JOURNAL OF THE COLLEGE OF SCIENCE, IMPERIAL UNIVERSITY,
TŌKYŌ, JAPAN.

VOL. XXI., ARTICLE 5.

A Contribution to the Genus Fusulina, with Notes on a Fusulina-Limestone from Korea.

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With 3 plates.

The recent advance in our knowledge of the Permocarboniferous Foraminifera is largely due to the works of Prof. E. SCHELLWIEN. He studied, among other forms, those in the Carnic Alps, found the long accepted separation of the genera, *Fusulina* and *Schwagerina*, to be of only a subgeneric value, and accordingly united them under the one genus *Fusulina*, which he proposed to divide into three subgenera. To me, however, it seems more natural to subdivide it into four.

In the following descriptions of these four subgenera, I propose the use of the designations, primary-, auxiliary- and transverse septa. By primary septa, I mean those longitudinal partitions marked on the surface as deep sutures,[1] and commonly called 'septa.' The auxiliary septa are those parallel to the former, but showing no suture on the outside; for they are mere stalactitic

1) The origin of the suture on the surface is evident from the explanation of SCHELLWIEN on the formation of the septa.

outgrowths of the wall; they are usually shorter, and always without a median lamella,[1] which is invariably present in the primary septa. The transverse septa (the 'Nebensepten' of C. SCHWAGER) are those at right angles to the other two, extending from the roof of a volution to its floor, when completely developed. When only the basal portion of the transverse septa is developed, they appear as spiral ridges, and form what are generally called the basal skeleton ('Basalskelet'). Although all the septa, like the wall itself, are often perforate throughout their entire length, yet it frequently happens that they are imperforate in their lower portion which then appears as a quite dense calcareous mass. The basal skeleton is also never perforated, the pores being evidently not physiologically necessary.[2]

Synopsis of the Four Subgenera.

1. FUSULINA s. s. Type: *F. cylindrica* FISCHER.

Shell fusiform or cylindrical, sometimes ellipsoidal, rarely acicular. Only the primary septa developed; these are much folded, especially near the umbilical ends.

2. SCHWAGERINA. Type: *S. princeps* EHRENBERG. (cfr. Pl. II., fig. 1).

Shell spherical in the typical species, fusiform in those approaching *Fusulina* s. s. With only the primary septa, which are slightly or not at all folded, except near the umbilical ends.

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1) The term may be inappropriate; but I mean by it a boundary line between two successive walls, which sometimes runs into the middle of the septa. See the remarks by SCHELLWIEN on the structure of the septa.

2) I agree with SCHELLWIEN in the view that the greater transparency of the wall and of the upper part of the septa is due to the intercalation of commonly transparent calcite, infiltrated in the pores; otherwise we have no reason to maintain the greater turbidity of the dense calcareous matter in the basal portion of the septa.

3. DOLIOLINA. Type: *T. lepida* SCHWAGER (Pl. II., figs. 2, 3).

Shell cylindrical in the typical species, but spherical in those approaching *Schwagerina*. Septa of two kinds; primary septa being straight and basal skeletons more or less developed.

4. NEOSCHWAGERINA. n. subg. Type: *N. craticulifera* SCHWAGER (Pl. I., figs. 3, 4).

Shell fusiform to spherical. Septa of three kinds: transverse septa numerous, and 1 to 4 auxiliary septa are found between each pair of primary septa.[1]

The above lines are with but slight modification,[2] an almost complete recapitulation of the passages in my former paper "On a *Fusulina*-limestone with *Helicoprion* in Japan." Since then two important papers treating this group of Foraminifera have been published, one by Prof. W. VOLZ and the other by Dr. G. H. GIRTY.

In a recent work on the geology of Sumatra,[3] VOLZ described a Carboniferous Foraminifera of the family Fusulinidae under the new name of *Sumatrina Annae*. This greatly interested me, as I had once found an unquestionably identical form in limestones from the province Bitchū in Japan, and from Ta-gai-tung, En-ngan-hsien, prov. Yun-nan, in China, and had taken it to be an undescribed species belonging to my *Neoschwagerina*. The reason why I describe the subgenus as sometimes fusiform is because I believe the Foraminifera is surely a form which should be included in it.

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1) C. SCHWAGER, one of the most excellent observers of the fossils of this group the world ever seen, seems to have already been disposed by a similar consideration to separate *S. craticulifera* from the other allies. (Carbon. Foram. aus China u. Japan. P. 142).

2) I here substitute 'auxiliary -epta' for my older term 'secondary septa.'

3) W. VOLZ: Zur Geologie von Sumatra. Geol. u. Paleont. Abhandl.

VOLZ defines his genus *Sumatrina* as follows: "Spindelförmige Fusuliniden mit einem aus 2–4 längs- and querreifen bestehenden Dachskelet." From this and the illustrations in his paper, it is beyond doubt that *Sumatrina* and *Neoschwagerina* refer to the same group of Foraminifera. The only point in which VOLZ differs from me is in regarding *Schwagerina craticulifera* SCHWAGER as a *Doliolina*[1] and hence making a generic distinction between this species and *Sumatrina Annae*. On the contrary, I am inclined to treat *Sumatrina Annae* and *Schwagerina craticulifera* together as one group, quite distinct from *Doliolina* whose type is *D. lepida*.

There is a species of *Neoschwagerina*—*N. globosa* sp. nov.- in the upper complex of the limestones at Akasaka, possibly a variety of *N. craticulifera*; it possesses more numerous transverse septa than the type form in the lower complex, the longer and shorter septa being alternate; the same can be said of the auxiliary septa (Pl. I., fig. 5). Such being the case, I cannot help thinking that the 'Dachskelet' of *Sumatrina Annae* is but a shortened structure of the auxiliary and the transverse septa. If I am right, it is clear that *Sumatrina* is a synonym of *Neoschwagerina*. It is much to be regretted that VOLZ made no reference to *S. craticulifera* in describing his *Sumatrina*.

According to Dr. G. H. GIRTY, his new genus *Triticites* is distinguished from *Fusulina* by having the septa "for the most part straight and not fluted except in the immediate vicinity of the axis, so that the greater portion of each chamber is not divided into chamberlets." The genotype is *T. secalicus* SAY sp. from the Coal Measure of the Mississippi valley. I would here

1) Ditto, p. 24.

express my great obligation to Dr. GIRTY who was kind enough to send me some specimens of the Foraminifera, thus enabling me to verify his description of them. As I examined their sections under the microscope, I was fully convinced of the correctness of his remarks on the peculiar structure of the form; yet I am still in doubt whether it is possible to separate satisfactorily the American form from the group of *Schwagerina* with a fusiform shell, such as *S. fusulinoides* SCHELLWIEN and *S. fusiformis* KROTOW. The former, according to SCHELLWIEN, has "die grosse Centralkammer, die Hin- und Herbiegung der Septen, die in der median Ebene nie den Boden erreichen, Merkmale welche den Fusulinen zukommen," while *Triticites secalicus* possesses, beside these characters, the thick septa of a *Fusulina* s. s. Therefore, until more important differences from *Fusulina* s. s. and *Schwagerina* are found, it seems to me unnecessary to keep *Triticites* as a distinct genus, or even as a new subgenus.[1)]

In addition to the above, let me remark briefly on some of the characters of *Fusulina*, which have been treated in detail by MÖLLER, SCHWAGER and SCHELLWIEN. The first thing to be noticed among these characters is the presence of connecting lamellae, which are found between the septa or between the septa and the wall. They are somewhat different in nature from the ramification of the primary septa, common in *Fusulina*. The occurrence of these connecting lamellae is very inconstant, and probably of no great significance. I once or twice met with lamellae of this kind in the transverse and longitudinal sections of *F. japonica* GUEMBEL var. from Tomuro, Asogori, prov. Shimo-

1) However, I am inclined to believe that a similar name will be needed in future for the prototype of *Fusulina* and *Schwagerina*, and its direct descendants, if such really occur. See p. 21.

tsuke, Japan (Pl. II., fig. 1). Under the microscope, they appear as dark compact lines quite distinct from the septa. They may perform the same function as the ramifications or infoldings of the primary septa, or the intercalations of auxillary and transverse septa, subdividing the chambers or chamberlets.

Secondly, I am in doubt about the following remark of Prof. SCHELLWIEN.[1]

"Es tritt sehr häufig eine Verdickung der zum Septum umgebogenen Kammerwand ein, indem sich auf einer oder beiden Seiten der Septallamelle Kalksubstanz absetzt, welche in der Regel dunkler gefärbt.....Sie wird in der Regel erst nach der Bildung der neuen Kammerwand ausgeschieden zuweilen aber auch schon, ehe die Bildung der späteren Dachwand erfolgt ist, wie eine Beobachtung bei *Fusulina japonica* lehrt." In all my slices of *Fusulina* I can find nothing which coincides with the above description; nor does the figure in his work to which he refers show anything of the kind. In all cases, the boundary between the calcareous substance of the primary septa and what he regarded as produced by a secondary acretion is not distinct and under the microscope they always seem to fade away on both sides.

Thirdly, the true nature of the median lamella, which is the direct continuation of the thin covering on the whole surface of the wall, is also doubtful. Dr. GIRTY has already objected to the long accepted view of the poriferous nature of the wall.[2] Though I am not in position to express anything definite here in regard to this matter, I give in fig. 3, pl. III., an interesting case of a natural staining of the wall. The figure shows a longitudinal, slightly oblique section, of *Neoschwagerina craticulifera* in a

1) SCHELLWIEN: Die Fauna des Karnischen Fusulinenkalks. P. 240.
2) GIRTY: l.c.

limestone block found in a Shiwon-cutting near Sakawa, province of Tosa. In microscopic sections, it almost always happens that the thin upper layer of the wall together with the median lamellae is stained deep brown, while those parts of the walls and the septa which appear to be thoroughly perforate, remain almost unstained. This fact seems to be in favour of the view that the median lamellae of the septa and the covering layer of the wall are of a different nature from the rest of the shell; but from this, I would not directly conclude the non-porosity of the shell.

SCHELLWIEN made mention of a particular case of the formation of septa in *Schwagerina* of the group of *Schwagerina Verbeeki*, saying "Es tritt nämlich häufig eine Verdickung des Septums ein, ehe die neue Kammerwand gebildet wird, wodurch bei der geringeren Stärke des Septums leicht der Anschein erweckt werden kann, dass die Scheidewand eingekeilt wäre. Diese Verdickung legt sich als ein dünner Beleg über das Septum."[1]

Taking these points in consideration, it appears to me that the whole external surface of the shell and of the septa of some, if not all *Fusulina*, is covered with a thin exogenous shell layer as in some other highly organized Foraminifera (for example, some species of the Genus *Rotalia*).

Fourthly, the infolding of the septa seems sometimes, though probably seldom, to occur also in the middle portion of the shell of *Schwagerina* as in *Fusulina* s. s. Such a case is seen in the outermost whorl of *Schwagerina princeps*, in a transverse section, from east of Yang-chao-shan, Wei-nung-hsien, prov. Kwei-tschou in China, as shown in fig. 1, pl. I.

Fifthly, '*Sumatrina*' *Annae* is said to possess, an extremely

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1) SCHELLWIEN: l.c., p. 258.

large chamber, and indeed that of *Fusulina* s. s. usually attains a large size; but in other subgenera the large chamber is of rare occurrence. Thus, *Schwagerina* is generally taken as including those forms which have a minute first chamber. Now, I go so far as to question whether the size of the first chamber is in any measure constant, for I have an example of a *Neoschwagerina* with a large first chamber, but quite similar to *N. craticulifera* in other respects (Pl. I., fig. 4).

The genus *Fusulina* has a very wide geographical distribution; consequently there is a considerable number of works relating to its occurrence in various parts of the world, many of which are not accessible to me. Moreover, it seems that not much reliance can be placed upon the statements of its occurrence, as we do not know whether in all cases the specific names are used in the sense taken by us. These and other circumstances render an exhaustive treatment of its distribution impossible; still we can get a general survey of the genus from the following summary of the more important literature of the subject.

American Border of the Pacific.

North America:—The distribution of *Fusulina*-limestone in North America is very extensive. Though *Fusulina* s. s. seems to be common in the above region, singularly, *Doliolina* and *Neoschwagerina* are at present very little known. Of *Fusulina*, especially the name of *F. cylindrica* FISCHER in its varieties is most frequently met with in the literature of the American Carboniferous; thus we find them reported from the Subcarboniferous limestones of Colorado, Kansas, Ohio, Nebraska, Iowa, Indiana, California, Wyoming, Utah, Illinois, Arizona and British

Columbia.[1] Unfortunately, none of them are fully illustrated, and it is by no means certain that they all belong to the same species. Schellwien[2] is of the opinion that some of the specimens of the so-called *F. cylindrica* from Iowa, Illinois, Indiana and Nebraska are distinct from the well known Russian species. *Triticites secalicus* SAY sp. from the Missouri region is one which was usually accepted as *Fusulina cylindrica*, but it has lately been separated from it by GIRTY and even made the type of a new genus. Beside these forms, SHUMARD[3] described *F. elongata* from New Mexico and Texas, and SCHELLWIEN[4] and SPANDEL[5] found *F.* cfr. *regularis* SCHELLWIEN in Kansas, Nebraska and Indiana. According to GIRTY[6] *F. elongata* SCHUM. occurs associated with *Productus semireticulatus* var., *Derbya*, *Meekella*, *Leptodus*[7] and *Richthofenia* in an upper Permian limestone of Western Texas. The last two genera of Brachiopoda being almost exclusively asiatic type, their record from the American Permian is specially noteworthy. Of *Schwagerina*, we know only *S. robusta* MEEK[8] from California found together with *F. cylindrica* and its variety *gracilis* (Mc Claud limestone, Boss' ranch).

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1) There is, indeed, a multitude of articles relating to the North American *Fusulina*. Those published before 1897 are found in S. WELLER's "A Bibliographic Index of North American Carboniferous Invertebrates" (Bull. U. S. Geological Survey, No. 153, 1898). 'Manual of Geology' of J. D. DANA (4th Edition), amongst others, gave me a fair understanding of the distribution of the fossiliferous deposits and their kinds. The later publications at my disposal are: G. H. GIRTY: The Carboniferous Formations and Fauna of Colorado. U. S. Geol. Surv. Prof. paper, No. 16, 1903. Do: The Relation of Some Carboniferous Fauna. Proc. Washington Acad. Sci. 1905. F. L. RANSOME: The Geology and Ore-deposits of the Bisbee Quadrangle, Arizona. U. S. Geol. Surv. Prof. p. No. 21. 1904.

