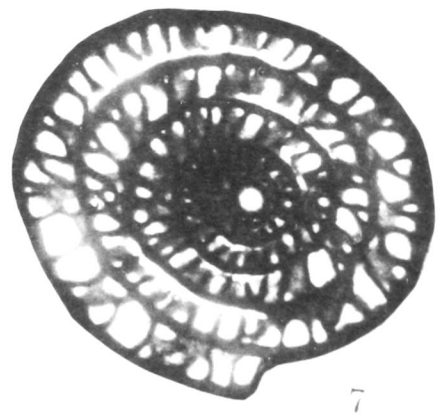

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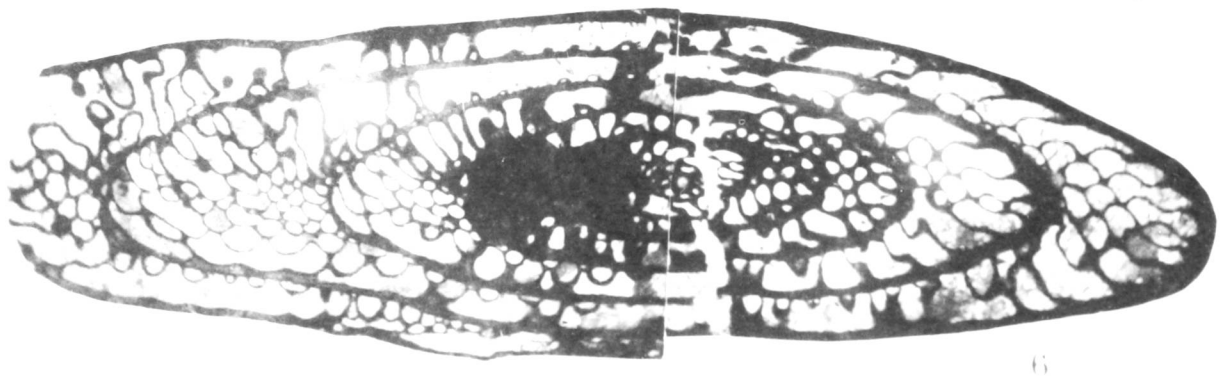

6

EXPLANATION OF

PLATE XVIII

(1) 159

PLATE XVIII.

All figures magnified about 15 diameters.

Figs. 1-10. *Schellwienia subnathorsti* Lee p. 102.

Figs. 1, 5, 7, 8, 10. Typical specimens from the Hsiaoching Limestone, Taichai, Chihli. 直隸台寨小青石灰岩.

Figs. 2, 9. Axial and median sections of slightly elongated and compactly coiled forms from the Shanching Limestone, Shimiao, S. Chihli. 直隸南部石廟山青石灰岩.

Fig. 3. Axial section of a rather loosely coiled variety from the Miaokou Limestone, Western Hills of Taiyuan, Shansi. 山西太原西山廟溝石灰岩.

Fig. 4. An elongated variety from Hsinan, N. Honan. 河南新安.

Fig. 6. A large variety showing a close relation to *Schellwienia nathorsti*, Suchieh Limestone, Pinting Basin, Shansi. 山西陽泉四節石灰岩.

Fig. 11. An intermediate form between *Schellwienia subnathorsti* and *Schell. nathorsti*, Chienshi Limestone, Pinting Basin, Shansi. 山西陽泉錢石.

Figs. 12, 13. *Schellwienia subnathorsti* var. From Hsinan, Honan, closely related to another undetermined variety figured in this plate (see Fig. 4) 河南新安.

Figs. 14-19. *Schellwienia nathorsti* Staff-Wedekind p. 98.

Figs. 14, 15. Axial sections of typical specimens from the Suchieh Limestone, Pinting Basin, Shansi. 山西陽泉四節石.

Fig. 16. A fairly common form in the Suchieh Limestone. Pinting Basin. 陽泉四節石.

Fig. 17. Median section, Miaokou Limestone, Western Hills of Taiyuan. 山西太原西山廟溝石灰岩.

Fig. 18, 19. Median sections. Suchieh Limestone, Pinting Basin, Shansi 陽泉四節石灰岩.

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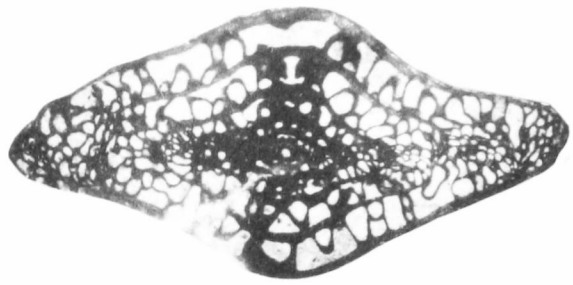

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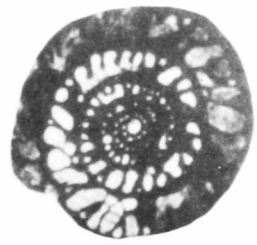

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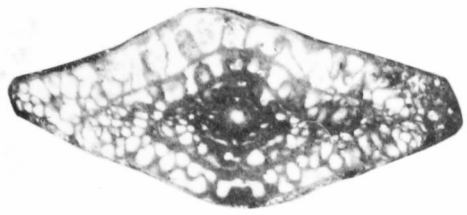

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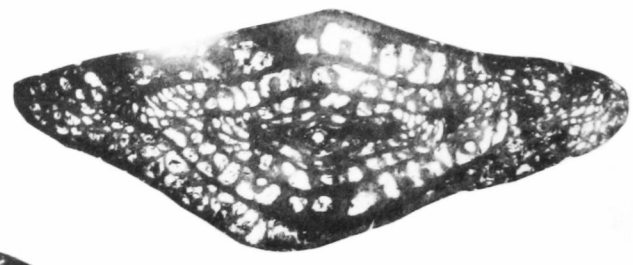

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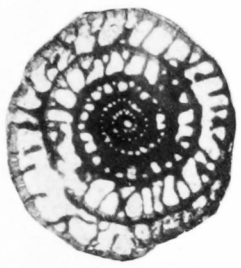

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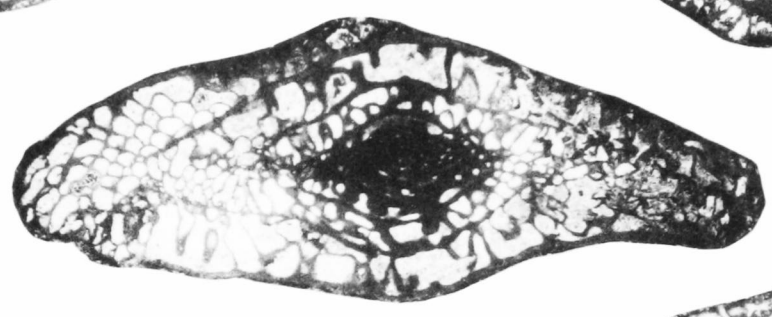

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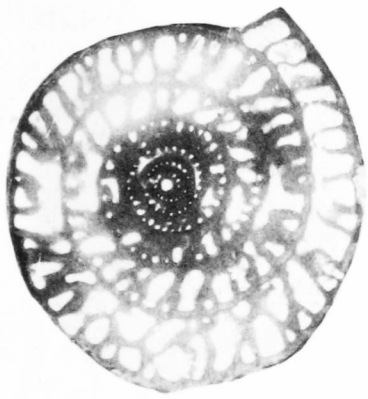

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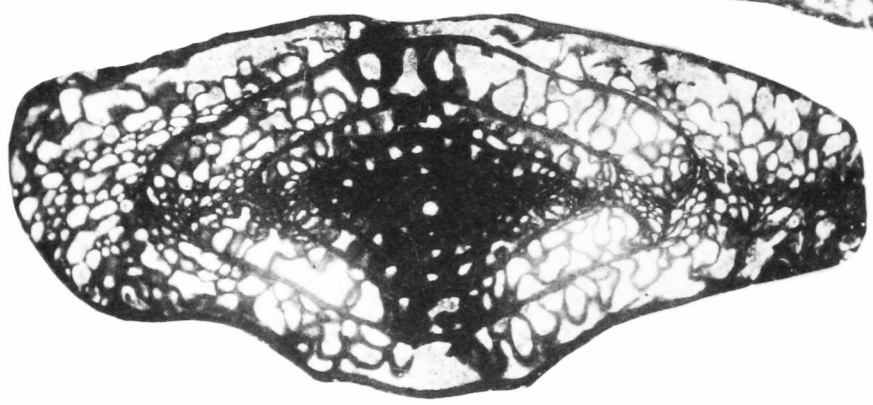

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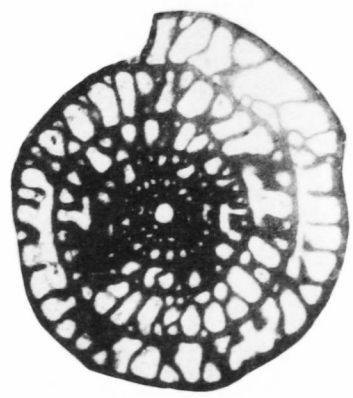

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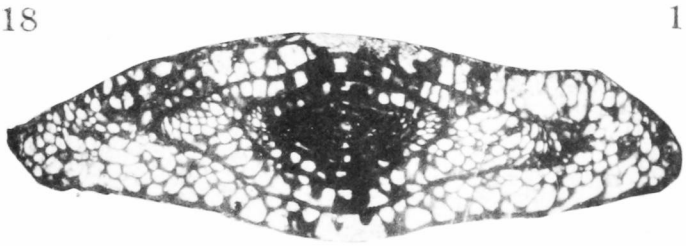

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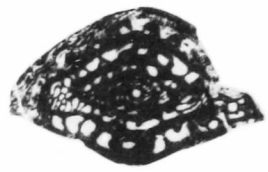

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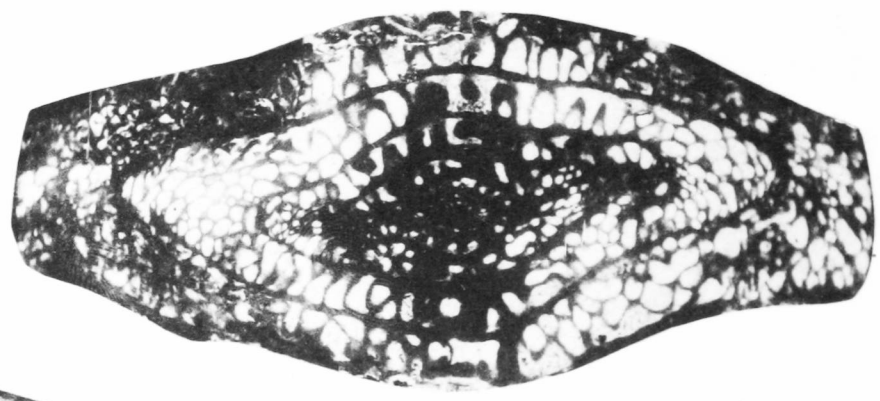

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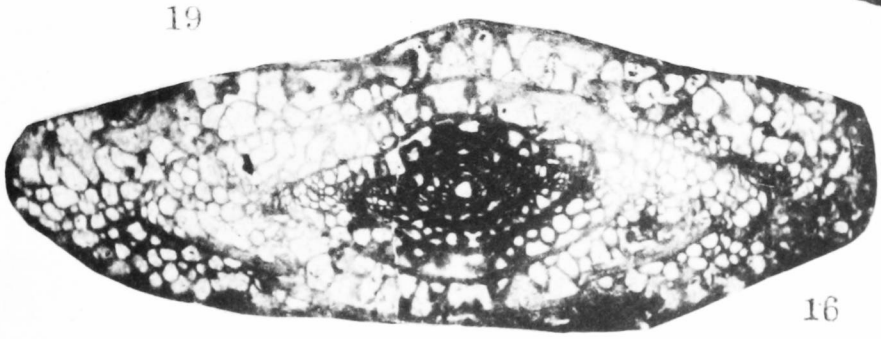

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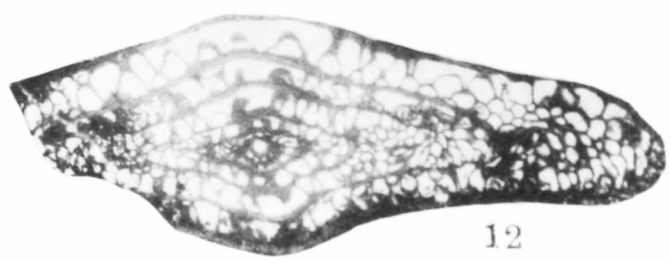


12

EXPLANATION OF

PLATE XIX

(1) 161

PLATE XIX.

All figures magnified about 15 diameters.

Fig. 6. *Schellwienia nathorsti* Staff-Wedekind. p. 98.

Diagonal section of a representative from the Miaokou Limestone, Western Hills of Taiyuan, Shansi. 山西廟溝石灰岩.

Figs. 1-5, 7-10. *Schellwienia nathorsti* var. *laxa* Lee (var. nov.) p. 101.

Figs. 1-3. Axial sections of typical specimens from the Suchieh Limestone, Pinting Basin, Shansi. 山西陽泉四節石.

Figs. 4, 8. An axial and a median section of typical specimens from the Chienshi Limestone, Pinting Basin, Shansi. 山西陽泉錢石.

Figs. 5, 7. An axial and a median section of typical specimens from the Miaokou Limestone, Western Hills of Taiyuan, Shansi. 山西太原西山廟溝石灰岩.

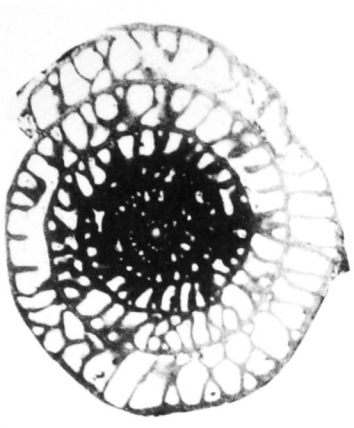
Figs. 9, 10. Two median sections of individuals from the Suchieh Limestone, Pinting Basin, possibly belonging to *Schellwienia nathorsti* s. str. 陽泉四節石灰岩.

Figs. 11-14. *Schellwienia longissima* Möller. p. 111.

Figs. 11, 12. Axial sections of typical specimens from Hungshanyao, Kansu. 甘肅永昌縣西五十里紅山窰.

Fig. 13. A typical specimen from Yaopo, Shahohsien, Chihli. 直隸沙河縣窰坡.

Fig. 14. A young individual or primitive form from Yaokou, Kansu. 甘肅高台南六十里窰溝.



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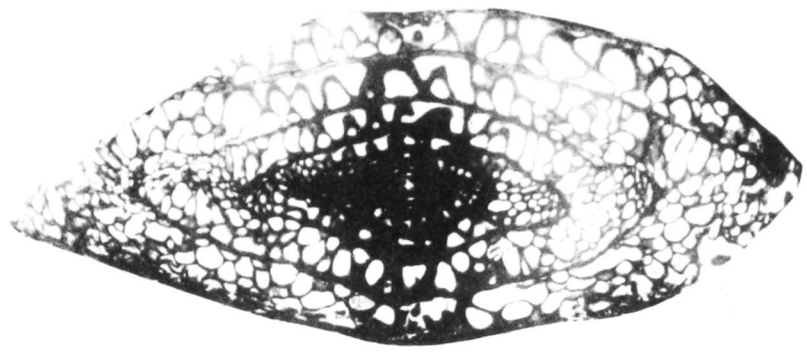

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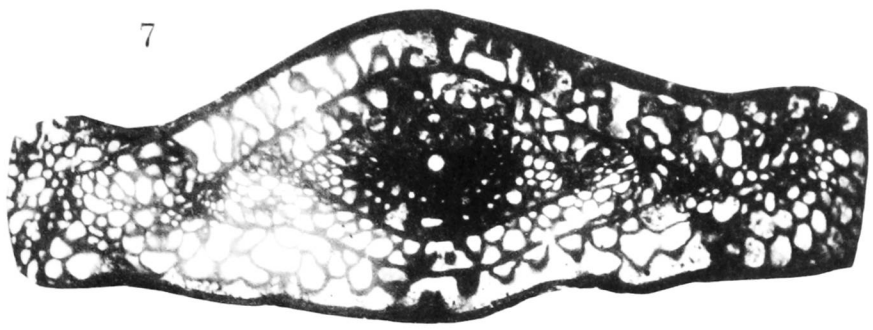

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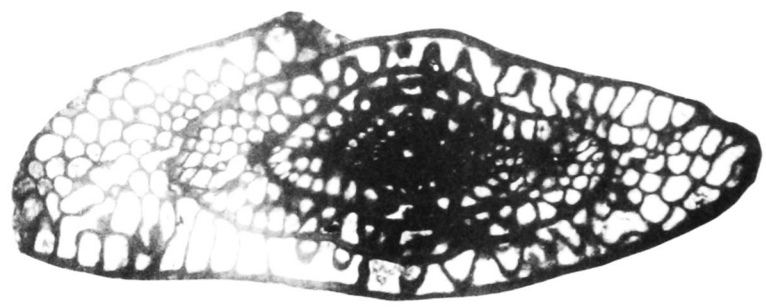

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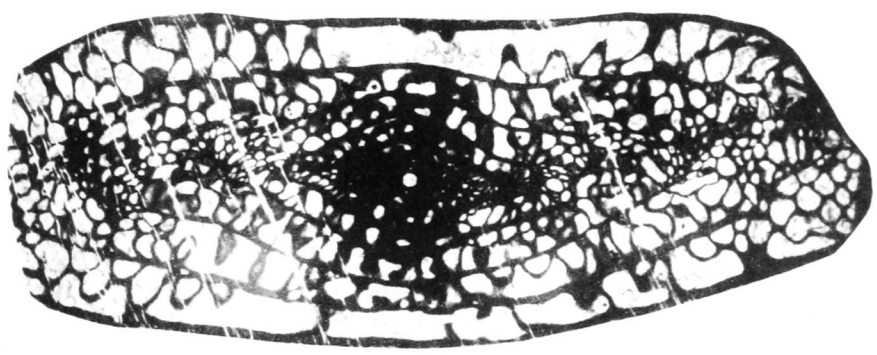

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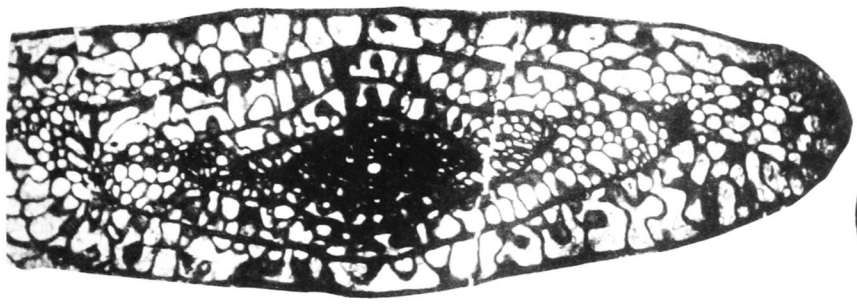

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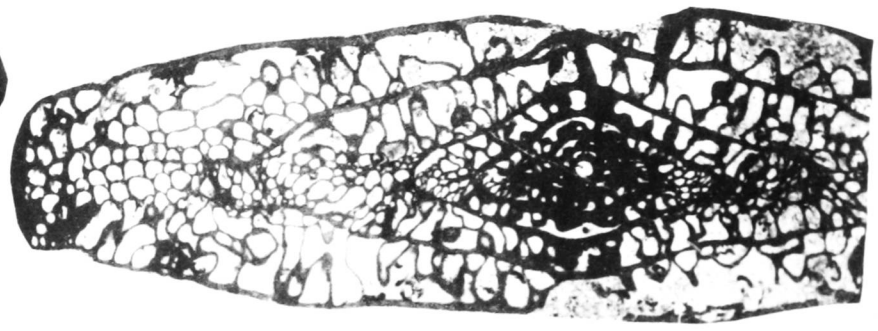

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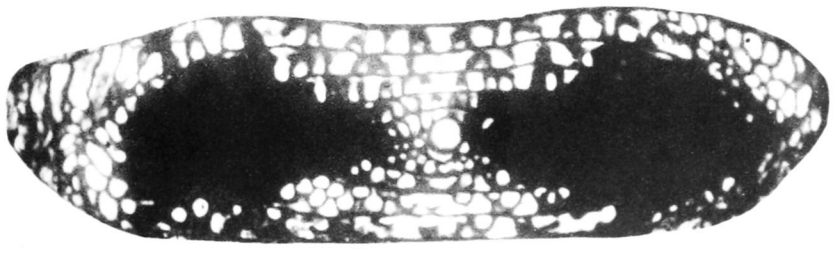

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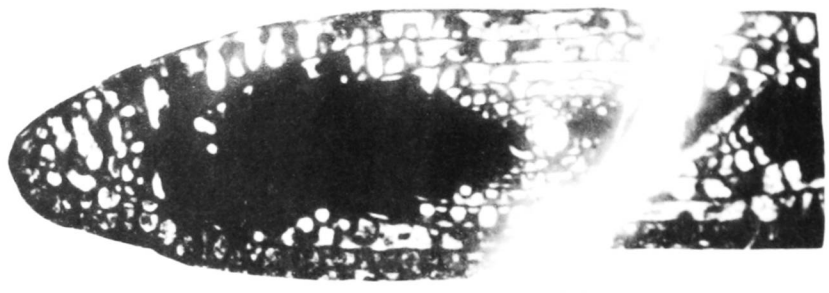

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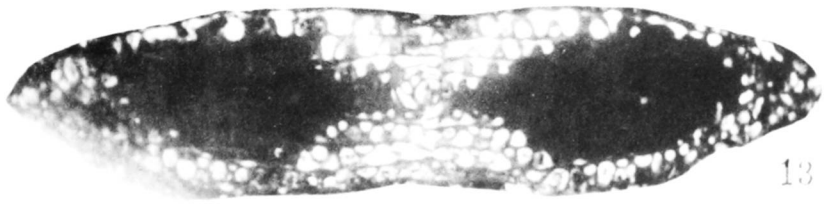

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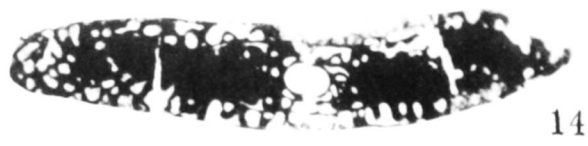

14

EXPLANATION OF

PLATE XX

PLATE XX.