2) SCHELLWIEN: Die Fauna des Karnischen Fusulinenkalks, p. 280.

3) B. F. SHUMARD: Notice of New Fossils from the Permian Strata of New Mexico and Texas. Trans. St. Louis Acad. Sci. Vol. I. 1858.

4) SCHELLWIEN: l.c. p. 251.

5) E. SPANDEL: Die Foraminiferen des Permocarbon von Hooser, Kansas, Nordamerika

6) GIRTY: The Upper Permian in Western Texas. Amer. Journ. Sci. 1902.

7) *Leptodus = Lyttonia.*

8) F. B. MEEK: Description of the Carboniferous Fossils. Pal. Calif. Vol. I, 1864.

Concerning *Neoschwagerina craticulifera* SCHWAGER from British Columbia, very recently communicated by SCHELLWIEN,[1] no detail have yet been published.

Guatemala:—In the departments of Quiche, Huehuetenango, Alta-and Baba-Verapaz there exist thick limestone and dolomite-deposits probably of the uppermost Carboniferous. The fauna in addition to *Fusulina granum avenæ* F. Römer which is a form first described from near Padang, Sumatra, consists of *Athyris, ambigua* David., *Synocladia, Productus semireticulatus* Mart. and *Lonsdaleia floriformis* Flem. sp.[2]

Asiatic Border of the Pacific.

Vladivostock:—*Fusulina*-limestone occurs along the coast of the Ussuri bay between the mouth of the river Mai-cha and Zymu-cha. According to Th. TSCHERNYSCHEW,[3] the *Fusulina* shows a peculiar form, being very long and having numerous (17–20) close volutions. Associated fossils are *Camarophoria Margaritowi* TSCHERN., *C.* sp., *Reticularia rostrata* KUT., *Productus irginæ* STUCK., and *P. cora* D'ORB. The author believes that the limestone corresponds to the *Schwagerina*-zone of Eastern Russia.

Korea:—In this peninsula, *Fusulina*-limestone is exposed near Phyong-yang. It will be described at some length later on.

Japan:—We encounter *Fusulina*-limestone in various parts of Japan: in the main island (Honshū), in Shikoku, and in

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1) SCHELLWIEN: Trias, Perm u. Carbon in China. 1902.

2) C. SAPPER: Grundzüge der Physikalischen Geographie von Guatemala. Petermans Mittheilungen. Ergänzungshefte No. 113. 1894. No. 127. 1899. *Fusulina* is said to be also found in a graywacke in this place.

3) TSCHERNYSCHEW: Die Oberkarbonischen Brachiopoden des Ural u. des Timan. Mémoires du Comité Géologique. Vol. XVI., No. 2. 1902, p. 731.

Kiushū; but thus far there is no evidence of its occurrence in Hokkaido (Yesso) and the Kurils (Chishima) in the north, or in Formosa (Taiwan) and the Loo-choo (Riukiu) in the south. Nothing is known at present of its occurrence in the southern half of Saghalien (Karafuto). Almost invariably the species of *Fusulina* are found in limestone, but there is a single instance of its occurrence in a slate, (as in 'Auerniggschichten' of the Carnic Alps), at Maiya, prov. Rikuzen, where the slate underlies the *Fusulina*-limestone.

The poverty of other fossils in *Fusulina*-limestones excepting crinoid remains seems to be a character not only peculiar to Japan and China, but also to the rest of the world. The limestones contain a rich fauna of Brachiopoda, with which Cephalopoda are rarely associated, only when *Fusulina* is present in very small numbers. They, no doubt, are a littoral formation, and this is the reason why Cephalopoda are also almost always lacking in the Japanese Anthracolitic fauna.[1]

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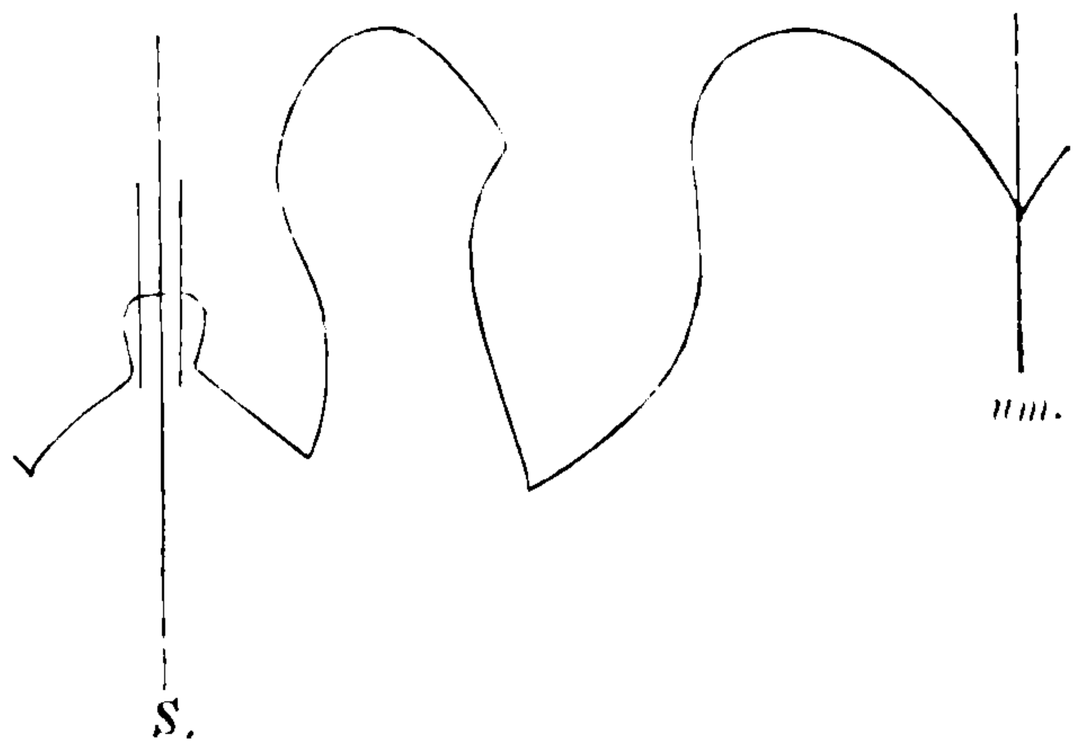
1) The Japanese Anthracolitic Cephalopoda which are now known me are only three. Of these two being quite imperfect in preservation but one deserves some notice. This is moreover very incomplete being in the state of a cast. The shell is small, diameter measuring 23 mm., with a large umbilicus and broad whorls, deeply covering the inner ones. The ventral side is broadly rounded, the whorls being lunular in cross section. No periodic grooves are impressed on the cast. The suture lines are beautifully shown; they are rather distant, simple and very characteristic. composed of two saddles and two lobes on one side of the shell. They may better be understood from the annexed woodcut in four times the natural size. From this and other characters, I consider it to belong to a species of *Gastrioceras*.



The specimen, mentioned above, is from Ōmi, Nishi-kubiki-gōri, prov. Echigo, and comes in association with *Productus* cfr. *spinulis* WAAG., *Spirifer* cfr. *Oldhamianus* WAAG., *P.* cfr. *undatus* DEFR., *Martinia?* sp. and *Schwagerina Verbeeki* GEINITZ.

It is not my intention in this place to enter into a detailed description of the stratigraphy of our upper Palæozoic strata and faunal contents; a very condensed account of them is found in late Dr. T. HARADA's work 'Japanischen Inseln', and 'The Outlines of the Geology of Japan' issued by our Imperial Geological Survey. Some authors are accustomed to regard our *Fusulina*-limestones as belonging to one and the same horizon, but such an assumption is at present without foundation in fact and can only be settled by a careful investigation, both stratigraphical and palæontological, of the limestones in question.

The only well known *Fusulina*-limestones of Japan are those of Kinshō-zan behind the small town of Akasaka, near the city of Ōgaki in the province of Mino. In this locality RICHTHOFEN got his fossils which SCHWAGER afterward studied. Geological studies of the district were subsequently undertaken by Professors GOTTSCHE,[1] KŌTŌ[2] and WAKIMIZU.[3] All these investigators agree in accepting two grand divisions of the limestone deposits, which have been designated, (as in the Carnic Alps, and Russia), as the *Fusulina*-and the *Schwagerina*-limestone series respectively. Both series are again subdivided into a number of zones in which, however, they do not quite agree. I examined more than a hundred microscopic sections of the limestones brought from all of these zones, mostly by Mr. WAKIMIZU, and came to the conclusion that the distribution of *Fusulina* among them quite justifies the two grand divisions of the strata. The distribution of the Foraminifera in the respective divisions is as follows:[4]—

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1) C. GOTTSCHE: Ueber Japanische Carbon. Zeit. d. deutsch. geol. Gesell. Bd. XXXVI. 1884.

2) B. KŌTŌ: Classification of the Carboniferous Limestones of Akasaka (in Japanese). Journ. Geol. Soc. Tōkyō. Vol. V. 1898.

3) T. WAKIMIZU: Limestone Beds of Kinshō-zan, Akasaka (in Japanese). Ditto. Vol. IX. 190.

4) YABE: A Trip to Kinshō-zan (in Japanese). Ditto. Vol. XI. 1904. The Second Trip. (in Japanese). Ditto. Vol. XIV. 1906.

Upper division—*Schwagerina*-limestone series.

Schwagerina Verbeeki. Very rich in a certain zone, alone or in association with the next species.

Neoschwagerina globosa sp. nov. (Pl. I., fig. 5; Pl. III., fig. 1). Present in almost all the zones.

Lower division—*Fusulina*-limestone series.

Schwagerina Verbeeki. Rare.

Doliolina lepida.
Neoschwagerina craticulifera. } These species are very abundant in a certain zone called "Samé", together with the next species.

Fusulina japonica.

Fusulina sp.

Neoschwagerina globosa. Very rare, if really present at all; I have once seen a doubtful trace of it in one of my slices.

The preponderance of *Neoschwagerina globosa* in the upper, and of *Fusulina* in the lower series makes the contrast very striking, and in this connection, there are two important facts to be mentioned:—(I) *Helicoprion Bessonowi* KARPINSKI, which was first found in the Artinskian of the Ural occurs at Hanawa, prov. Shimotsuke, in a limestone with abundant *Fusulina japonica* var.[1] (II) *Neoschwagerina globosa* seems more closely allied to *N. craticulifera* of SCHELLWIEN found in the '*Doliolina*'-limestone lying immediately beneath a limestone with *Xenodiscus tangticus* SCHELLWIEN of the lower Triassic in Semenow mountains of north-eastern Tibet,[2] than to the typical *N. craticulifera* from Japan and China.

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1) YABE: On a *Fusulina*-limestone with *Helicoprion* in Japan. Ditto. Vol. X. 1903.

2) E. SCHELLWIEN: Trias, Perm u. Carbon in China. Schriften d. Physikalökonom. Gesell. zu Koenigsberg. 1902. Paleozoische u. Triadische Fossilien aus China. FUTTERER's Durch Asien III. 1907.

China:—*Fusulina*-limestones are extensively developed in various parts of China, in the provinces of Yun-nan,[1] Se-tschuan,[2] Kan-su,[3] Kiang-si,[4] Kiang-su,[5] Hu-pei,[6] Kwei-schou,[7] and Tibet.[8] According to SCHWAGER,[9] LORENTHEY,[10] DOUVILÉ,[11] and SCHELLWIEN,[12] they contain *Fusulina brevicula* SCHWAGER, *F. japonica* GÜMBEL, *F. Richthofeni* SCHWAGER, *F. cylindrica* FISCHER, var. *gracilis* MEEK., *F. alternans* SCHELLW. *Schwagerina princeps* EHRENBERG, *S. Verbeeki* GEINITZ, *Doliolina lepida* SCHWAGER, *Neoschwagerina craticulifera* SCHWAGER, and a few other allied, but undeterminable forms. The limestones are referred to several distinct zones of different ages in the upper Carboniferous and Permian. Several specimens of them from China also have come into my hands through the courtesy of Messers JIMBŌ, YAMADA, OGAWA, and HIRABAYASHI; some of them are from places probably new to science, therefore it may be better to mention the localities of my samples, with the names of Foraminifera contained in them.

1) Ta-gai-tung, En-nang-hsien, prov. Yun-nan.[13] (YAMADA's coll. No. 31).

Fusulina sp.
Schwagerina Verbeeki
Neoschwagerina craticulifera
N. (*Sumatrina*) *Anna*

Besides, *Fusulinella* and *Bigenerina*.

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1) 雲南 2) 四川 3) 甘肅 4) 江西 5) 江蘇
6) 湖北 7) 貴州 8) 西藏

9) SCHWAGER: Carb. Foram. aus China u. Japan. RICHTHOFEN's China IV.

10) E. LORENTHEY: Microskopische Untersuchungen der Paleozoischen Gesteine SZECHENY's Ostasien III. 1899.

11) H. DOUVILLÉ: Examin des Foss. raporte de la Chine par la mission LECLERE. Comptes Rendu. CXXX. 1900.

12) SCHELLWIEN: l.c.

13) 雲南省恩安縣大岩洞

2) Uchai, Ta-kuan, prov. Yun-nan.[1] (YAMADA's coll. No. 35).

Schwagerina Verbeeki

3) Ho-chang, between Ho-tung and Tsu-chung, Wei-nung-chou, prov. Kwei-schou.[2] (YAMADA's coll. No. 16.)

Fusulina sp.

Doliolina lepida

Besides, *Fusulinella* (the same species as the above).

Bigenerina, Tetrataxis.

4) Between Ho-tang and Hsia-ma-kwan, Wei-nung-chou, prov. Kwei-schou.[3] (YAMADA's coll. No. 13).

Fusulina cylindrica

5) East of Yang-chao-shan, Wei-nung-chou, prov. Kwei-schou.[4] (YAMADA's coll. No. 17).

Schwagerina princeps

6) East of Ho-tang, Wei-nung-chou, prov. Kwei-schou. (YAMADA's coll. No. 15).

Schwagerina sp.? not exactly determinable.

7) Che-hai, Hui-tso-hsien, Tong-chuan-fu, prov. Yun-nan.[5] (YAMADA's coll. No. 26).

Schwagerina ? not exactly determinable.

8) West of Man-kan-shan, Tien-chien-hsien, prov. Se-tschuan,[6] (YAMADA's coll. No. 37).

Fusulinella, the same form as found in the rocks No. 1 and 3.

9) Pong-tsze, prov. Kiang-si.[7] (coll. by JIMBO).

Fusulina sp. indet.

Besides, *Endothyra* and *Bigenerina.*

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1) 雲南省大關廳五寨
2) 貴州省威寧廳后場（黑塘茨中）
3) 貴州省威寧廳后場（下馬崗）
4) 貴州省威寧廳羊角山
5) 雲南省東州府會澤縣者海
6) 四川省天全州門坎山
7) 江西省彭澤

10) Northwest of Long-cha-chong, Ping-shing-hsien, prov. Kiang-si.[1] (coll. by HIRABAYASHI).

Schwagerina Verbeeki

Neoschwagerina sp. nov. aff. *craticulifera.*

11) Liu-yüan-kang, Shin-ngan-hsien, prov. Kiang-si.[2] (coll. by HIRABAYASHI).

Schwagerina sp, indet. (*S. princeps*) ?

Fusulina sp.

12) Kwan-choang, Fu-liang-hsien, Kiang-si.[3] (coll. by HIRABAYASHI).

Fusulina sp. indet.

13) Temple of Lei-yin-ko, Yen-shen-chen, suburb of Po-schan-hsien, prov. Schan-tung.[4] (coll. by OGAWA).

Fusulina sp. indet.

14) Colliery of Nan-chao-ching, South-east of Po-shan-hsien, prov. Schan-tung.[5] (coll. by OGAWA).

Fusulina sp. indet.

Indo-australian-continental Border of the Pacific.

Luan-prabang, Indochina :—Near the base of the Trias, there is a limestone with *Lonsdaleia* and *Schwagerina.*[6]

Tenasserim :—In a dark limestone are found, beside *Schwagerina Oldhami* NŒTLING, *Lonsdaleia salinaria* WAAGEN and WENTZEL, *Productus sumatrensis* RŒMER, *Pleurotomaria* aff. *durga* WAAGEN, and a few other fossils.[7]

1) 江西省萍鄉縣龍家冲西北
2) 江西省興安縣柳源坑
3) 江西省浮梁縣官莊村
4) 山東省博山縣顔神鎮雷音閣下
5) 山東省博山縣南掛井
6) LAPPARENT: Traité de Géologie III. edition, p. 942.
7) F. NOETLING: Carboniferous Fossils from Tenasserim. Rec. Geol. Surv. India. XXVI. 1893.

Padang, Sumatra :—The lower *Fusulina*-limestone contains *F. granum avenæ*, *F.* sp., 5 species of *Bigenerina*, *Productus sumatrensis* ROEM, *Spirifer Damesi* FLIEGEL, *Bellerophon convolutus* v. BUCH, *Pleurotomaria Nikitini* FLIEGEL, *Naticopsis sumatrensis* ROEM., etc., while the upper *Doliolina*-limestone contains *Doliolina Verbeeki*, *Neoschwagerina craticulifera*, *N.* (*Sumatrina*) *Annæ* VOLZ, and also rarely *Fusulina granum avenæ*. FRECH, FLIEGEL and VOLZ[1] believe the age of the *Doliolina*-limestone to be the uppermost Carboniferous.[2]

Coasts along the Mediterranean Sea.

Persia :—According to MÖLLER,[3] the *Fusulina*-limestone of the eastern Albours-range contains *Fusulina Verneuili* MÖLLER and *Schwagerina princeps* EHRENBERG ; these are associated with Brachiopoda such as *Orthotetes crenistria* PHILL. and *Productus semireticulatus* MART.

Turkestan :—In the Charat of Bokhara, close to the Turkestan frontier, there are two horizons of *Fusulina*-limestone, according to A. KRAFFT.[4] The *Fusulina*-limestone of the upper

1) F. ROEMER: Ueber eine Kohlenkalkfauna der Westkueste von Sumatra. Paleontographica XXVII. 1880. F. FRECH: Die Steinkohlenformation, 1899. FLIEGEL: Die Verbreitung des Marinen Obercarbon in Süd-und Ostasien. Zeits. d. deutsch. geol. Gesel. Bd. L, 1898. W. VOLZ: Zur Geologie v. Sumatra.

2) *Fusulina*-limestone of Borneo is frequently mentioned in the literature of *Fusulina*, evidently copied from a note in the Geological Magazine of 1875. But according to FLIEGEL's comment in the Zeitschrift der deutschen geologischen Gesellschaft, the note in the Geological Magazine being an abbreviated translation of STACHE's paper which appeared in Verhandlungen der k. k. geol. Reichsanstalt, Borneo was originally an unfortunate missprint for 'Sumatra.'

KAYSER also made mention of occurrence of a *Fusulina*-bearing rock in Timor (Geolog. Formationskunde II edition 1902), but nothing is known at present about its details.

3) MÖLLER: Ueber Einige Foraminiferen-fuhrende Gesteine Persiens. (Jahrb. d. k. k. geol. Reichsanstalt. Bd. XXX. 1880.

4) A. KRAFFT: Geologische Ergebnisse einer Reise des Charat Bokhara. Denkschrift. d. k. AKAD. Wiss. Mat. Nat. Klasse. Bd. LXX. 1901.

Carboniferous attains a thickness of almost 300 m. and contains *Fusulina* sp., a characteristic short and swollen form with irregular spirals. This limestone is followed above by a younger complex of tuff, tuff-sandstones and black *Fusulina*-limestone. The last rock contains two different forms of *Fusulina*, one of which is an ally of *F. japonica* and probably identical with *F. Möllerі* described by ROMANOWSKY in the third part of his "Materialien zur Geologie des Turkestans", while the other resembles *F. brevicula* and *F. multiseptata*. The above determination of the fossils was made by SCHELLWIEN who, however, found no trace of *Schwagerina* and *Doliolina* in these limestones. According to BOGDANOWICH and SUESS,[1] a limestone with *Fusulina* occurs also at Jatantschi-tag and on the southern flank of Tekelik-tag, eastern Turkestan. The latter regarded it of Moskow stage.

Salt-range :—The rich fauna of the lower *Productus*-limestone of the Salt-range also contains many forms of *Fusulina* s. s. The total absence of *Doliolina* and *Neoschwagerina* in this and other divisions of the Anthracolitic deposits and the corresponding deposits of the Himalayas gives to them an aspect very different from those of China. The species of *Fusulina* have been described by SCHWAGER,[2] who distinguished the following species : *F. kattaensis* SCHWAGER, *F. pailensis* SCHWAGER, *F. longissima* MÖLLER, *F.* sp. indet. The occurrence of *F. longissima* MÖLLER (this specific identification is sometimes disputed), formerly restricted to Russia, is very important. The fauna accompanying the *Fusulina* of the Salt-range is too well known to be repeated in this place.

Balia Maaden and Cilician Tarsus, Asia Minor :—According

1) E. SUESS: Beiträge z. Geol. u. Paleont. Centralasiens.
2) SCHWAGER: Protozoa in Salt-range Fossils. Pal. Indica. Ser. XIII., I., 7. 1887.

to ENDERLE[1] and SCHELLWIEN, many forms of *Fusulina* occurs in a complex of limestones of Hadi Veli Oglou and Aktchal Dagh near Balia Maaden. From Hadi Veli Oglou, Schellwien mentions *Doliolina* aff. *lepida*, *Neoschwagerina craticulifera*, *Schwagerina princeps*, *Fusulina japonica* and *F. tenuissima* which are in association with *Productus* cfr. *sumatrensis*, *Naticopsis*, *Bellerophon*, *Pleurotomaria*, *Murchisonia* etc. while from Aktchal Dagh *N. craticulifera* and *S. princeps* are recorded.

Also in Cilician Tarsus, a limestone with *Fusulina cylindrica* seems to occur.

Island of Chios :—We owe much to TELLER[2] for our knowledge of the existence of a *Fusulina*-limestone in this island. STACHE,[3] who made a study of the collection made by Teller, mentions the existence of *F. Suessi* STACHE and *F. elongata* SCHUM. in the limestone.

Palermo, Sicily :—In 1872, Permian limestones with a rich fauna were found in the Sosio valley in the Province of Palermo in Sicily. The fauna has been described in detail by GEMMELLARO[4] and is remarkable for the numerous Cephalopoda that it contains (fifty nine species of Ammonites and eighteen species of Nautilus), showing an affinity on one side to the Artinskian forms, and in the other, to some of the *Productus*-limestones. The two genera of Brachiopoda, *Richthofenia* and *Leptodus*, characteristic of the Asiatic Permocarboniferous deposits, are also known from this place. At Rocca di S Benedetto, the *Fusulina*-limestone is described as covered by a loose 'Calcare Grossalono.' To my

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1) J. ENDERLE: Ueber eine Anthracolithische Fauna von Balia Maaden in Kleinasien. Beitr. z. Geol. u. Paleont. Osterr.-Ung. u. Orients. Bd. XIII. 1900.

2) Denkschrift d. k. Akad. d. Wiss. Mat. Nat. Classe. Bd. XL. p. 344.

3) Verhandlungen d. k.k. geol. Reichsansatalt. 1879. p. 371.

4) G. G. GEMMELLARO: La Fauna del Calcari con Fusulina. 1887–88.

regret, details about the species of *Fusulina* are unknown to me as in the case of the Island of Chios, Brazil and North America.

Carnic Alps:—The *Fusulina*-limestones and the fauna contained therein have lately been treated in details by FRECH, SCHELLWIEN and GORTANI.[1] SCHELLWIEN distinguished the following four horizons of the limestones according to the distribution of the species of *Fusulina*:—

4) Highest zone (Trogkofelschichten).

Fusulina alpina SCHELLW. var. *communis?*

Fusulina regularis SCHELLW.

Schwagerina fusulinoides SCHELLW.

Schwagerina princeps EHRENB.

Beside the above forms, there are also *Steinmannia*, a genus of calcareous sponge also found in the Salt-range and in Japan,[2] *Productus cancrini* VERN., *Scachinella variabilis* GEMM., *Spirifer tibetanus* DIENER, *Spirifer Wynnei* WAAGEN, *Thalassoceras microdiscus* GEMM., *Popanoceras* sp. etc.

3) Zone of a *Schwagerina*-limestone.

Fusulina alpina var. *communis*

Fusulina multiseptata SCHELLW.

Fusulina tenuissima SCHELLW.

Schwagerina princeps.

2) The principal zone of *Fusulina*.

Fusulina alpina var. *fragilis*

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1) E. SUESS: Ueber das Vorkommen von Fusulinen in den Alpen. Verh. d. k. k. geol. Reichsanstalt. 1870. F. FRECH: Die Steinkohlenformation. 1899. E. SCHELLWIEN: Die Fauna des Karnischen Fusulinenkalks II. Theil. Paleontographica Bd. XLIV. 1898. M. GORTANI: Fossili rinvennti in un primo saggio del calcare a *Fusuline* di Forni-Avoltri (alta Carnia occidentale). 1903. (by review). Do: Sul rinvenimento del Calcare a *Fusulina* presse Forni-Avoltri nell alta Carnia occidentale. 1902. (by review).

2) YABE: Materials for a Knowledge of the Anthracolitic Fauna of Japan. Journ. Geol. Soc. Tōkyo. Vol. IX. 1902.

Fusulina alpina communis
Fusulina multiseptata
Fusulina regularis
Fusulina incisa SCHELLW.

1) The lowest zone of *Fusulina*.

Fusulina alpina var. *antiqua*
Fusulina alpina var. *communis.*
Fusulina tenuissima

In the lowest zone there are also *Amblysiphonella* sp., *Lonsdaleia floriformis* FLEM., *Spirifer fasciger* KEYS., *S. trigonalis* MART., var. *lata* SCHELLW., *Reticularia lineatus* MART., *Productus semireticulatus* MART.

Asturia, Spain :—A *Fusulina*-limestone forms the base of the upper Carboniferous exposed in the district ; it contains, beside *Fusulina cylindrica* and some other forms of the same genus, an important leading fossil *Spirifer mosquensis.*[1]

Para, Brazil :—The Carboniferous fauna of Tapajos is very rich in Corals, Crinoids, Bryozoa, Brachiopoda, Lamellibranchiata, and Gasteropoda, while *Fusulina* is very rare. The last is reported to occur at Itaituba.[2]

Russian Sea.

Russia :—In central Russia, the upper Carboniferous series is divided into two well known groups :—the lower or Moscovian stage (horizon of *Spirifer mosquensis*) and the upper or Gshelian stage (horizon of *Chonetes uralica*).

In the upper Carboniferous rocks of the Ural mountains, two

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1) MEUNIER reported the occurrence of a limestone containing *Fusulina* at Morvan, central France, but according to F. FRECH, it is not a true *Fusulina* but a *Fusulinella*.

2) KATZER : Grundzüge der Geologie des unteren Amazonas Gebietes, 1903.

faunistically different horizons may be likewise distinguished:— the lower (C_2) (horizon of *Spirifer mosquensis*) and the upper (C_3) (horizon of *Productus cora*). The latter is a *Fusulina*-limestone and is covered by that of *Schwagerina*.

In the Oka-Kljasma and Oka-Wolga basins, the horizon of *Chonetes uralica* is overlaid by *Schwagerina* Dolomite.

As may be seen from the above, the *Schwagerina*-limestone of the Ural mountains, must be placed on a somewhat higher level than the Gshelian stage. The Artinskian marls and sandstones (Cpg) conformably overlie the *Schwagerina* horizon.

The species of *Fusulina* which is a genus very widely distributed in the Russian Carboniferous and Permian, was fully worked out by MÖLLER a quarter of a century ago. According to the works of MÖLLER, and those of KROTOW, STUCKENBERG, SIBIRIZEW, and TSCHERNYSCHEW[1] which subsequently appeared, I

	Moskau stage	*Cora* stage	*Schwagerina* stage	Permo-carboniferous
Fusulina Bocki	—	—	×	—
cylindrica	×	×	—	—
var. *gracilis*	?	?	—	—
longissima	?	×	×	×
montipara	×	×	×	×
prisca	×	×	×	—
uralica	—	×	×	—
ventricosa	?	×	×	—
Verneuili	×	×	×	×
Schwagerina fusiformis	—	—	×	—
princeps	—	×	×	×
robusta	—	×	×	—

1) EHRENBERG: Mikrogeologie. BRADY: Notes on a Group of Russian Fusulinae. Ann. Mag. Nat. Hist. 1876. FRECH: Die Steinkohlenformation. TRAUTSCHOLD: Die Kalkbrüche von Mjatschkowo. Nouv. Mem. de la Soc. Imp. d. Naturalistes de Moscou. 1874–76. TSCHERNYSCHEW: Note sur le rapport des dépots carbonifères russes avec ceux de l'europe occidentale. Ann. de la géol. du Nord. Bd. 17. 1890. (by review). Do: Die Obercarb. Brachiopoden des Ural u. des Timan. KROTOW: Geologische Forschungen am westl. Ural-Abhänge in den Gebieten von Tscherdyn u. Ssolikamsk. 1888. STUCKENBERG: Allgemeine Geologische Karte von Russland. Mém. comité Géol. XVI., 1898. SIBIRZEW: Allgemeine Geol. Karte v. Russland. Ibid. XV., 1896. Guide des Excursions du VII. Congrès Géologique International.

have made the above mentioned table of the vertical range of the most important species of Russian *Fusulina*.