All figures magnified about 15 diameters.

Figs. 1-14. *Schellwienia longissima* Möller. p. 111.

Fig. 1. A typical, cylindrical form with a broad median depression. Taching Limestone, Shimiao, S. Chihli. 直隸磁縣石廟大青石灰岩.

Fig. 2. A relatively stumpy form from Yichenhsien, S. Shansi. 山西翼城縣.

Fig. 3. A form slightly inflated in the median part and pointed in the umbilical ends. Yehching Limestone, Taichi, S. Chihli. 直隸南部台寨野青石灰岩.

Figs. 4, 6. Axial sections of two typical representatives from the Yihsien coalfield, Shantung. 山東嶧縣.

Figs. 5, 7, 12, 13. Specimens from Hungshanyao, Kansu. 甘肅紅山窯. Fig. 5 almost indistinguishable from Fig. 1.

Fig. 8. An individual with an abnormally large initial chamber, Shanching Limestone, Shimiao, S. Chihli. 直隸南部石廟山青石灰岩.

Fig. 9. A form with an unusually sharp median depression. Suchieh Limestone, Pinting, Shansi. 山西陽泉四節石.

Fig. 10. A typical specimen from the Shanching Limestone, Shimiao, S. Chihli. 直隸石廟山青石灰岩.

Fig. 11. A typical specimen from the Yaoku Limestone, Pinting Basin, Shansi. 山西陽泉腰固石.

Fig. 14. A typical median section, Yehching Limestone, Taichai, S. Chihli. 直隸台寨野青石灰岩.

Fig. 15. *Schellwienia longissima* var. *tenuis* Lee (nom. nov.) p. 117.

Median section, Yatzetsi, Shenhsien, N. Honan. 河南陝縣鴨子嘴.

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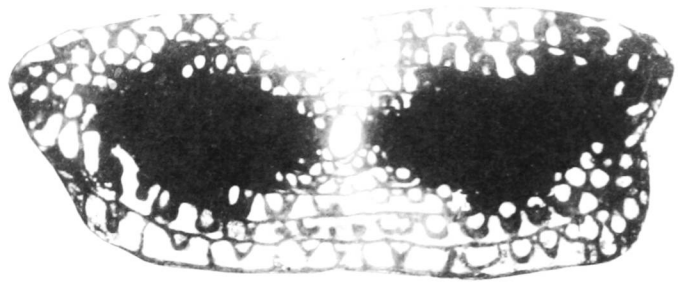

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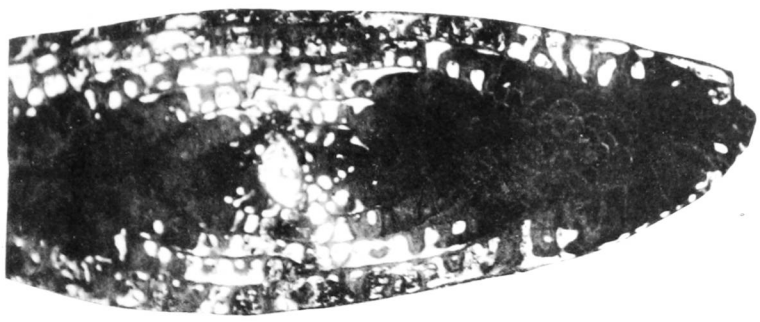

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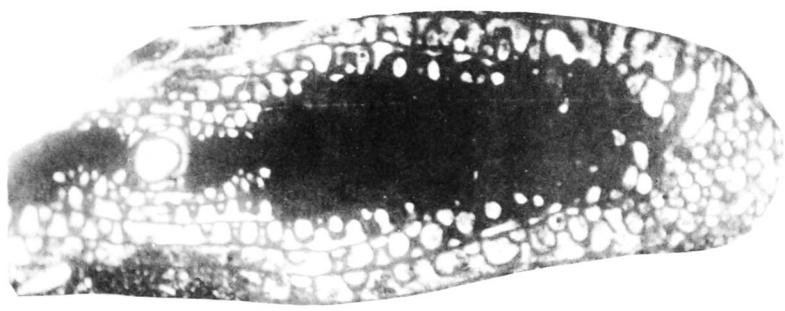

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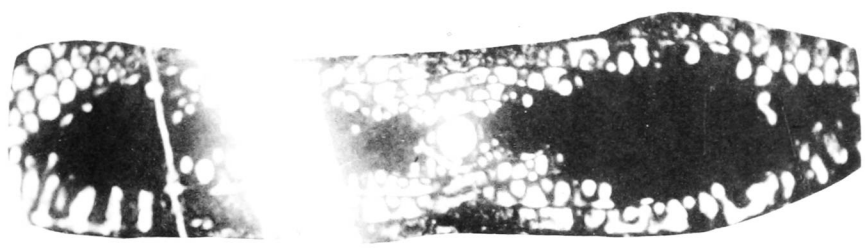

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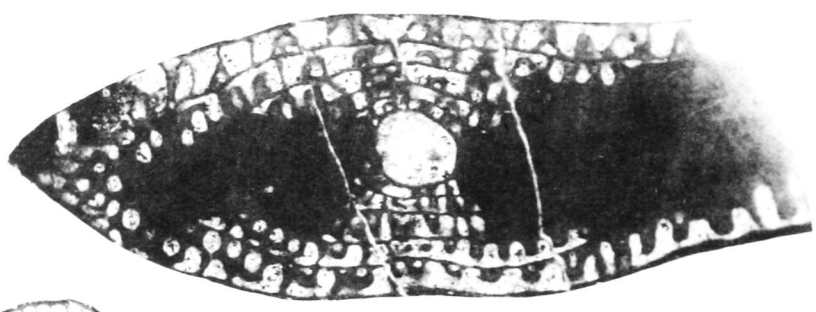

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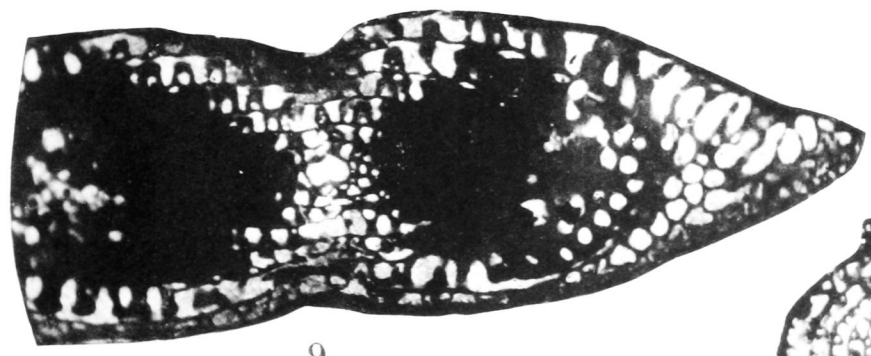

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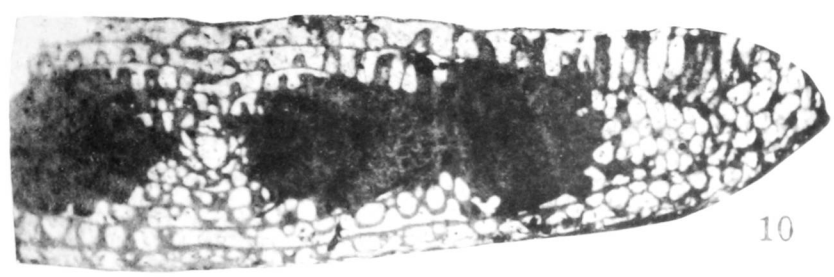

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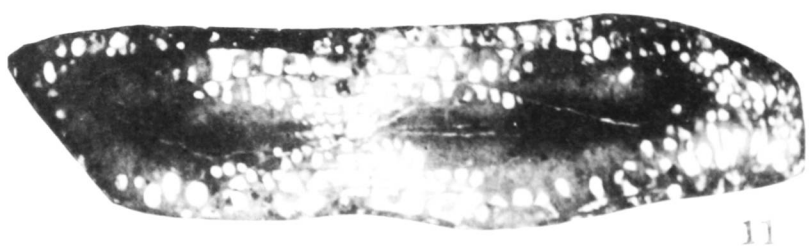

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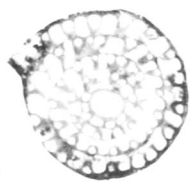

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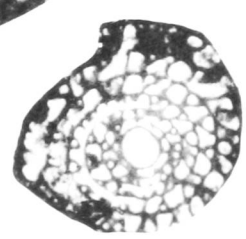

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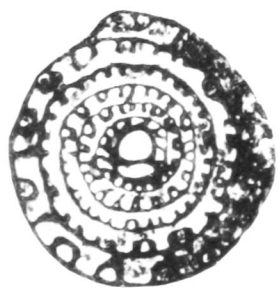

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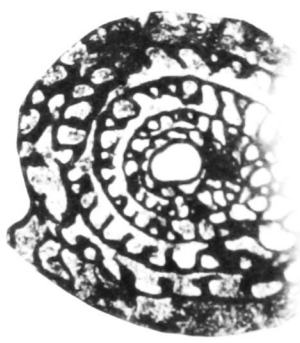

15

EXPLANATION OF

PLATE XXI

(1) 165

PLATE XXI.

All figures magnified about 15 diameters.

Figs. 1-4. *Schellwienia longissima* var. *phaselus* Lee p. 116.

Figs. 1, 2. Typical specimens from Yaopo, Shahohsien, S. Chihli. 直隸南部沙河縣窯坡.