C. v. Voight has found a limestone with abundant *Schwagerina princeps* near Symperopol in the Crimean peninsula, this is an important discovery, for it indicates the existence of an open connection between the Russian and the Mediterranean sea in the Carboniferous time.[1]

Arctic Ocean.

Spitzbergen:—J. G. ANDERSON and GÖES[2] observed a limestone with *Fusulina cylindrica* and *Spirifer mosquensis* in Spitzbergen; but TSCHERNYSCHEW doubts the correctness of the determination of the *Fusulina*. The limestone overlies the Culm deposit and the Devonian.

Bear Island:—We owe to ANDERSON our knowledge of the existence of a *Fusulina*-limestone of the middle Carboniferous age in this Island. According to this author, the fauna consists of *Fusulina cylindrica* FISCHER. *Camarophoria isorynchа* M'COY, *Syringopora ramulosa* GOLDF.? and a Cyathophylloid coral.

Prince Albert Land:—Salter described a *Fusulina* from the Carboniferous limestone of this island under the name of *F. hyperborea*, a form closely allied to *F. longissima* according to MÖLLER.

The next table, imperfect as it is, owing to the want of uniformity in the limit of species among various authors, clearly

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1) TSCHERNYSCHEW: Die Obecarbonischen Brachiopoden des Ural u. des Timan. p. 681.

2) ANDERSON. Ueber die Stratigraphie u. Tectonic der Baren-insel. Bull. Geol. Inst. Upsala, 1900. GÖES: Oefvers. Vet. Akad. Forhandl. 1883.

shows that *Neoschwagerina* and *Doliolina* (including *Sumatrina*) have their distribution almost entirely confined to the Pacific ocean, which seems to be their proper habitat.

Studying the *Fusulina* of the Carnic Alps, SCHELLWIEN arrived at an important conclusion.[1] According to this author, species of *Fusulina* s. s. bear a local nature in striking contrast to *Schwagerina princeps* and many other allied forms, which show a wide distribution. TSCHERNYSCHEW,[2] however, considered this view as direct contradiction to the theory of derivation of *Schwagerina* from *Fusulina* s. s. and pointed out the occurence of some Carnic species and a variety of Salt-range species in the Russian Carboniferous. Be that as it may, it seems to me that the derivation of *Schwagerina* from *Fusulina* has no relation to the view maintained by SCHELLWIEN.

Table showing the Distribution of the Important Species of the Genus *Fusulina*.[3]

	Pacific Ocean.					Mediterranean Ocean.				Russian Sea.	Arctic Ocean.	
	Guatemala.	N. America.	Japan.	China.	Padang, Timor.	Brazil.	Persia, Asia Minor etc.	Salt-Range.	S. Europe.		Pr. Albert isl.	Spitzbergen.
FUSULINA.	×	×	×	×	×	×	×	×	×	×	×	×
alpina var. *antiqua*	—	—	—	—	—	—	—	—	×	—	—	—
var. *communis*	—	—	—	—	—	—	—	—	×	—	—	—
var. *fragilis*	—	—	—	—	—	—	—	—	×	—	—	—
alternans	—	—	—	×	—	—	—	—	—	—	—	—
Bocki	—	—	—	—	—	—	—	—	—	×	—	—
brevicula	—	—	—	×	—	—	—	—	—	—	—	—
complicata	—	—	—	—	—	—	—	—	×	—	—	—

1) SCHELLWIEN: Karnischen Fusulinenkalk. p. 280.

2) TSCHERNYSCHEW: l.c. p. 280.

3) There are many other species of *Fusulina*, not enumerated below; for they have not been fully illustrated by the authors themselves; such are *F. Hefferi* STACHE, *F. Suessi* STACHE.

Table showing the Distribution of the Important Species of the Genus *Fusulina*—(*Continued.*)

	Pacific Ocean.					Mediterranean Ocean.				Russian Sea.	Arctic Ocean.	
	Guatemala.	N. America.	Japan.	China.	Padang, Tenasserim.	Brazil.	Persia, Asia Minor etc.	Salt-Range.	S. Europe.		Pr. Albert isl.	Spitzbergen.
cylindrica	—	×	—	×	—	—	×?	—	×?	×	—	×?
var. *gracilis*	—	×	—	×	—	—	—	—	—	×?	—	—
elongata	—	×	—	—	—	—	—	—	—	—	—	—
exilis	—	—	×	—	—	—	—	—	—	—	—	—
granum avenae	—	—	—	—	×	—	—	—	—	—	—	—
hyperborea	—	—	—	—	—	—	—	—	—	—	×	—
incisa	—	—	—	—	—	—	—	—	×	—	—	—
japonica	—	—	×	×	—	—	×	—	—	×	—	—
kattaensis	—	—	—	—	—	—	—	×	—	×?[2]	—	—
longissima	—	—	—	—	—	—	×	×?[3]	—	×	—	—
Möllori	—	—	—	—	—	—	×	—	—	—	—	—
montipara	—	×?[1]	—	—	—	—	—	—	—	×	—	—
multiseptata	—	—	—	—	—	—	—	—	×	×[2]	—	—
pailensis	—	—	—	—	—	—	—	×	—	—	—	—
prisca	—	×?[1]	—	—	—	—	—	—	—	×	—	—
pusilla	—	—	—	—	—	—	—	—	×	—	—	—
regularis	—	×	—	—	—	—	—	—	×	—	—	—
Richthofeni	—	—	—	×	—	—	—	—	—	—	—	—
tenuissima	—	—	—	—	—	—	×?	—	×	—	—	—
uralica	—	—	—	—	—	—	—	—	—	×	—	—
ventricosa	—	×	—	—	—	—	—	—	—	×	—	—
Verneuili	—	×?[1]	—	—	—	—	×?	—	—	×	—	—
SCHWAGERINA	—	×	×	×	×	—	×	—	×	×	—	—
fusiformis	—	—	—	—	—	—	—	—	—	×	—	—
fusulinoides	—	—	—	—	—	—	—	—	×	—	—	—
Oldhami	—	—	—	—	×	—	—	—	—	—	—	—
princeps	—	—	×	×	×	—	×	—	×	×	—	—
robusta	—	×	—	—	—	—	—	—	—	×	—	—
secalicus (*Triticites*)	—	×	—	—	—	—	—	—	—	—	—	—
Verbeeki	—	—	×	×	×	—	—	—	—	—	—	—
DOLIOLINA	—	—	×	×	—	—	×?	—	—	—	—	—
lepida	—	—	×	×	—	—	×?	—	—	—	—	—
NEOSCHWAGERINA	—	—	×	×	×	—	×?	—	—	—	—	—
Annae (*Sumatrina*)	—	—	×	×	×	—	—	—	—	—	—	—
craticulifera	—	—	×	×	×	—	×?	—	—	—	—	—
globosa	—	—	×	×?	—	—	—	—	—	—	—	—

1) After MÖLLER.

2) After TSCHERNYSCHEW.

3) Specific identity of the Salt-range and Russian forms was doubted by SCHELLWIEN.

The consideration of the vertical range of the genus *Fusulina* is also very difficult to summarize at present; for the geological age of the *Fusulina*-limestones of various parts of the world, is for most cases, still in dispute. For instance, there are two different views about the age of the lower Productus-limestone of the Salt-range[1] and of the 'Doliolina'-limestone of the old Pacific coast; some regard them as of the uppermost Carboniferous, while others consider them as Permian.

It is evidently misleading to consider a species of *Fusulina* to have a much restricted vertical range: to give only one instance, *F. montipara* is common in all deposits from the zone of *Spirifer mosquensis* up to the Artinskian formation in Russia. But as is usually the case, there is of course a possibility of less longevity in the case of the more lately evolved forms which have attained a higher complication of structure.

The distribution of the four subgenera of *Fusulina* in time is fundamentally different from that of *Orbitoides* of the later Cretaceous and Tertiary. In this latter genus, we can count at present four principal subgenera, namely *Orbitoides* s.s., *Orthophragmina*, *Lepidocyclina* and *Miogypsina*, which appeared in almost regular succession, each confining its distribution to a certain geological age, for example, *Orbitoides* s.s. to the Cretaceous, *Orthophragmina* to the Eocene, *Lepidocyclina* to the Oligocene and *Miogypsina* to the Miocene.[2] In the case of *Fusulina*, such a replacement of an older type by a younger seems never to have happened; the species belonging to a

1) WAAGEN: Salt-range Fossils, Geological Resnlt. Pal. Indica. LAPPARENT: Note sur les calcares a Productus du Salt-range. Bull. Soc. Geol. France 1903. TSCHERNYSCHEW: Die Obercarb. Brachiopoden. NOETLING: Ueber des Verhaltniss zw. Productuskalk und Ceratitenschichten. There are many other works by the last named author on this subject.

2) Some Italian authors deny to accept this view of Douvillé and Schlumberger on the geological range of the Foraminifera.

structurally lower type, retained for ages its characters rigid and unshifting, the times and circumstances produced highly structural types, but hardly influenced the survival of the ancestral forms.

The derivation of *Neoschwagerina* either from *Doliolina* or directly from *Schwagerina* is a point still undetermined; however, it is almost certain when tracing the development of *Neoschwagerina craticulifera* from the initial chamber onward, that the first numerous chambers are already with transverse septa though not with auxiliary ones. Therefore it is not impossible that *Neoschwagerina* is but an improved form of *Doliolina*, unless the basal skeletons are transverse septa much shortened by degeneration, contrary to my present belief.

The subgenus *Doliolina* is *Schwagerina*, only one step higher in structure, and their relationship is so close that the form known as *S. Verbeeki* may likewise be called *D. Verbeeki*.

Triticites secalicus and some other forms, included in *Schwagerina* by KROTOW and SCHELLWIEN, undoubtedly show vestiges of a common ancestral group from which the typical *Fusulina* and *Schwagerina* sprang. The prototype, we have many good reasons to believe, might have been an elongate form, either fusiform or cylindrical, composed of some number of closely coiled volutions and divided into chambers more or less completely formed by numerous strecheḍ septa. Therefore if many of the lower Carboniferous forms of *Fusulina* could be found and their structural details made known, the mutual relations between *Schwagerina* and *Fusulina* s.s. would be cleared up.

NOTES ON A FUSULINA-LIMESTONE FROM KOREA.

The discovery of a *Fusulina*-limestone in Korea is especially noteworthy, as it proves the existence of Anthracolitic deposits in more or less extension in a land geologically little known.[1]

When I examined a slice of Korean limestone brought back by Mr. N. FUKUCHI, my attention was immediately attracted to small foraminiferal remains which I took for a *Fusulina* in a state of very bad preservation; but unfortunately other sections of the same rock, since prepared, did not reveal any more reliable forms. At my request, Mr. T. IKI of the Imperial Geological Survey, very kindly paid a good deal of attention to the subject, while inspecting mines in the peninsula, and brought back many specimens of limestones which he placed at my disposal for examination. These limestones are all from the neighbourhood of Phyong-yang.[2]

Our knowledge of the *Fusulina*-limestone and its associated rocks in Korea is at present very imperfect; an area along the Tai-dong-gang[3] below Phyong-yang is coloured by GOTTSCHE in his geological map as Tertiary, while the surrounding region is

1) In one of my former papers, Mesozoic Plants from Korea (Journ. Sci. Coll. Imp. Univ. Tōkyō, Vol. XX., No. 8, 1905), I proved the Mesozoic age of a thick complex, on the evidence of a fossil flora, widely spread in a region including the greater part of the Kyong-syang-Do and a part of the Chhung-chhyong-Do and Chol-la-Do. The plants found in the slate which GOTTSCHE referred to the Carboniferous, on account of the occurrence of his supposed *Neuropteris* in it, though not yet studied in detail, so far as my own opinion is concerned, is probably of a Triassic age. Also there is some doubt about the occurrence of *Fusulina*-limestone in Korea mentioned by H. CREDNER (Elemente d. Geologie. 1897, p. 467) and G. FLIEGEL (Zeitschrift d. deutsch geol. Gesell. Bd. L.); the original paper if there be one, is not accessible to me.

2) 平壤.

3) 大同江 (Tai-dong-river).

entirely included in the crystalline schists. In p. 869 of his text, he gives the following accounts of the younger complex:—

"? Tertiär. Die Hügel, auf denen Phyong-yang steht, zeigen theils am Ufer des Tatung, theils an ihrem nördlichen Hänge folgendes Profil von unten nach oben:

1. Feinkörniger Sandstein mit undeutlichen Pflanzenresten und bis 4 cm. grossen Kohlenschmitzen, durch eine 2 m. starke Conglomeratbank getrennt von ..... 70 m.
2. gelblichen, auch schwärzlichen Mergeln, ohne Versteinerungen ..... 40 m.
3. fest, graue Mergelschiefer, ohne Versteinerungen ..... 25 m.
4. leicht zerreibliche Sandsteine mit einzelnen Geröllen ..... 5 m.

140 m.

In 1. fanden sich sowohl im unteren Theil, als in der Conglomerat-bank wohl erhaltene Kieselhölzer, welche Herr. Dr. J. Felix in Leipzig als neue Arten der Gattungen *Araucarioxylon* und *Cedroxylon* erkannt hat. Die erstere Gattung ist nach seiner Mittheilung von Carbon bis in's Tertiär, die letztere vom Rhæt bis in die Gegenwart nachgewiesen. Die Schichten von Phyong-yang, welche sich auch auf dem linken Ufer noch 15 li gegen Südost, im Ganzen auf 40 li verfolgen lassen, sind also rhætisch oder jünger. Das Liegende derselben bilden theils krystallinische Schiefer, theils (zwischen Phyong-yang und Samdeung) Kalke von unbekannten Alter."

Phyong-yang has long been known for some coal seams exposed in its environs, partly workable and of wide reputation

in the peninsula; FUKUCHI, in a report (in Japanese) of the coal-survey, briefly refers to the geology of the district as follows:

"Near Phyong-yang, there are three different rock series exposed:—(1) the Palæozoic composed of slate and limestone, (2) the Phyong-yang series consisting of three parts, the upper composed of sandstones, the middle of alternations of sandstones and of at least three coal seams and the lower of shales, and (3) alluvial along the Tai-dong-gang. At three spots (one near Mun-syu-bong[1] and two at Mu-no-san[2]) a limestone with *Fusulina* was seen beneath the lower shale of the Phyong-yang series, but the exact relation between them is unknown."

In one of his reports, Mr. T. IKI[3] also gives the similar result of his observation on this coal bearing series; he could not, as I am informed, make out a distinct stratigraphical break between the shale with the coal-seams and the same with the limestone-lenses. Besides, there is another series of sandstone exposed at the north of the Tai-dong-gang near Phyongyang which often contains imperfect impressions of plants and sometimes makes an approach to a conglomerate, with numerous inclusions of pebbles. The latter he doubtfully referred to mesozoic.

Although it is impossible at present to correlate the respective layers of the profile made by GOTTSCHE with those of the one made by IKI and FUKUCHI, this much is certain, that the so-called Tertiary of the former corresponds, at least partly, to the coal-bearing series of the latter; for GOTTSCHE had pointed out the occurrence of his Tertiary (?) deposit also at a place 15 Korean li (≒6 km.) south of Phyong-yang, where there are no

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1) 紋水峯 (Mt. Mun-syu). 2) 霧露山 (Mt. Mu-no).
3) Journ. Geol. Soc. Tōkyō. Vol. XIII., p. 173. 1906 (in Japanese).

other rocks than those of the coal-bearing series of Iki and Fukuchi.

Admitting the correctness of Felix and Gottsche's view, there must be at least two divisions of rock series, one post-Rhætic and the other Anthracolitic. That there is a gradual transition between them is hardly conceivable; but the locality from which Gottsche collected *Araucarioxylon* and *Cedroxylon* not being exactly known, the boundary between these two formations is at present also unknown.[1]

I found *Fusulina* in specimens of limestone from the following places near Phyong-yang:—

I) From a small exposure along the railway cutting near Kaika-dong[2] on the southern side of Mu-no-san (coll. by Fukuchi).

The limestone is compact and dark-grey, traversed by numerous irregular fine calcite veins: microscopically no other organic remains than small circular sections of crinoid stems and

Fusulina sp. indet. aff. *Richthofeni* Schwager

are found. The latter is very seldom in the rock.

II) Ko-pan-san,[3] in a valley of (coll. by Iki).

The limestone is black in colour and is carbonaceous, also with numerous fine calcite veins. Under microscope, we find

Fusulina sp. indet. aff. *Richthofeni* Schwager.

Stacheia sp.

Bigenerina Bradyi Möller sp.

Lagena sp.

---

1) At about 1½ ri (≒6 km.) west of Phyong-yang appears a thick complex of sandstone and shales of a nature similar to those to the east and south, but lacking limestone-lenses, and accompanying thick conglomerate beds. What is especially important in Iki's observation is the occurrence of limestone-pebbles in the above conglomerate. Iki took this formation as of decidedly younger age than the coal-bearing one, and therefore, it stands without relation to the present problem.

2) 開科洞　　3) 古坊山 (Mt. Ko-pan).

III) Kotch-jyang-kol,[1] west of the Sam-deung[2] coal-field (coll. by IKI).

The limestone is extremely light coloured, with numerous small pullets of rather irregular form and size. Among the pullets are found numerous minute shells of Foraminifera, some of which probably belong to the young of *Fusulina*.

A similar rock is also reported by IKI and FUKUCHI as exposed near Mun-syu-bong. There is a limestone kilne, situated at the northern foot of Mu-no-san.

The geological age of this limestone is surely Anthracolitic, but to what part of it the rock belongs, is impossible to say.

DESCRIPTION.

FUSULINA sp. indet.

Pl. III., figs. 4 and 5.

Fig. 5, Pl. III. shows a transverse (slightly oblique) section of a *Fusulina* through its first chamber; it is the best I have ever seen in the thin slices of Korean limestone. This *Fusulina* is very small in size, with about four volutions, and attaining only 1.0 mm. in diam.; the volutions increase regularly and at the same time gradually in height, though they are not so closely coiled as in *F. japonica* GUEMBEL. The rate of growth of each volution is to be estimated as follows,-x-, x, x, 7, 9, 12, 14, 18, 20,....., the first three figures showing dimensions not capable of being measured with any accuracy. The walls are

1) 串場街　　2) 三登

thin (nearly 0.03 mm. in the outermost volution) while the septa are still thinner. As was seen from one of the transverse sections, the latter become especially thin near the umbilical end. The shell has numerous septa which number about 30 in the fourth volution ; infoldings of the septa are numerous and similar to those of *F. Richthofeni* SCHWAGER, except near the umbilical end.

Fig. 4 shows a longitudinal section, very excentrically made, of a *Fusulina*, whose specific identity with the above is rendered probable by its small size, the similarity in the relative thickness of the wall and septa, and above all by the absence of any other forms belonging to a clearly distinct species in many slices of the same rock. The areolar ramification of the septa at the umbilical end is not so conspicuous as in *F. Richthofeni*, a species which otherwise very much resembles our form in structure. This section, though taken very excentrically, also affords us some idea of the general aspect of the species ; it may be called cylindrical rather than fusiform. The canals of the pores are simple, and have a breadth somewhat less than 0. 01 mm.

In several respects, this Korean form is also not unlike *F. cylindrica* Fischer, though provided with many distinguishing features ; for instance *F. cylindrica* has first chamber excessively large in comparison with our form; the ramification of the septa near the umbilical end is also not quite alike in these two.

From the above explanation of the accompanying figures, it will be seen that there is a peculiar small form of *Fusulina* s.s. in Korea, probably distinct from any of the described forms. I once took it for a local, dwarf variety of *F. Richthofeni*, a form hitherto found in China, but this needs verification from the examination of more numerous and better materials.

LAGENA sp. indet.

Pl. I., fig. 6.

With some hesitation, I refer a form known from a single longitudinal section to the genus *Lagena*. It appears to be pear-shaped, somewhat produced at one end, and has a thin calcareous and finely poriferous shell. I once met with quite a similar form while examining a slice of a 'Kuro' limestone of Akasaka, prov. Mino, which agrees with the Korean not only in outline and structure, but also in dimensions.

It attains 1.1 mm. in length and 0.6 mm. in breadth.

BIGENERINA BRADYI MÖLLER sp.

Pl. II., fig. 5.

Compare:

1876. *Textularia eximia* BRADY: Monograph of Carb. and Perm. Foram. P. 132, pl. X., figs. 27–29.

1897. *Cribrostomum Bradyi* MÖLLER: Foram. d. Russ. Kohlenkalk. p. 53, pl. III., figs. 1a-e; pl. VI., fig. 1, text figures 18, 19.

I compare the form represented in the above figure to *Bigenerina Bradyi* from the Russian and British limestones; the shell is small, attaining only 1.1 mm. in length and 0.55 mm. in breadth, composed of two rows of 4 and 5 alternating chambers which are then followed by a uniserial one. It appears in the section, more parallel sided than the typical form figured in the above cited works; this is probably due to the slight obliquity of the section from the median plane.

Its resemblance to the Russian and British species is very striking, and so that they at least show a close relationship to each other, if they are not really identical.

STACHEIA sp. indet.

Pl. III., fig. 6.

Fig. 6 shows a peculiar form. In a thin slice of a limestone, there is a peculiar form not hitherto met with in the *Fusulina*-limestones of Japan and China. In spite of its great imperfection, however, it seems to me to be a fragmentary specimen of a species of the genus *Stacheia*. It possesses only 7–8 concavo-convex chambers in succession each embracing previous ones except at its peripheral margin. These chambers are subdivided into numerous chamberlets by more or less radial partitions which are almost complete. The chamberlets are radially elongated and of a varying breadth. The wall and partitions are rather thin, uniform and imperforate; they appear granular, being preserved in quite a different manner from those of *Fusulina* and *Lagena* which occur in association.

If its determination as the genus *Stacheia* is correct, its occurrence in the Korean limestone is of some interest; for it is by no means a common genus, though not rare in some Carboniferous limestones of England,[1] the Carnic Alps,[2] and European Russia.[3] *Stacheia Grewinki* MÖLLER[4] from Persia may

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1) H. B. BRADY: A Monog. of Carb. and Perm. Foram. p. 107.

2) SCHELLWIEN: Die Fauna d. Karnischen Fusulinenkalks. p. 263.

3) MÖLLER: Die Foram. d. Russ. Kohlenkalks. p. 78.

4) MÖLLER: Ueber Einige Foraminiferenführende Gesteine Persiens. Jahrb. d. k.k. geol. Reichsanst. Bd. XXX. 1880.

probably belong to another genus. *Stacheia* has a range from Silurian to Lias.[1]

In conclusion, I desire to express my obligations to the gentlemen who have had the kindness to allow me to use materials collected by them. To Prof. M. Yokoyama, I also tender my best thanks for his courtesy in looking over this paper while in manuscript.

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1) CHAPMAN counted six species of the genus in the Rhaetic rock of Somerset; some of them are indeed specifically identical with those of Carboniferous (CHAPMAN: Rhaetic Foraminifera from Somereset. Ann. Mag. Nat. Hist. XVI. 1895). Also a Devonian species found by SCHUBERT in a limestone of Bohemia is very like *S. polytrematoides* BRADY from Carboniferous. (R. J. SCHUBERT u. Ad. LIEBUS: Vorläufige Mittheilung ü. Foraminiferen aus dem Böhmischen Devon. Verh. d. k. k. geol. Reichsanstalt 1902. p. 66). Therefore, the Foraminifera though interesting in itself, has no value for geological correlation.

Postscript.

Very recently, Prof. YOKOYAMA found *Podozamites lanceolatus* and *Cladophlebis Whitbyensis* in a collection of plant-remains from Kam-peuk-uön near Phyong-yang. This comfirms Mr. IKI's view, mentioned above; but without further knowledge on the geological relation extisting between the plant bed and the coal bearing formation, the problem on the geological age of the latter above alluded to, is left unsettled for ever.

The remarkable occurrence of a peculiar, elongate species of *Fusulina* in a calcareous sandstone of Tsukitate, near Kesennuma, prov. Rikuzen, was accidentally omitted in the note on Japanese *Fusulina* (p. 11).

H. YABE.

A CONTRIBUTION TO THE GENUS FUSULINA.

PLATE 1.

Reference to Plate I.

Fig. 1. *Schwagerina princeps* EHRENBERG, from the east of Yang-chao-shan, China. Transverse section. × 20.

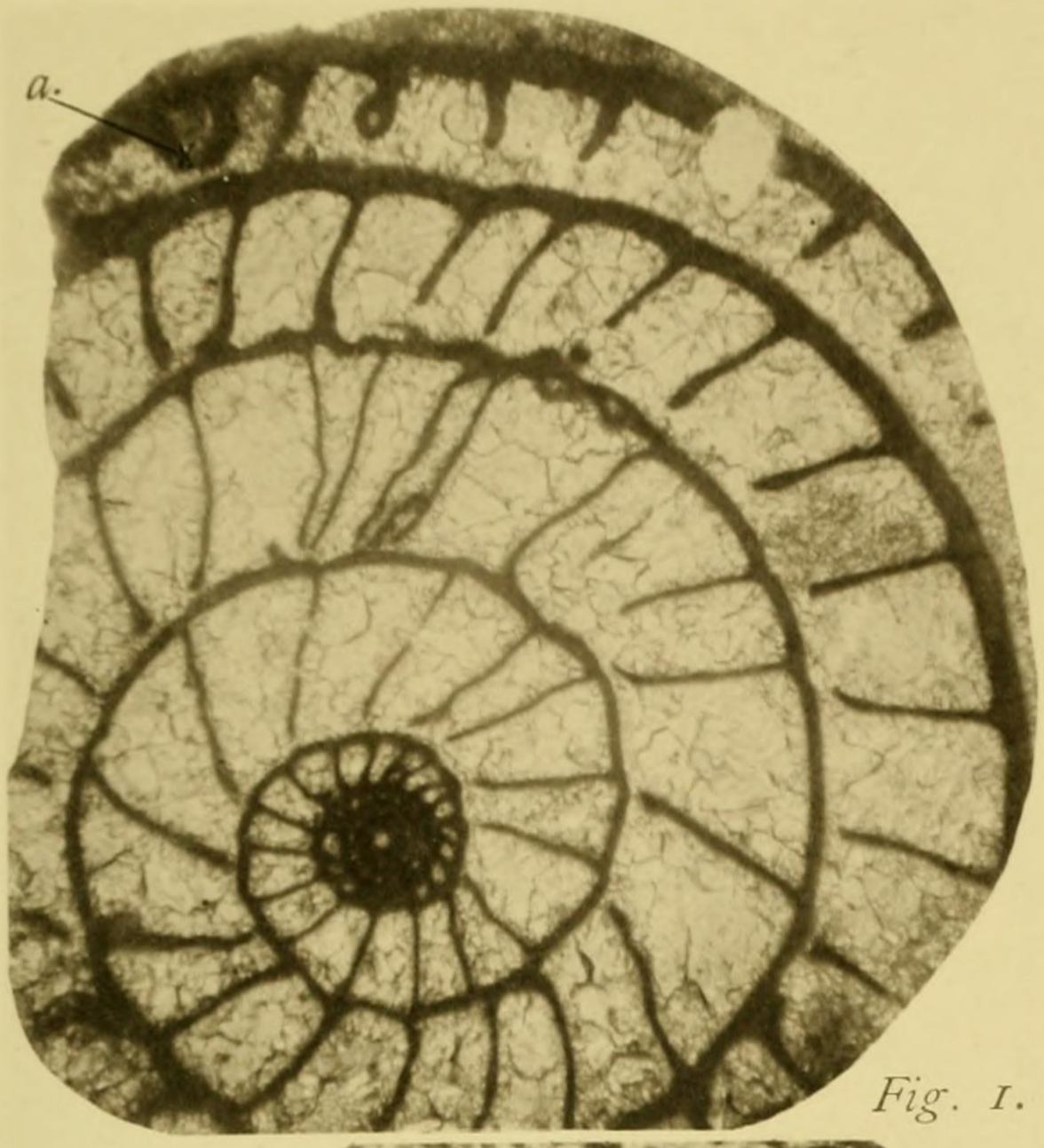
Fig. 2. *Schwagerina Verbeki* GEINITZ, from Tochikubo, prov. Iwaki, Japan. Longitudinal section. × 20. a, septa; b, basal skeleton.