Fig. 3. A specimen from the Taching Limestone, Shimiao, S. Chihli. 直隸南部石廟大青石灰岩.

Fig. 4. A median section showing an irregularly shaped initial chamber and confused arrangement of the inner spiral chambers, doubtfully referred to this variety. Shanching Limestone, Shimiao, S. Chihli. 直隸石廟山青石灰岩.

Figs. 8-11, 13, 14. *Schellwienia longissima* var. *compacta* Lee (var. nov.) p. 116.

Fig. 8. A fully-grown, typical specimen, Taching Limestone Shimiao, S. Chihli. 石廟大青石灰岩.

Figs. 9-11, 13. Individuals of premature growth. 9, 13, from Hungshanyao, Kansu; 10, from Yatzetsi, Shenhsien, Honan; 11, from Taching Limestone, Shimiao, S. Chihli. 石廟大青石灰岩.

Fig. 14. A median section from Hungshanyao, Kansu. 甘肅,紅山窯.

Figs. 5-7, 12, 15, 17. *Schellwienia longissima* var. *?compacta*. This group of *Schell. longissima* is characterized by their generally impoverished appearance and peculiar shape of initial chamber. They possibly belong to a distinct variety. 5 and 17, from Yehching Limestone, Taichai; 6, Shanching Limestone, Liuhokou; 7, 12, and 15, Shanching Limestone, Shimiao.

Fig. 16. A young individual of *Schellwienia longissima* in a boulder of limestone found at Tungtayao, West of Taiyuan, Shansi.

Fig. 18. A diagonal section of a rare specimen of *Schellwienia longissima* var. with double initial chamber; Taching Limestone, Shimiao, S. Chihli. 石廟大青石灰岩.

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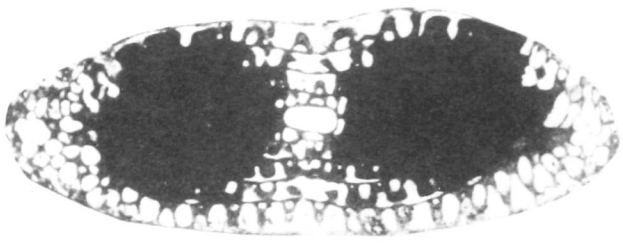

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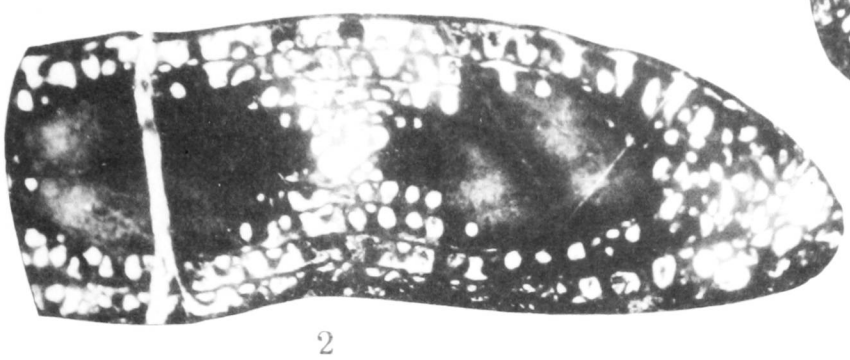

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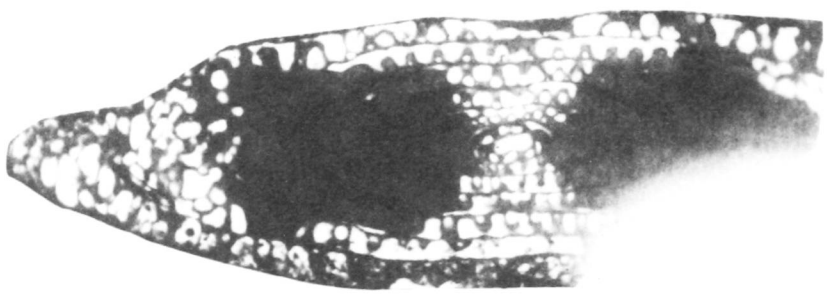

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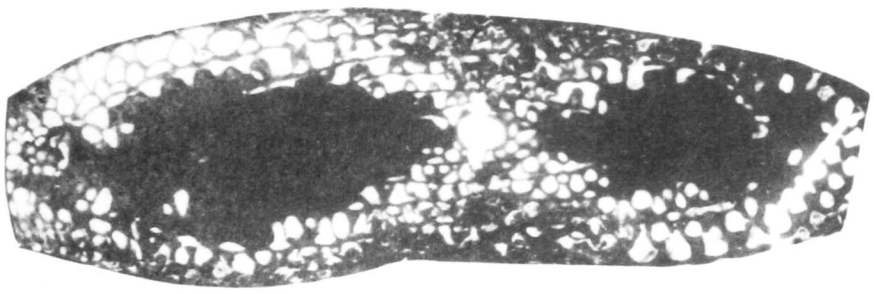

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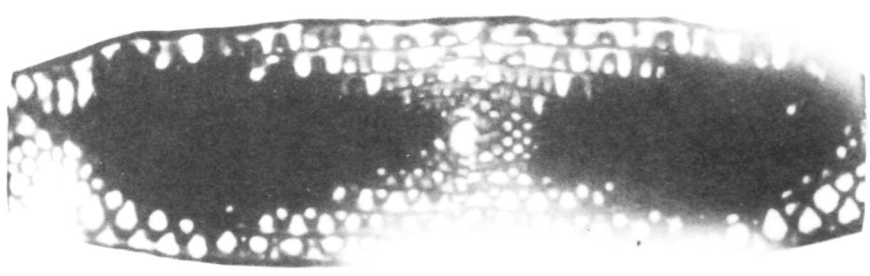

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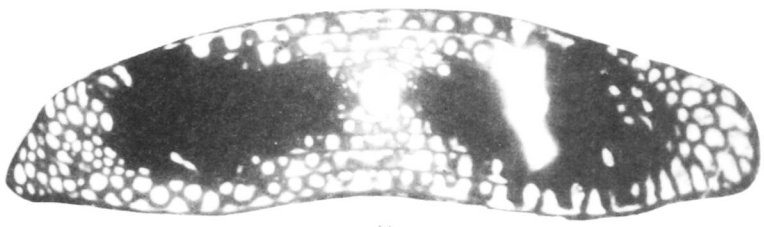

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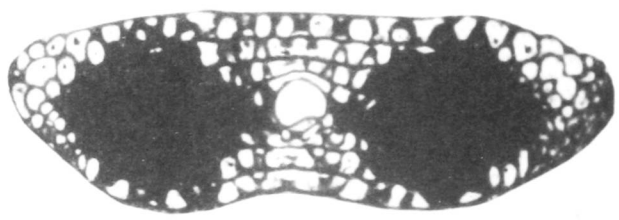

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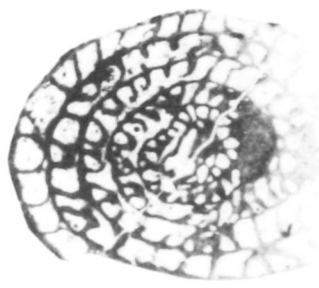

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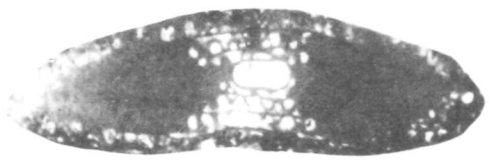

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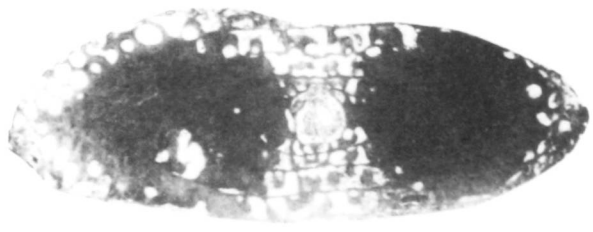

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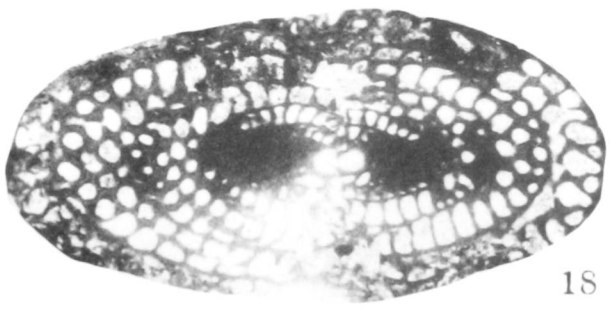

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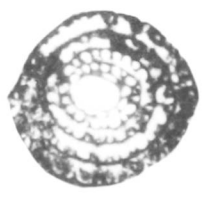

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EXPLANATION OF

PLATE XXII

(1) 167

PLATE XXII.

All figures magnified about 15 diameters.

Figs. 1-5. *Schellwienia longissima* var. *tenuis* Schellwien em. Lee p. 117

Fig. 1. A typical specimen from the Taching Limestone, Shimiao. 石廟大青石灰岩.

Fig. 2. A typical specimen from the Taching Limestone, Taichai. 台寨大青石灰岩.

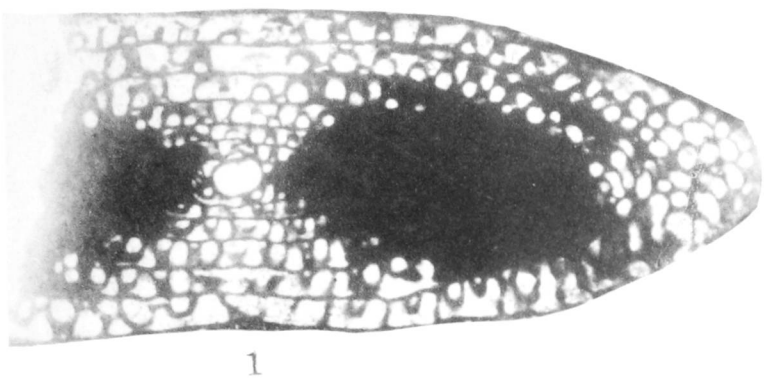
Fig. 3 A more elongated form from Hungshanyao, Kansu. 甘肅紅山窯.

Figs. 4, 5. Median sections, Shanching Limestone, Liuhokou, N. Honan.

Figs. 6-17. *Schwagerina fusulinoides* Schellwien p. 118.

Figs. 6-15. Fully-grown individuals from Hsinho, Kansu. 甘肅新河.

Figs. 16, 17. Young individuals from the same locality. 甘肅新河.