Fig. 3. *Neoschwagerina craticulifera* SCHWAGER, from Akasaka, prov. Mino, Japan. Longitudinal section. × 20.

Fig. 4. *Neoschwagerina craticulifera* SCHWAGER, with a large first chamber, from Ōkubo, prov. Bitchū, Japan. Cross section. × 18.

Fig. 5. *Neoschwagerina globosa* YABE, from Akasaka, prov. Mino, Japan. Longitudinal section. × 48. a, long transverse septa; b, short transverse septa; c, primary septa in a parallel section. Notice the fine poriferous nature of the wall and the upper portion of the septa.

Fig. 6. *Lagena* sp. indet., from Phyong-yang, Korea. Longitudinal section. × 48.



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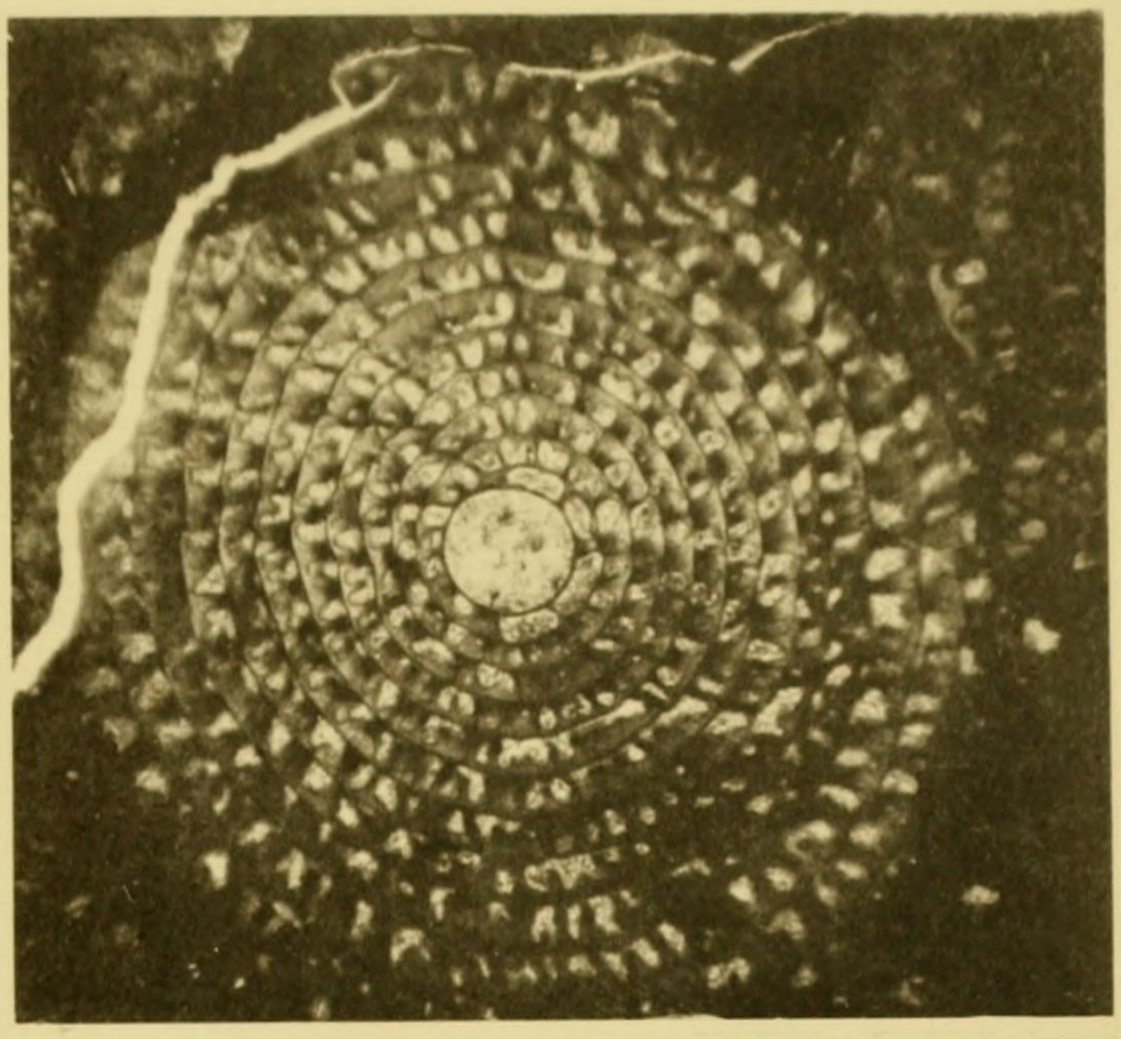
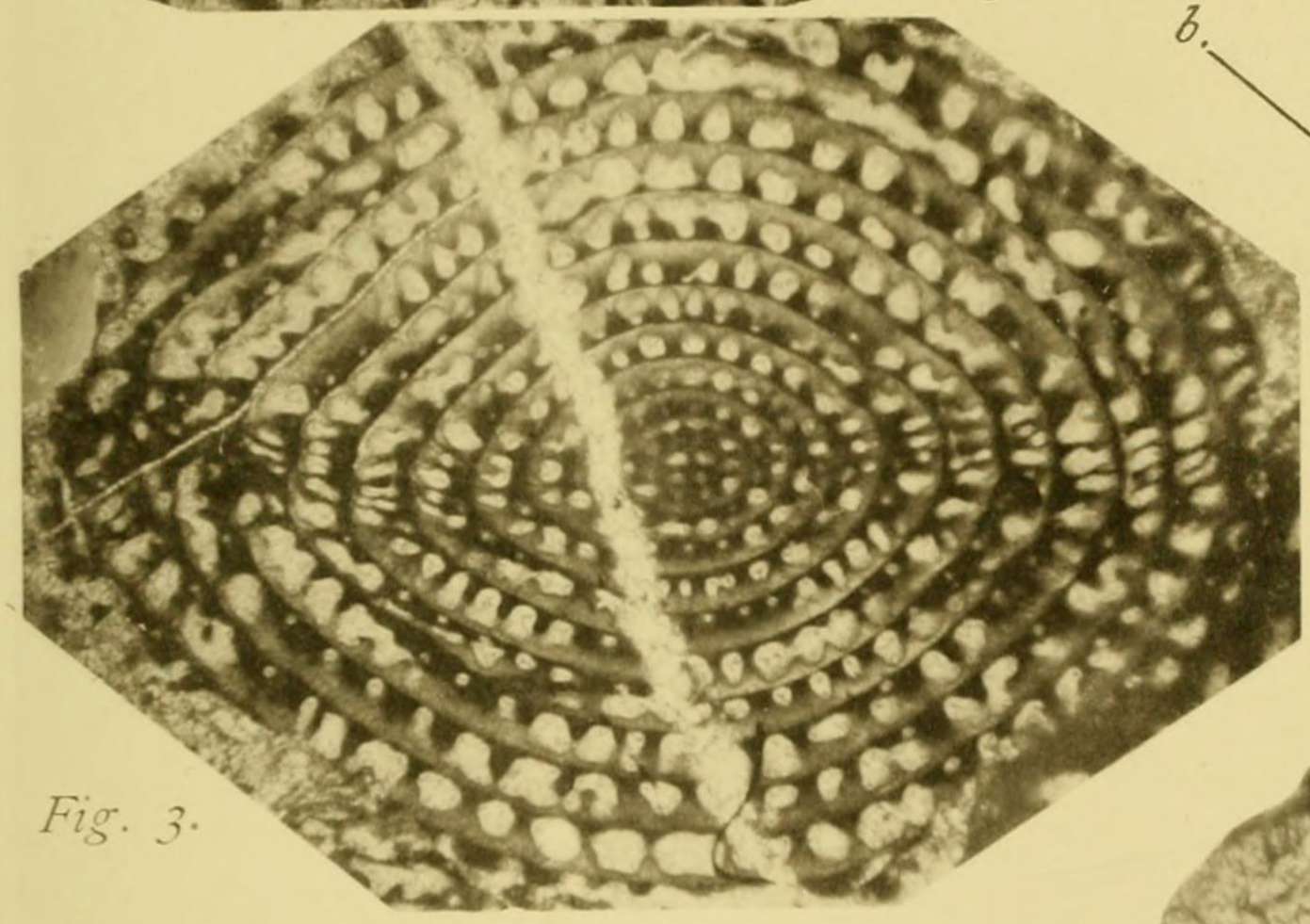


Fig. 4.



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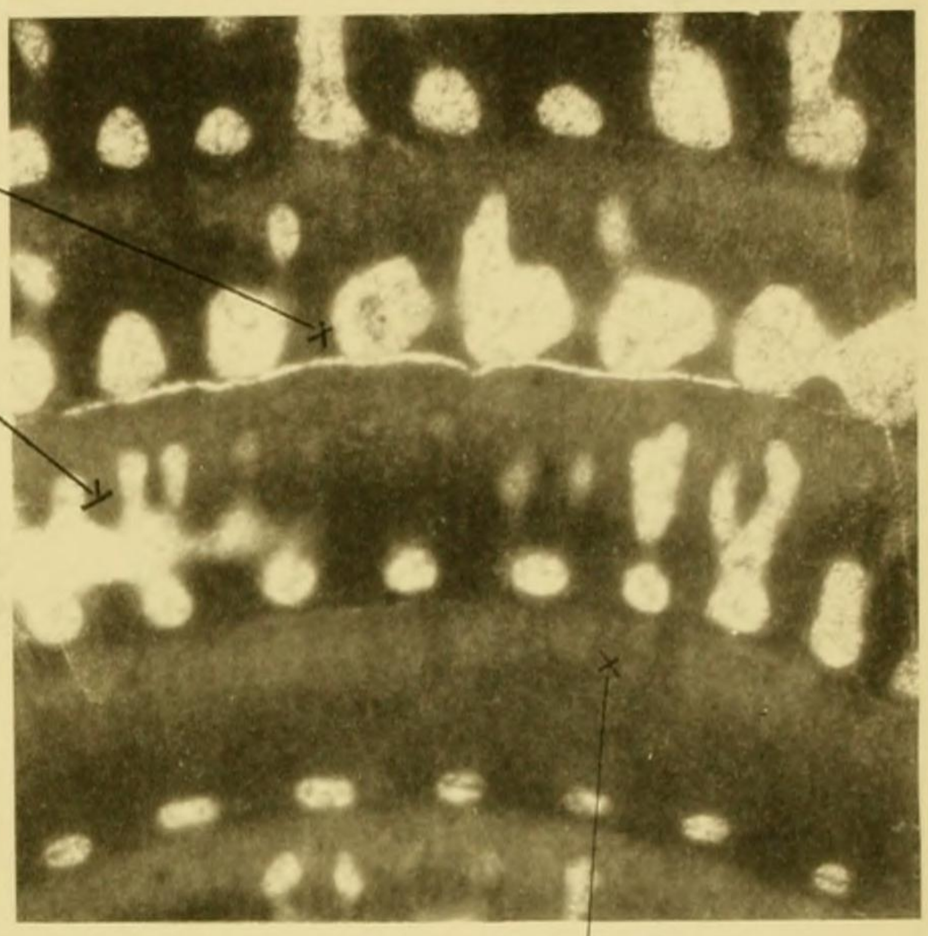

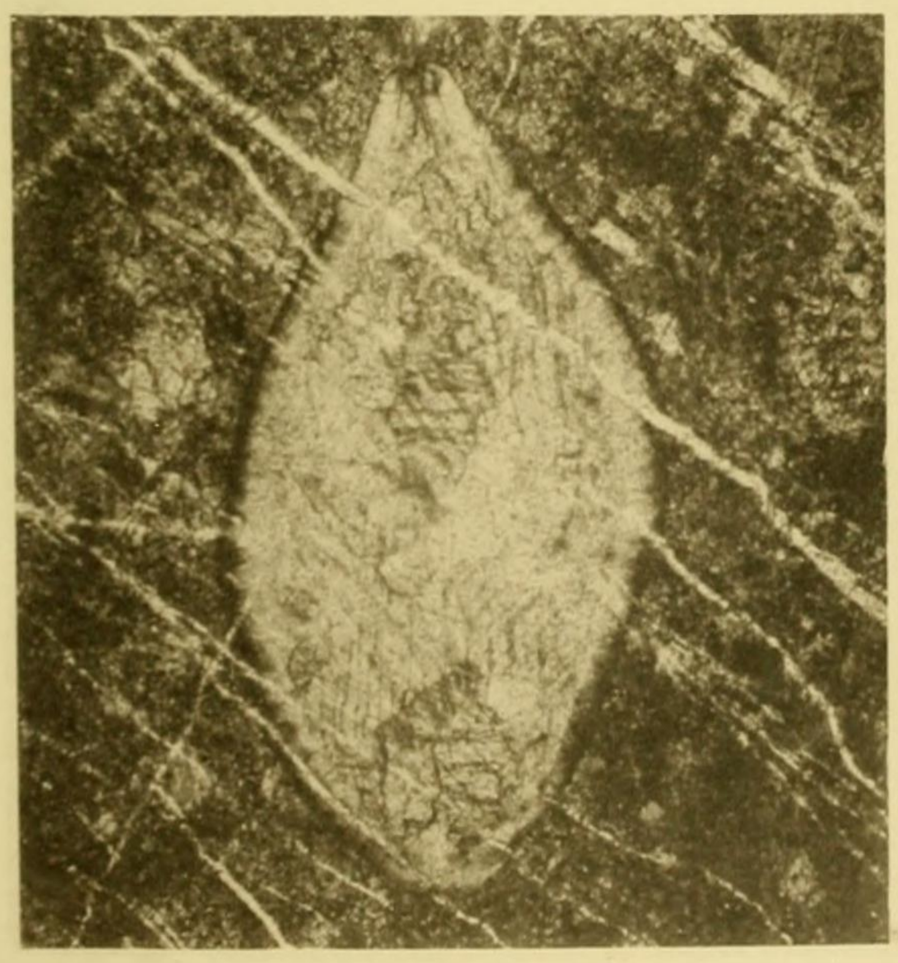

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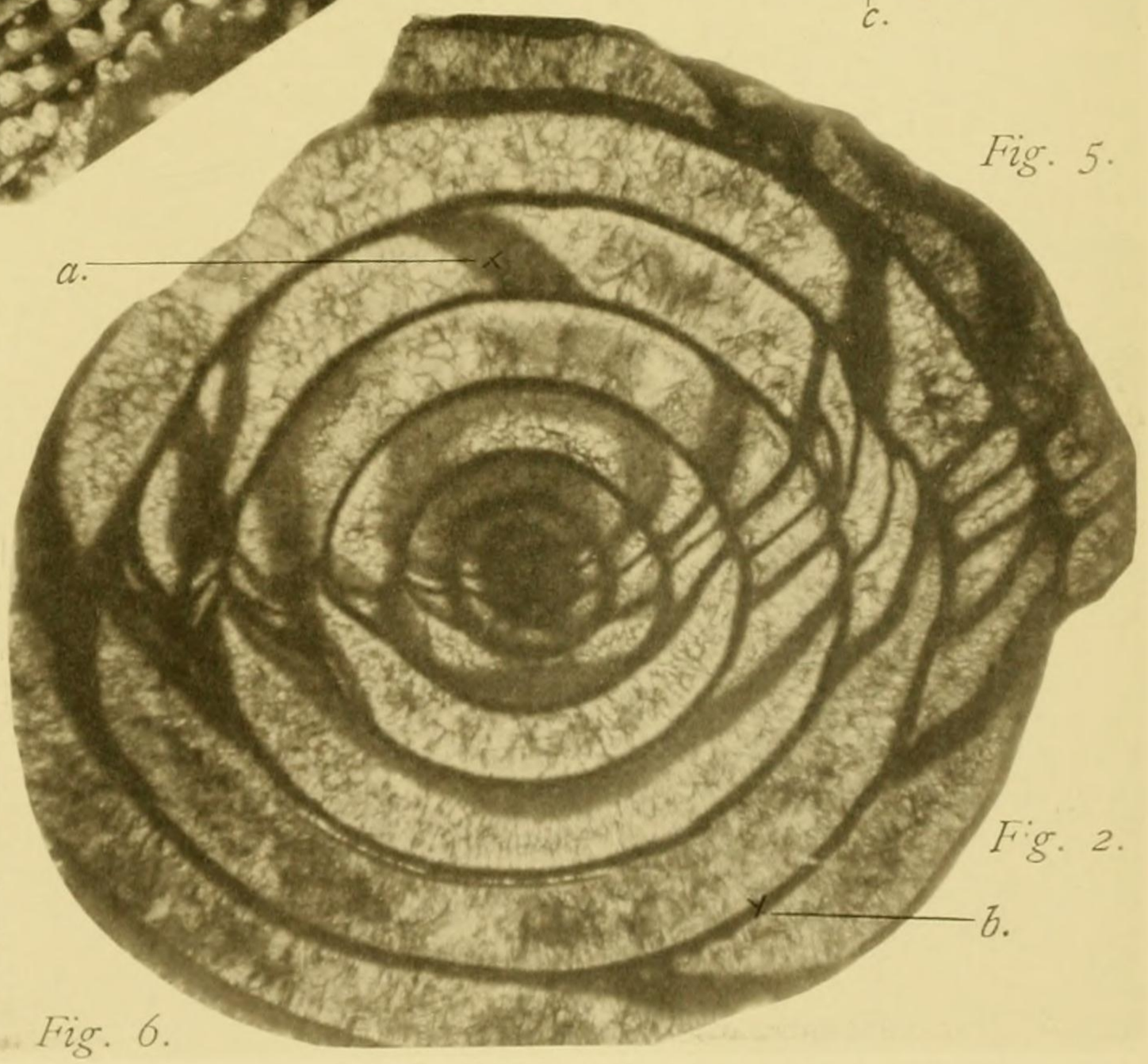


Fig. 5.

Fig. 2.

H. YABE.

A CONTRIBUTION TO THE GENUS FUSULINA.

PLATE II.

Reference to Plate II.

Fig. 1. *Fusulina japonica* GÜMBEL var., from Asogori, prov. Shimotsuke, Japan. Longitudinal section. × 20. a, connecting lamella.

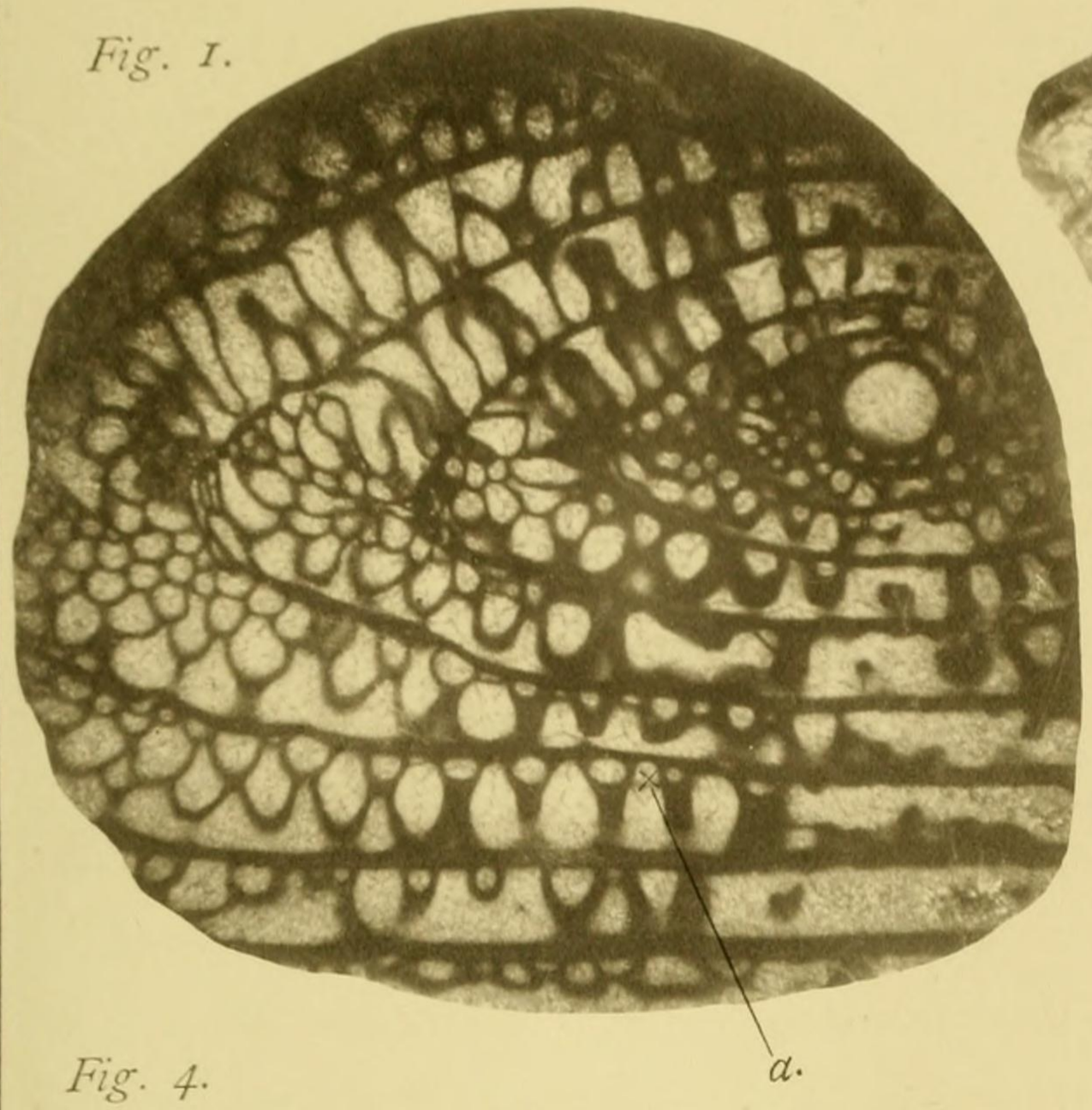
Fig. 2. *Doliolina lepida* SCHWAGER, from Akasaka, prov. Mino, Japan. Cross section, taken somewhat excentric. × 48. a, basal skeleton, in a parallel section.

Fig. 3. Ditto. Longitudinal section, taken somewhat excentric. × 48. a, basal skeleton; b, primary septa.

Fig. 4. *Neoschwagerina Annae* VOLZ, from Ōkubo, prov. Bitchū Cross section. × 20.

Fig. 5. *Bigenerina Bradyi* MÖLLER? from Phyong-yang, Korea. Longitudinal section. × 48.

Fig. 1.



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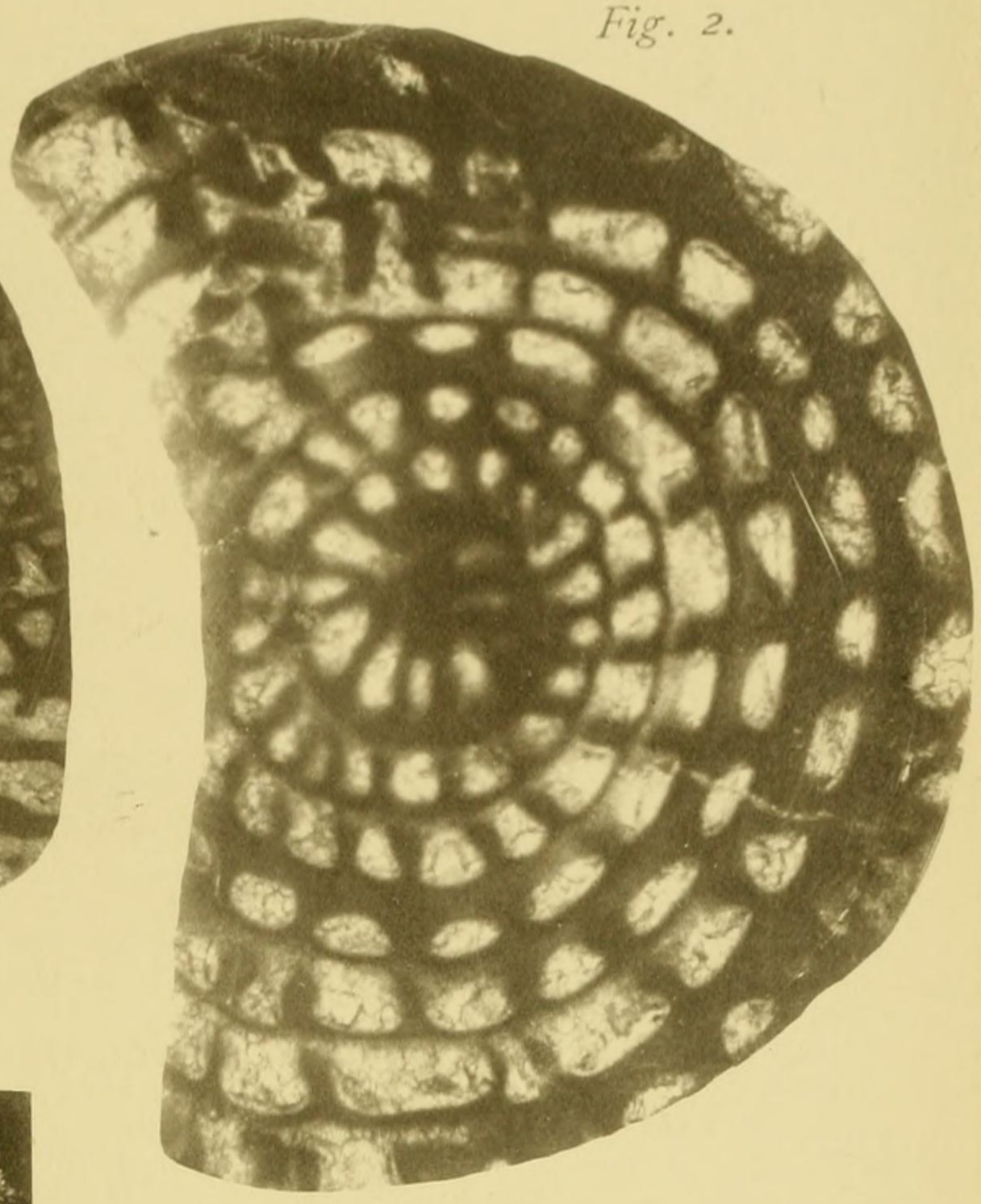

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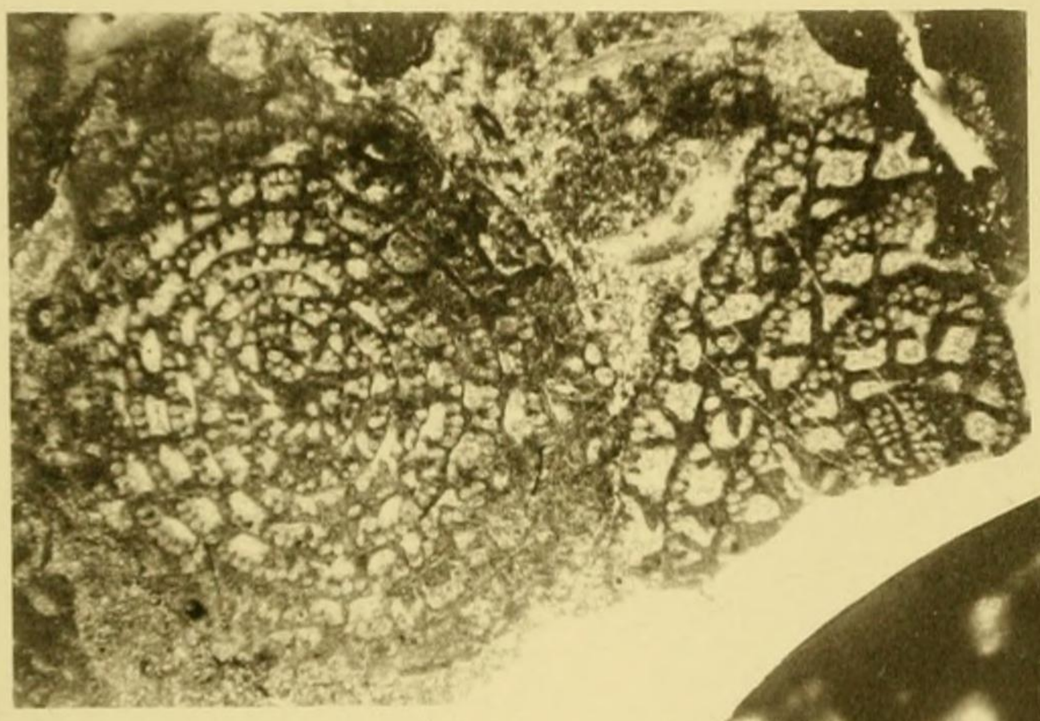