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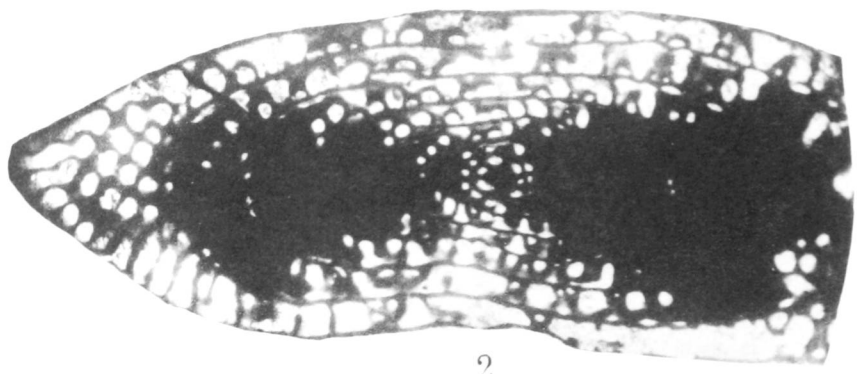

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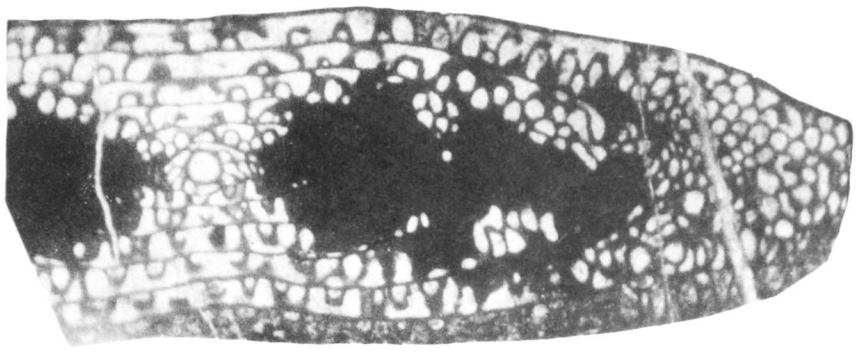

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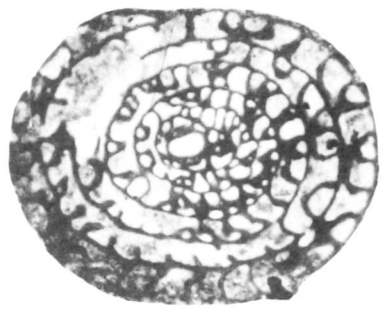

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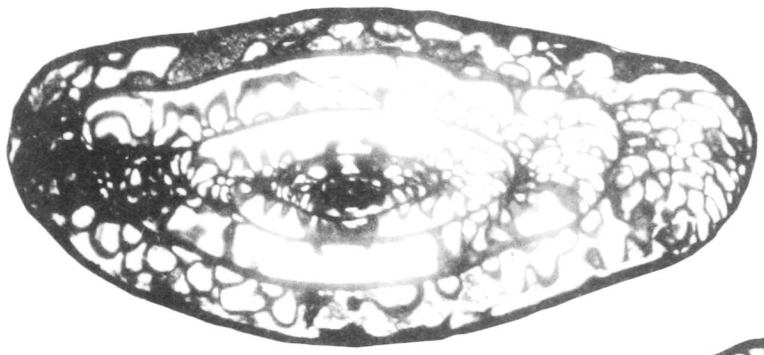

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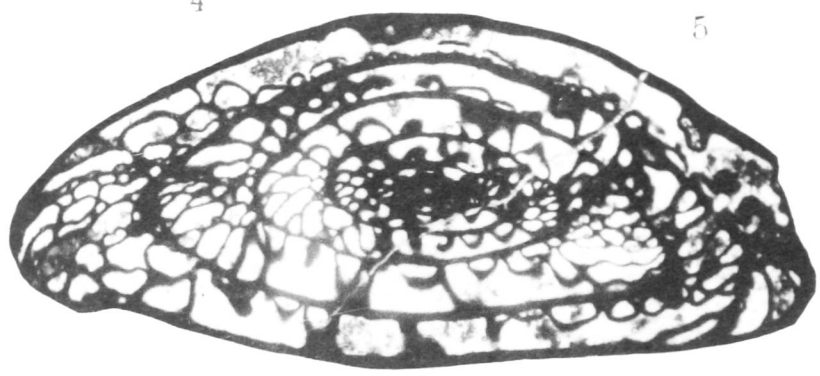

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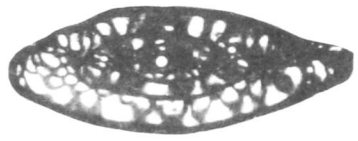

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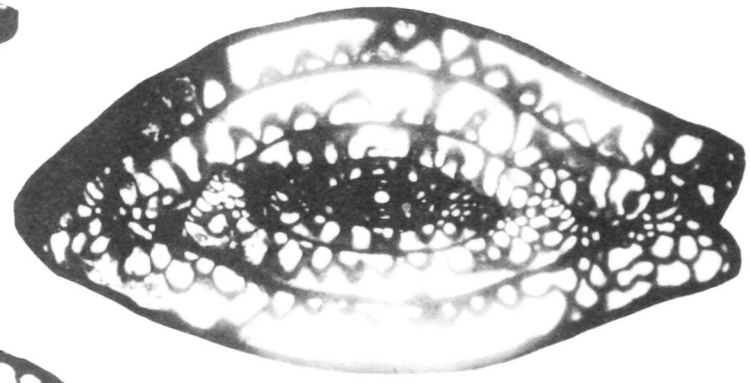

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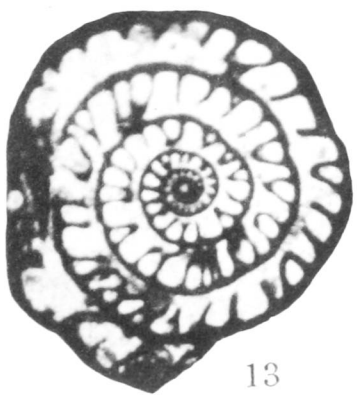

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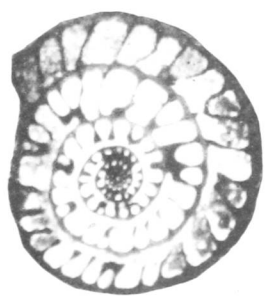

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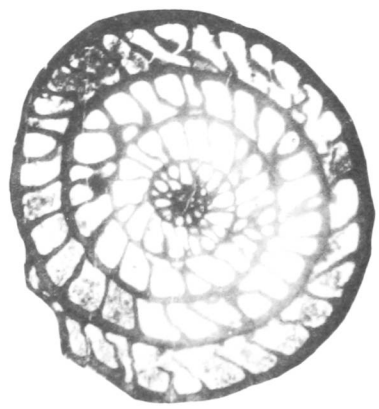

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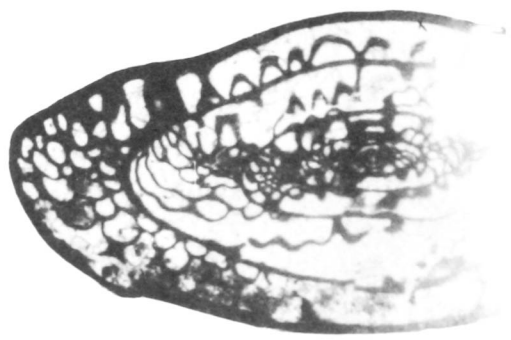

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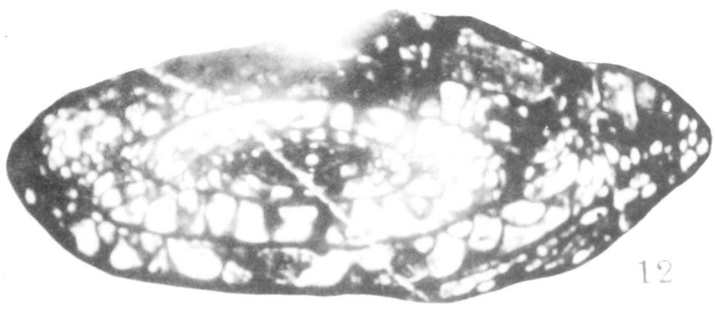

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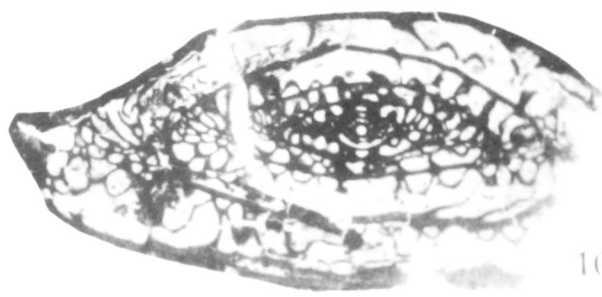

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17

EXPLANATION OF

PLATE XXIII

PLATE XXIII.

All figures magnified about 15 diameters.

Fig. 1. *Schwagerina wongwenhaoi* Lee. p. 121.

A slightly oblique, submedian section of a specimen from the Hsiaoching Limestone, Liuhokou, N. Honan. 河南六河溝小青石灰岩.

Fig. 2. *?Schwagerina moungthensis* Deprat p. 120.

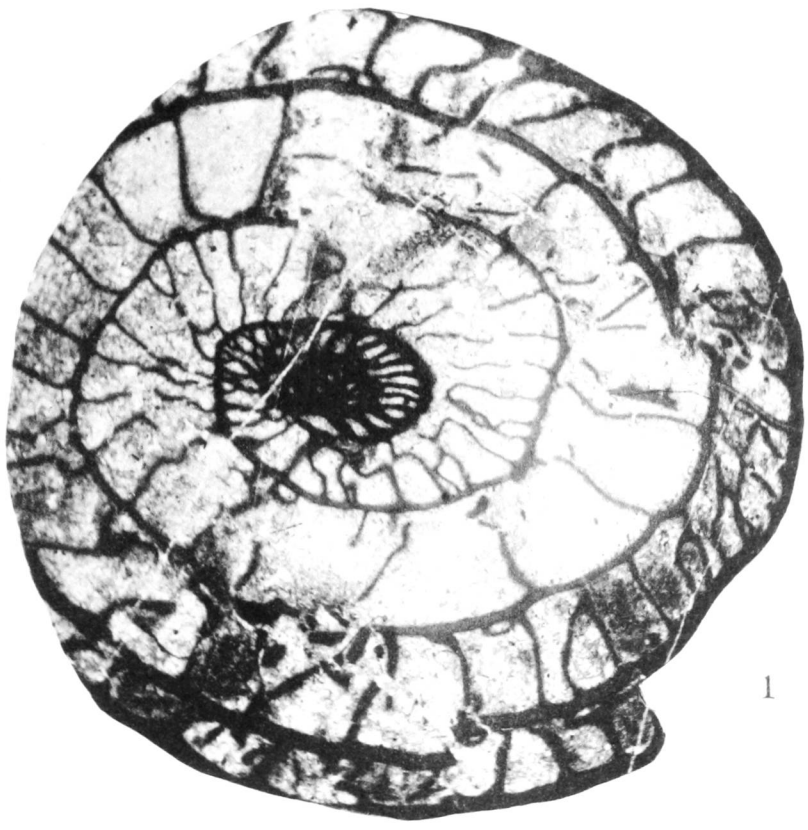
Oblique section of a specimen from Yichen, S. Shansi. 山西翼城縣.

Fig. 3, 4. *Schwagerina moungthensis* Deprat. p. 120.

Fig. 3. Para-axial section
Fig. 4. Submedian section
} Wuhutsui, S. Manchuria. 奉天五湖嘴.

Figs. 5, 6. *Schwagerina tinvenkiangi* Lee p. 121.

Showing appreciable folding of the antethecæ throughout the successive volutions and the otherwise schwagerinoid characters. Yatzetsi, Shenhsien, Honan. 河南陝縣鴨子嘴.



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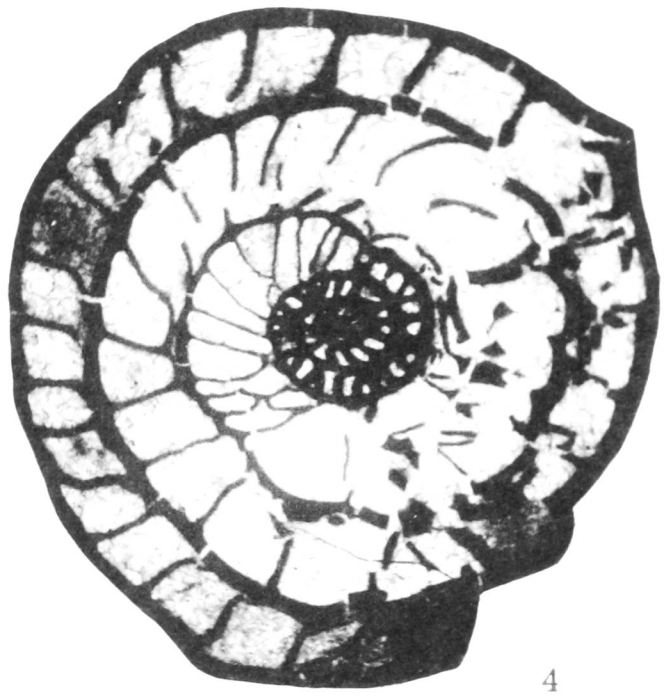

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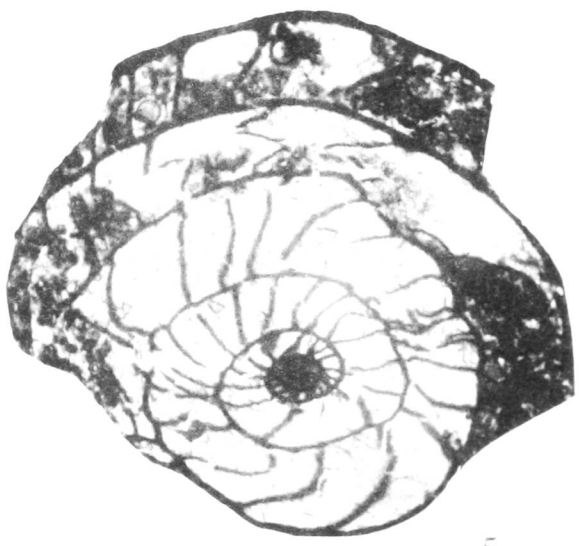

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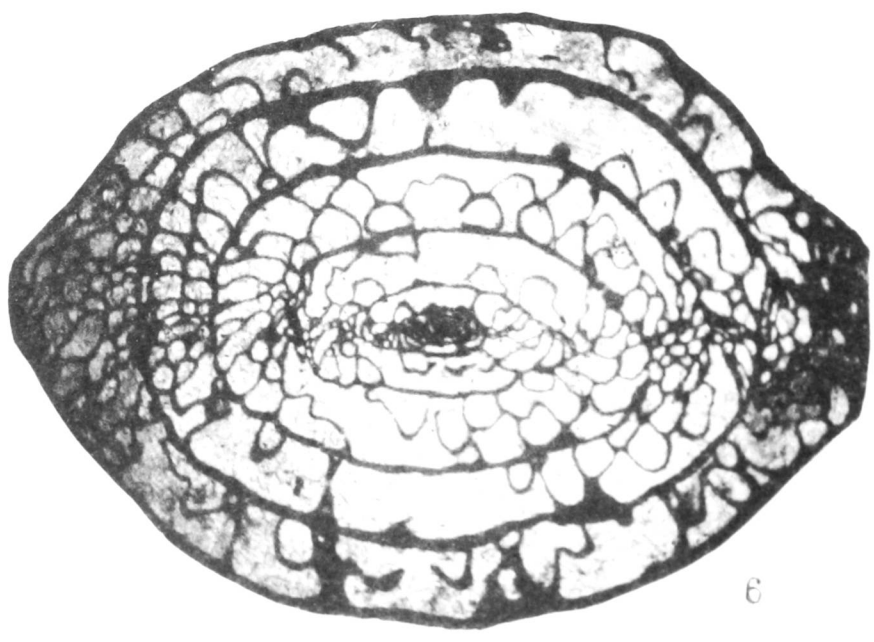


6

EXPLANATION OF

PLATE XXIV

PLATE XXIV.

All figures magnified about 15 diameters.

Figs. 1, 2. *Schwagerina wongwenhaoi* Lee. p. 121.

Two median sections of typical specimens from the Hsiaoching Limestone, Taichai, S. Chihli, (台寨小青石灰岩) showing two distinct stages of development: Inner volutions possess all the common characters of a *Schellwienia*, while the outer volutions are decidedly schwagerinoid.

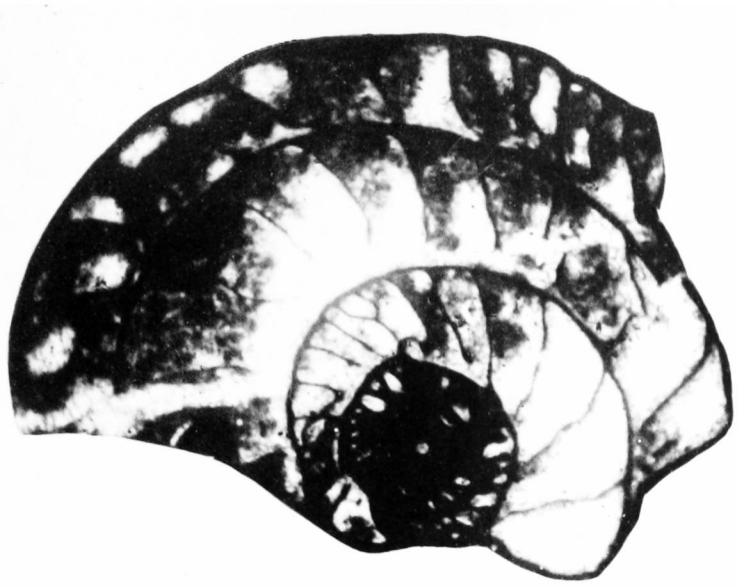
Fig. 3. A diagonal section of an intermediate form between *Schellwienia* and *Schwagerina*, Houshi Limestone, Pinting Basin, Shansi. 山西陽泉猴石.

Figs. 4-6. *Schwagerina princeps* Ehrenberg. p. 122.

Fig. 4. Median section, Yihsien, Shantung. 山東嶧縣.

Fig. 5. Median section, Yatzetsi, Shenhsien, Honan. 河南陝縣鴨子嘴.

Fig. 6. A submedian section of a specimen from Shenhsien, Honan. 河南陝縣鴨子嘴.



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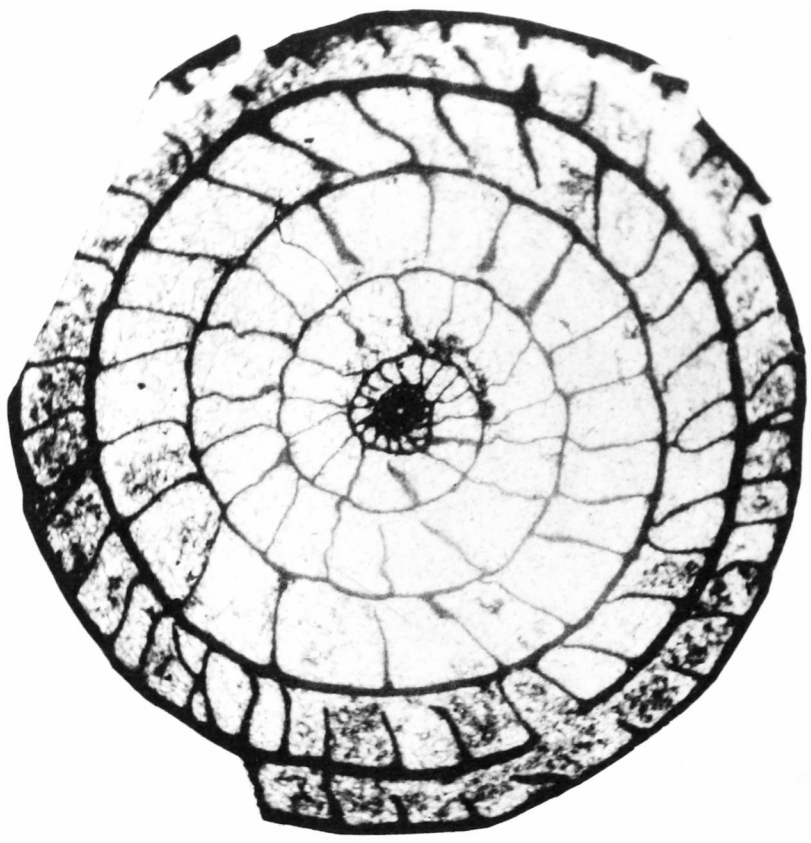

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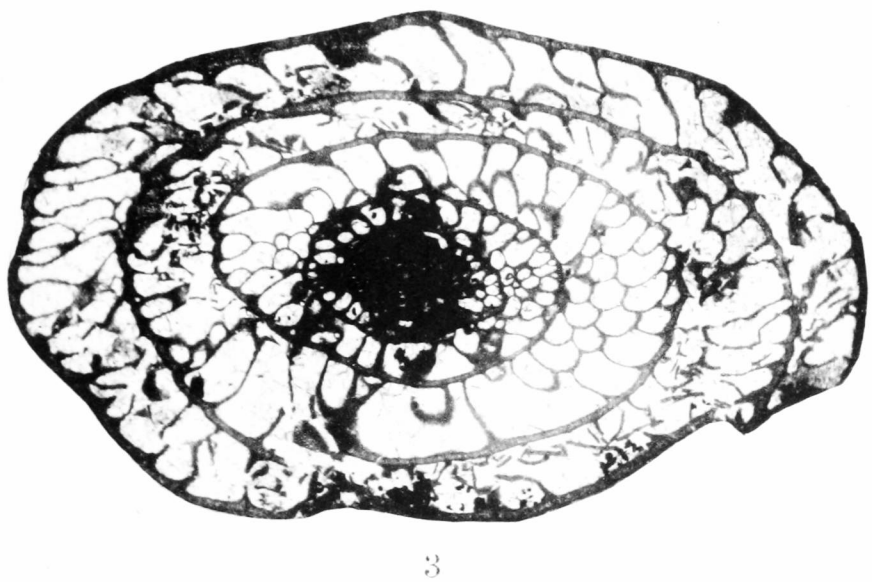

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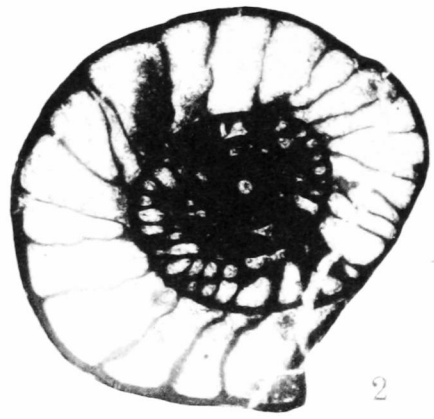

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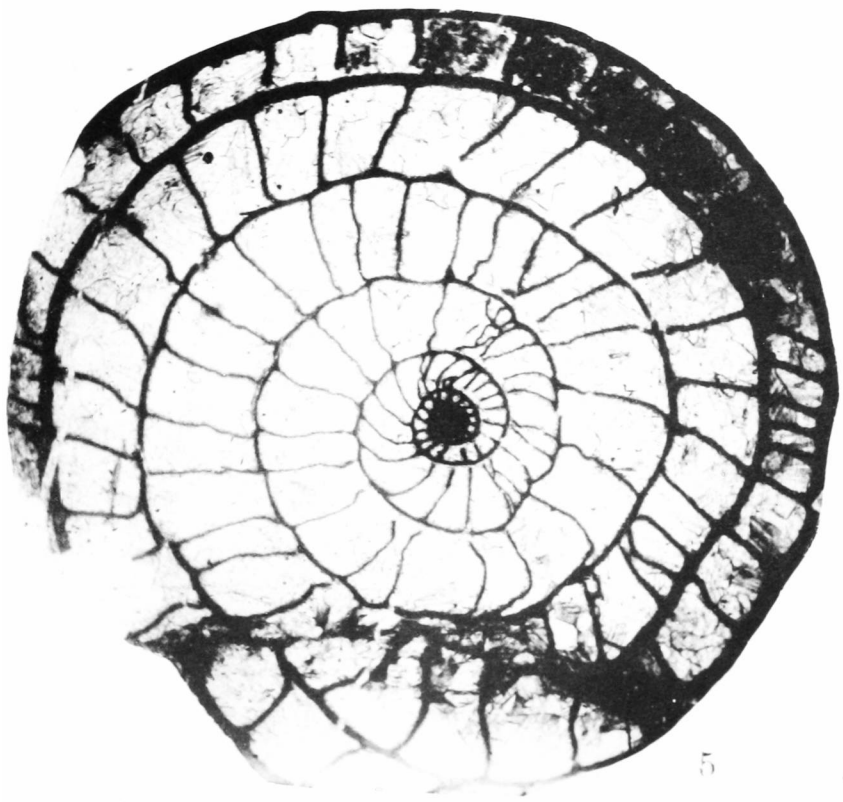

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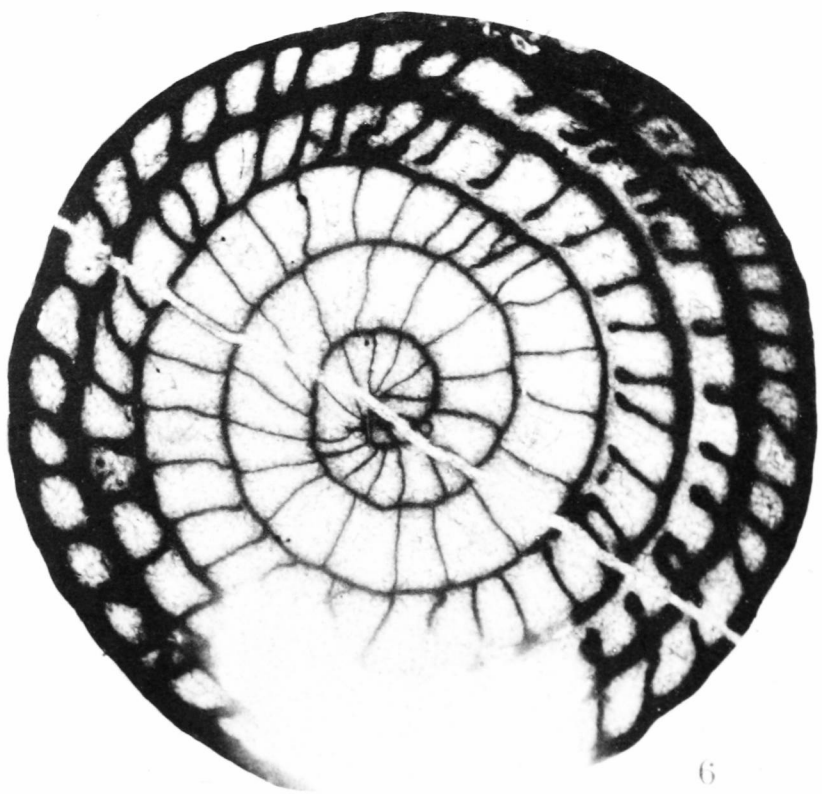

6

THE GEOLOGICAL SURVEY OF CHINA

Palæontologia Sinica

中 國 古 生 物 誌

Palæontologia Sinica

Preliminary announcement of Volumes and Fascicles designed to cover the material at present in the collections of the Survey. Where not definitely arranged for, the authorship of the fascicle is not given. Except in published fascicles, the number of pages and plates is approximate. The arrangement of the fascicles within the volumes is subject to change.

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VOL. IV.

Mesozoic Plants of China

(Arrangements for the description of the Mesozoic plants have not yet been made).

SERIES B.

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VOLS. III, IV & V.

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The detailed description of the large collection of prehistoric ceramics and other artifacts will be entrusted to a number of specialists. Details about the names of the different authors and the titles of their contributions can not be given at present. The various fascicles of Vols. III to V. are calculated to camprise 850 pages English and 300 pages Chinese text, with 124 plates (15 in color).

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Paris: Masson & Cie, 120 Boulevard St. Germain.

Leipzig: Max Wag, Königstrasse 3.

New York: A. G. Seiler & Co., 1224 Amsterdam Ave.

中國北部之蜓科

太原系石灰岩中之蠼、適得其反。兩者境界判然。一若有間斷存乎其間。本溪系中之生物、與俄國莫斯科系相同者甚多。故其所屬之年代、當爲中石炭紀。而太原系中之蠼則、有爲東亞之特產者、有與歐俄、北氷洋、東阿爾魄士、及中亞諸地所產者一致、間亦雜有印度鹽嶺之特種、其屬於上石炭紀、似無可疑。數年前、資料不足、著者頗疑中國北部之蠼科、與北美之產品有相類似者。茲積本國之材料甚夥、復得亞勃林及勃蘭瑪二夫人之贈品。反復研究之餘、始諗知當時意見之謬。夫此等動物、僅能生存於淺海之底、前已言之。今發見於太平洋東西兩岸者、絕無直接交通之痕迹、是亦大洋永久存在之一證歟。

凡經著者所研究之材料、現皆陳列於北京大學地質陳列館。並一一附以記號、以便就正於同道。

(19)山西南部。袁復禮君在山西翼城介休臨汾等地、得蠖若干種。據云煤系中祇見含蠖石灰岩一層。其發育之情形似與河南之西北部相類似。

(20)保德煤田。據王竹泉君之調查、此處含蠖石灰岩共有三層。上層名保德石灰岩、厚約十公尺。中層名巴簍溝石灰岩。下層名張家溝石灰岩。大煤在保德石灰岩與巴簍溝石灰岩之間。

(七)甘肅

(21)紅山窰（永昌縣西五十里）。據袁復禮君之報告、此處煤系中之石灰岩、多至六七層。然祇見其中一層含有蠖科。

(22)羊虎溝（紅山窰西三四十里）。岩層未詳。

(23)新河（山丹縣西四十里）。據袁復禮君之調查、含蠖石灰岩共有兩層。本篇所載之標本、皆來自上層。

(24)窰溝（高台縣南六十里）。含蠖石灰岩祇有一層。

前述各處之含蠖石灰岩、就其中所含之蠖種而論、可分爲兩系。在上者稱爲太原系。居下者稱爲本溪系。本溪湖煤田之含蠖石灰岩、皆屬於本溪系。煙台之煤系至少有一部分屬之。五湖嘴煤系之下部亦屬之。其他如距張家口北二百公里之含蠖石灰岩、唐山石灰岩、章邱煤田之徐家莊石灰岩、山西之口泉石灰岩、平定石灰岩、畔溝石灰岩、巴簍溝及張家溝石灰岩、甘肅之羊虎溝石灰岩。皆屬於本溪系、其他列舉之各石灰岩、則皆屬太原系。

本溪系之石灰岩中祇有 *Staffella, Neofusulinella Girtyina* 三亞族之蠖而絕無 *Schellwienia, Schwagerina*。

(五)山東

(12)章邱煤田。含蠟石灰岩之層數頗多、最下者名徐家莊石灰岩。主要煤層在含蠟石灰岩以上。

(13)博山煤田。含蠟石灰岩至少有兩層。

(14)嶧縣煤田。含蠟石灰岩層數未詳。大煤在石灰岩以上。

(六)山西

(15)大同煤田。有含蠟石灰岩一層名口泉石灰岩。在石炭紀之大煤以下。其層位恰與唐山石灰岩相當。

(16)平定煤田。含蠟石灰岩共六層最上者名猴石。厚二公尺。其下爲錢石。厚一・五公尺。再下爲固石。厚三公尺。再下爲四節石。厚一・八公尺。再下爲腰固石。厚不及一公尺。最下爲平定石灰岩。厚未詳。固石四節石腰固石相距甚近、幾可視爲一層。大煤厚五公尺有餘。在腰固石下約十五公尺之處。

(17)太原西山。據那林君之調查、太原西山一帶之含蠟石灰岩共有五層。其最下者分數單層、間以砂岩頁岩、統名畔溝石灰岩。各單層均甚薄。其上者爲廟口石灰岩、厚五公尺至十二公尺不等。再上爲毛兒溝石灰岩、厚四公尺至八公尺。再上爲斜道石灰岩、厚二三公尺。最高者爲東大窰石灰岩。此等石灰岩之露頭。以月門溝、東大窰、斜道一帶、最爲清晰。主要之煤層、在東大窰石灰岩以上。

(18)太原東山。據那林君之調查、太原東山之煤系、亦夾有五層石灰岩。其最高者名關底溝石灰岩、厚約四公尺。其下者名石齊凹溝石灰岩、厚約三公尺。再下爲關門溝石灰岩。厚一公尺至三公尺。再下爲南窰溝石灰岩、厚二公尺至八公尺。最下爲澗道溝石灰岩、厚一公尺至三公尺。

(5)唐山煤田。據馬幼君之報告、唐山煤田中、祇有含蠑石灰岩一層。名唐山石灰岩。厚一二公尺。在大煤之下約八十公尺。

(6)臨城煤田。據王竹泉趙亞曾田奇瑋三君之調查、及其他報告、本煤田中之含蠑石灰岩、至少有四層。在上者名北村石灰岩。厚一・二公尺。其下者名後溝村石灰岩、厚二・八公尺。再下者名祁村石灰岩。厚四・六公尺。最下者似由數薄層積合而成。茲定名曰臨城石灰岩。主要之煤層在祁村石灰岩以下。

(7)沙河煤田。含蠑石灰岩至少有三層。上二層各厚約一・三公尺。最下者厚三四公尺。煤層散布於此等石灰岩及其他砂岩頁岩之間。大煤（俗名底界）在下層石灰岩下十一二公尺之處、

(8)磁縣煤田。由磁縣之彭城迤南、至河南之六河溝煤田一帶、含煤系之地層、大致相同。趙亞曾君曾作詳細之報告。此帶地域之含蠑石灰岩共有五層。最下者名大青石灰岩、厚五六公尺。其上者爲小青石灰岩。再上者爲復青石灰岩。再上者爲山青石灰岩。再上者爲野青石灰岩。此等岩層之厚、除復青有時達三四公尺而外、餘皆不過一公尺左右。常有薄煤層散布於其間。大煤遠在野青石灰岩以上。

(四)河南

(9)六河溝煤田。含蠑石灰岩之層次及其與大煤之關係、與磁縣煤田相同。

(10)新安縣城北六十里。安特生君在此曾採集若干種化石、屬於蠑科。此處似祇有含蠑石灰岩一層、大約與大青相當。

(11)陝縣鴨子嘴溝。含蠑石灰岩至少有一層。

公尺者。砂岩頁岩及煤層夾雜於其間。足證低級蠖科繁殖之地、乃淺海、非大洋也。通中國北方各省、除直隸西北部而外、凡有古生時代煤系之處、幾無一不夾含蠖石灰岩。主要煤層之地位、往往可依特種含蠖石灰岩之層位而預爲測定。卽此一端、可知純粹古生物學上之研究、與鑛業之發展、關係何等密切。吾國之從事鑛業者、諒早已見及於此、無待贅言。茲將本篇中各項材料出產之地點及岩層、逐一列舉如次、以供一覽。

（一）奉天

（1）本溪湖煤田。據趙亞曾君之調查、此地計有三層含蠖石灰岩。最上一層名本溪石灰岩、厚五・五公尺。中層名小峪石灰岩、厚一・八公尺。下層名螞蟻石灰岩、分二小層、有黃色砂質頁岩間於其間。總厚約六公尺。煤層皆在此等石灰岩層之上。

（2）煙台煤田。層序不明

（3）五湖嘴煤田。據趙亞曾及小澤儀明二君之調查、此處之含蠖石灰岩、有七八層之多。厚薄不等。最上一二薄層、趙君稱爲楊樹溝石灰岩。中部之石灰岩層、由數層疊積而成、多含燧石。其上部漸變爲頁岩、總厚六・四公尺。統稱爲五湖嘴石灰岩。下部石灰岩計有三四單層。其中最厚者、達八公尺。名三嶺石灰岩。主要煤層、在五湖嘴石灰岩以上。

（二）察哈爾

（4）張家口北約二百公里之處。有含蠖石灰岩一層露出。

（三）直隸

(11) *Fusulina* { *Girtyina* / *Schellwienia* / *Schwagerina*

Boultonia 一族、初發見於中國。迄今祇得二種。其體極微、最長者不過二糎有半。普通之長度、不過一糎左右耳。此族之特色、除其體殼纖微而外、尚有二段之發育。其內部各旋之旋轉軸、常與外部各旋之旋轉軸異向。且其內部各旋短而粗、形狀近於扁球。而外部各旋、則中部隆起、兩端尖細、其狀似筵。旋壁之構造不易辨識、大約由隔膜及蜂巢層兩者而成。旋壁略形摺皺、口隙及口環在外部各旋中、頗爲顯著。

Fusulinella 體殼亦不甚大。壁之構造、四層皆備。前壁平直、蜂巢層之蜂巢構造、往往不易辨識。口環甚爲發育。此族可分爲兩亞族。旋軸之長小於旋徑或與旋徑相等者、屬 *Staffella*。成筵狀者、屬 *Neofusulinella*。

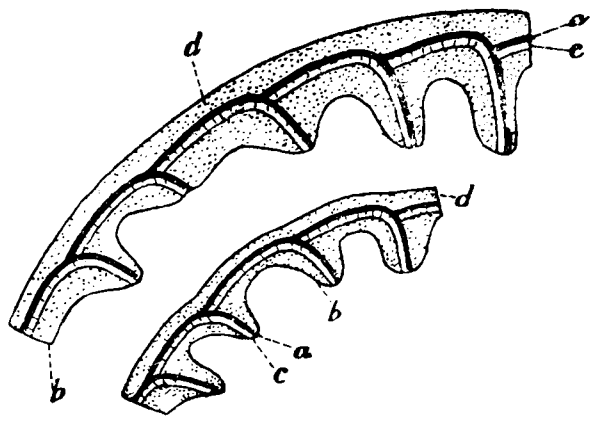
Fusulina 一族、或成筵形、或成筒形、間亦有狀如扁球者。此族最爲繁殖、可分爲三亞族。（a）*Girtyina*。旋壁亦分四層、唯外壁蓋極薄。蜂巢層之蜂巢結構、多不清晰。前壁摺皺甚多、口環頗爲發育。（b）*Schellwienia*。旋壁大抵由隔膜及蜂巢層二者組成。蜂巢層之蜂巢狀構造、極爲顯著。內部一二旋、間有帶壁蓋者。然以絕無壁蓋者居多。前壁常帶摺皺、但依種類不同、摺皺有疏密之別。口環時有時無。（c）*Schwagerina*。常成球狀、體格頗大、普通與苜宿相等。蠑殼旋轉之數頗多。旋轉之展開極速。旋壁之構造與 *Schellwienia* 相同。前壁或平直、或略形摺皺。口環甚小。僅見於內部各旋。

（乙）分佈及層位

含蠑之石灰岩、在中國北部分布甚廣。層次亦多。每層有厚不及一公尺者、有二三公尺者、間亦有厚至十餘

(甲)構造及分類

本篇所論列者、大都爲低級之蠖。其構造上之要素、計有數端。(一)胎房、(二)旋房、(三)旋壁、(四)前壁、(五)口隙、(六)口環。胎房多成球狀、亦有成橢球狀、或其他不規則之形狀者。旋房以胎房爲起點。節節伸展、作螺旋式。其兩端常尖而中部擴大。狀如筵、故定名爲蠖。旋壁之組織、最複雜者分爲四層。其極內及極外兩層、厚薄不勻、質疏色暗、名曰壁蓋(如第一圖ｂｄ)。中間二層之在外者、堅而薄、幾不透光、名曰隔膜(如第一圖ａ)。其在內而與壁蓋緊接者、名蜂巢層。常透明、厚薄亦勻、成蜂巢之狀。中有無數小孔、與隔膜垂直。小孔有時較粗、以顯微鏡窺之、顯然可睹。(參考第一版攝影第五圖第八版第一圖等)亦有時極細、了無痕迹可尋。前壁之構造、間有與旋壁相同者。然大多數則糢糊不可攷證。前壁有平正者、有摺皺者。口隙成新月或半月形、位於前壁之中部。其爲原生質出入之孔道、毫無可疑。口之兩旁、有物隆起、一若防原生質之潰散者然、(如第一版撮影第二圖第五圖)是名口環。



第一圖 Fusulinella 之橫斷面圖

依此等構造、中國北部所產之蠖科、迄今已發見者、可分三族(Genus)、及若干亞族如次。

(一) *Boultonia*

(二) *Fusulinella* { *Staffella* / *Neofusulinella*

中國北部之蠑科

北京大學地質學系古生物研究室　二

中國北部之蠏科（即紡錘蟲）

李四光著

緒言

此篇之作、已歷四春秋、乃遲至今日、始能公諸於世者、一則以資料廣佈全國、搜集匪易。再則以製造薄片、須準一定之方位、排置至爲困難。況於學校授課之餘、勉事研究、爲時已無幾矣。邇者雖積歲月之工作、得薄片兩千餘幅、種類四十有奇。而衡以億萬其徒、當時棲息於海底者、則亦泰山之與毫末耳、其不足以儘種類之別、勿待言也。

蠏之軀殼至微、雖千萬成羣、埋沒於岩石之中、往往不易發見。而數年來中國地質調查所竟能搜集大宗資料、且無一不詳加標記、層序井然、足徵奔走於野外者、勤敏如何。儻此篇略有貢獻之可言、其功不在著者、而實在野外調查諸君也。海外同道、亦莫不紛紛贊助、樂觀此篇之成。如瑞典力克士博物館、及亞勃薩拉大學之維曼教授、慨然以該國學者數十年來在北氷洋一帶所獲之材料、悉贈予著者、作比較研究之資。俄國地質調查所、及莫斯科大學之帕布洛夫教授、亦以優美之標本相贈。美國之亞勃林夫人、及勃蘭瑪夫人、舉其在中美及美國極西南部、歷年親身搜集之材料、強半予余。而勃蘭瑪夫人、並詳細示余以葛達魯蒲山脈一帶含蠏岩層之層位。凡此等等、皆與著者以莫大之助力。特誌數語、以表感謝之忱。

本篇中繪圖及撮影各件、多賴赤瀨川安彥及徐光熙二君之力。製造薄片、得趙亞曾君之助。葛利普教授及余妻淑彬、欣然任讐校之勞。余所感於衷者、尤非數語所能盡也。

民國十六年四月著者誌於

古生物誌乙種第四號

第一册

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李四光著

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