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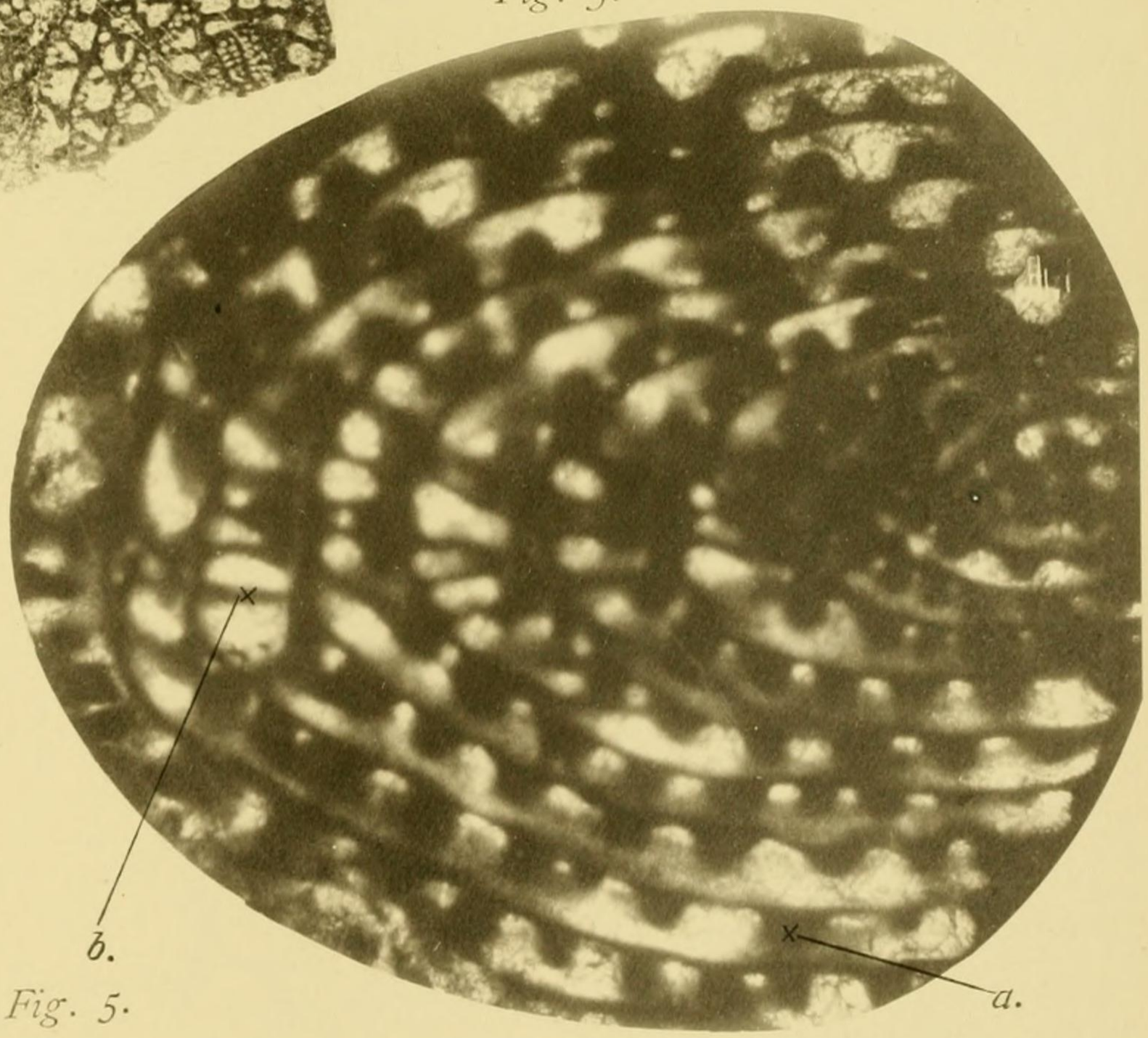


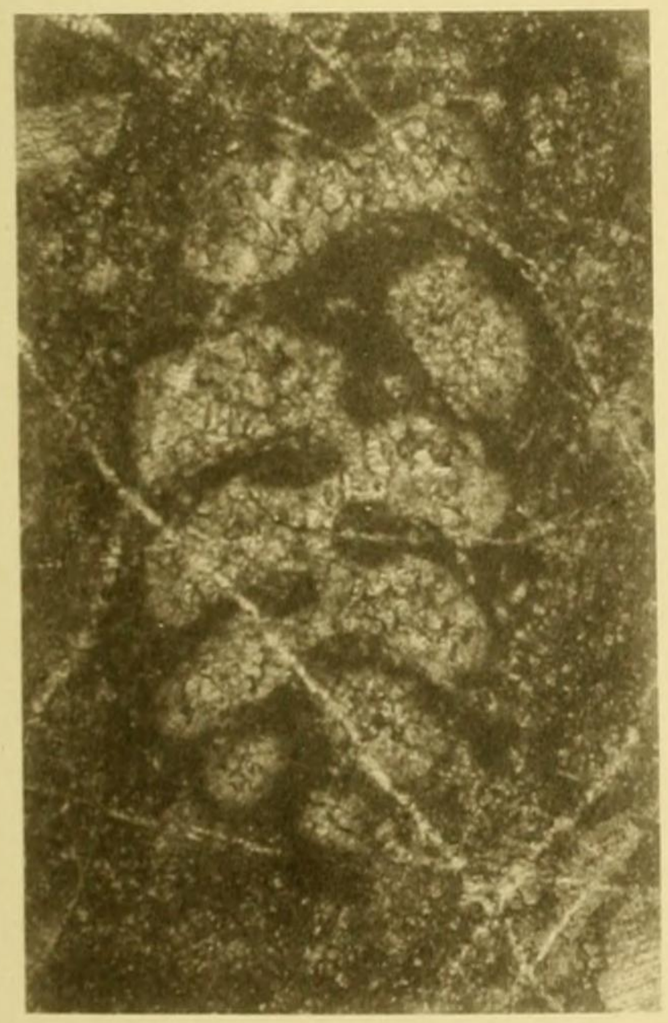


Fig. 5.

H. YABE.

A CONTRIBUTION TO THE GENUS FUSULINA.

PLATE III.

Reference to Plate III.

Fig. 1. *Neoschwagerina globosa* YABE, from Akasaka, prov. Mino. Tangential section. × 20. a and d, transverse septa ; b, primary septa ; c, auxiliary septa.

Fig. 2. *Schwagerina Verbeeki* GEINITZ var., from U-chai, prov. Yun-nan, China. Cross section. × 20.

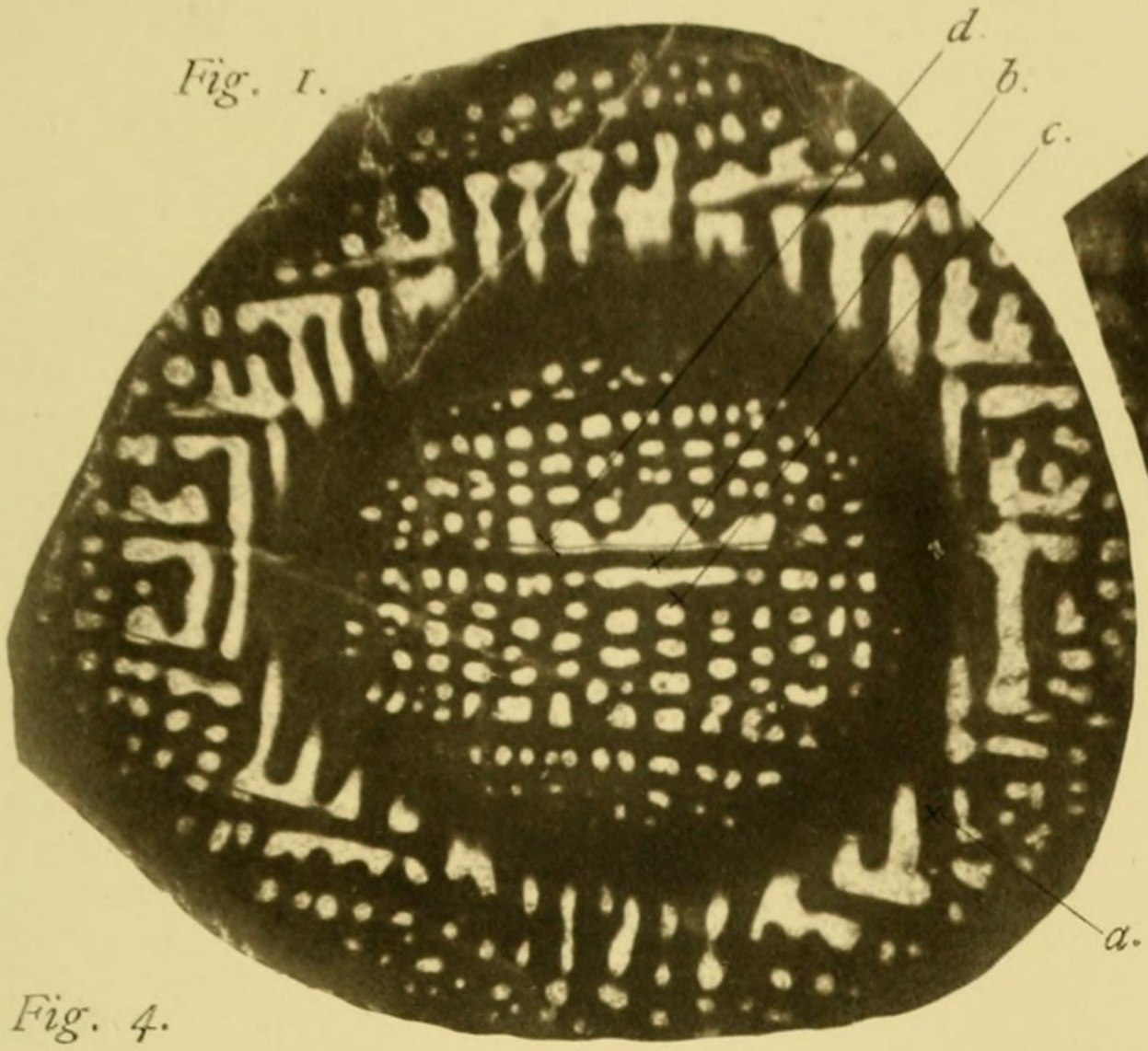
Fig. 3. *Neoschwagerina craticulifera* SCHWAGER, from Sakawa, prov. Tosa, Japan. Tangential section. × 48. Drawn from a photograph. Notice the outer layer of the shell and median lamellae of septa stained to yellowish brown.

Fig. 4. *Fusulina* aff. *Richthofeni* SCHWAGER, from Phyong-yang, Korea. Tangential-section. × 48.

Fig. 5. Ditto. Cross section. × 48.

Fig. 6. *Staffella* sp. indet., from Phyong-yang, Korea. Longitudinal section. × 48. Drawn from a photograph.

Fig. 1.



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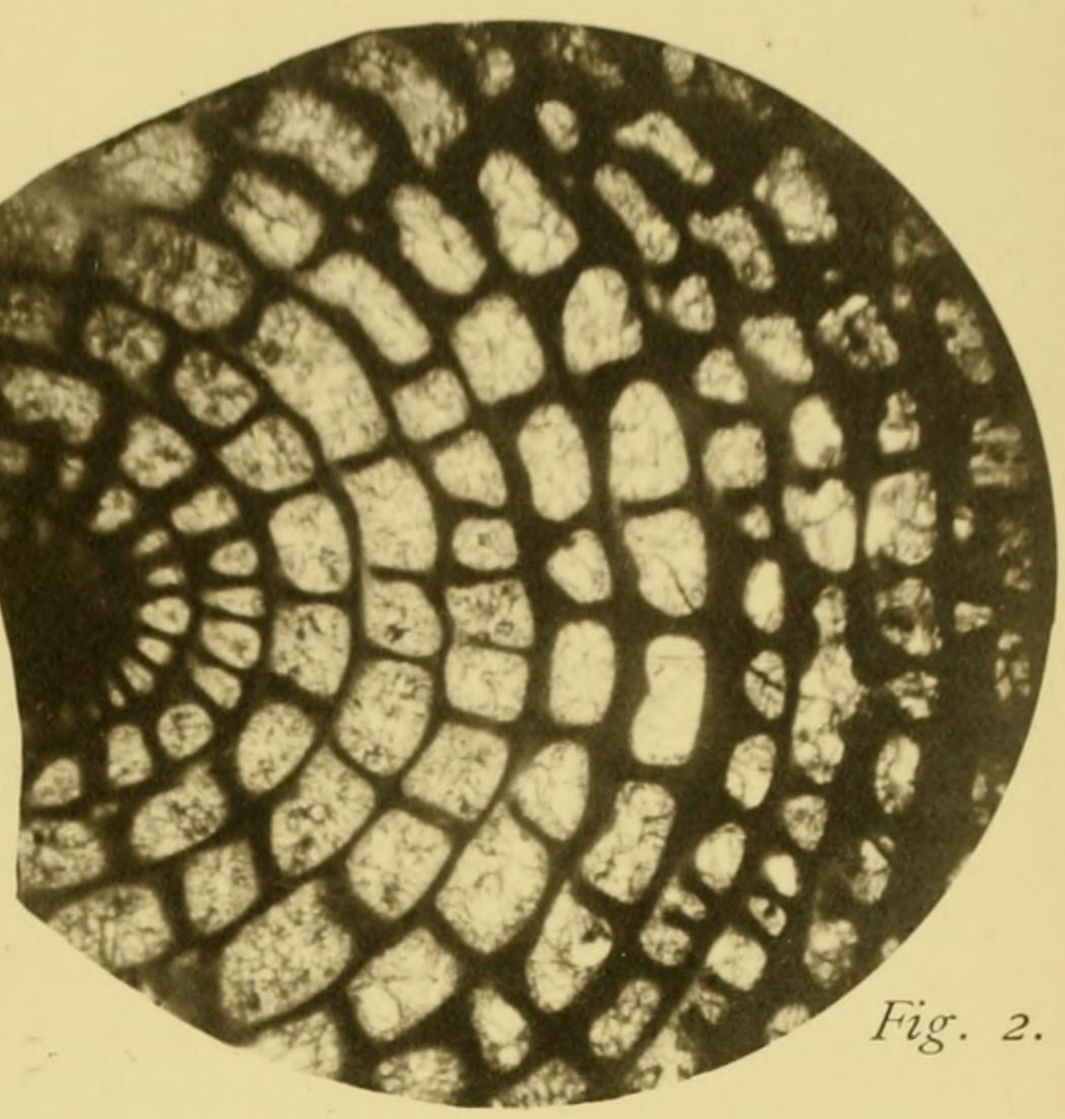

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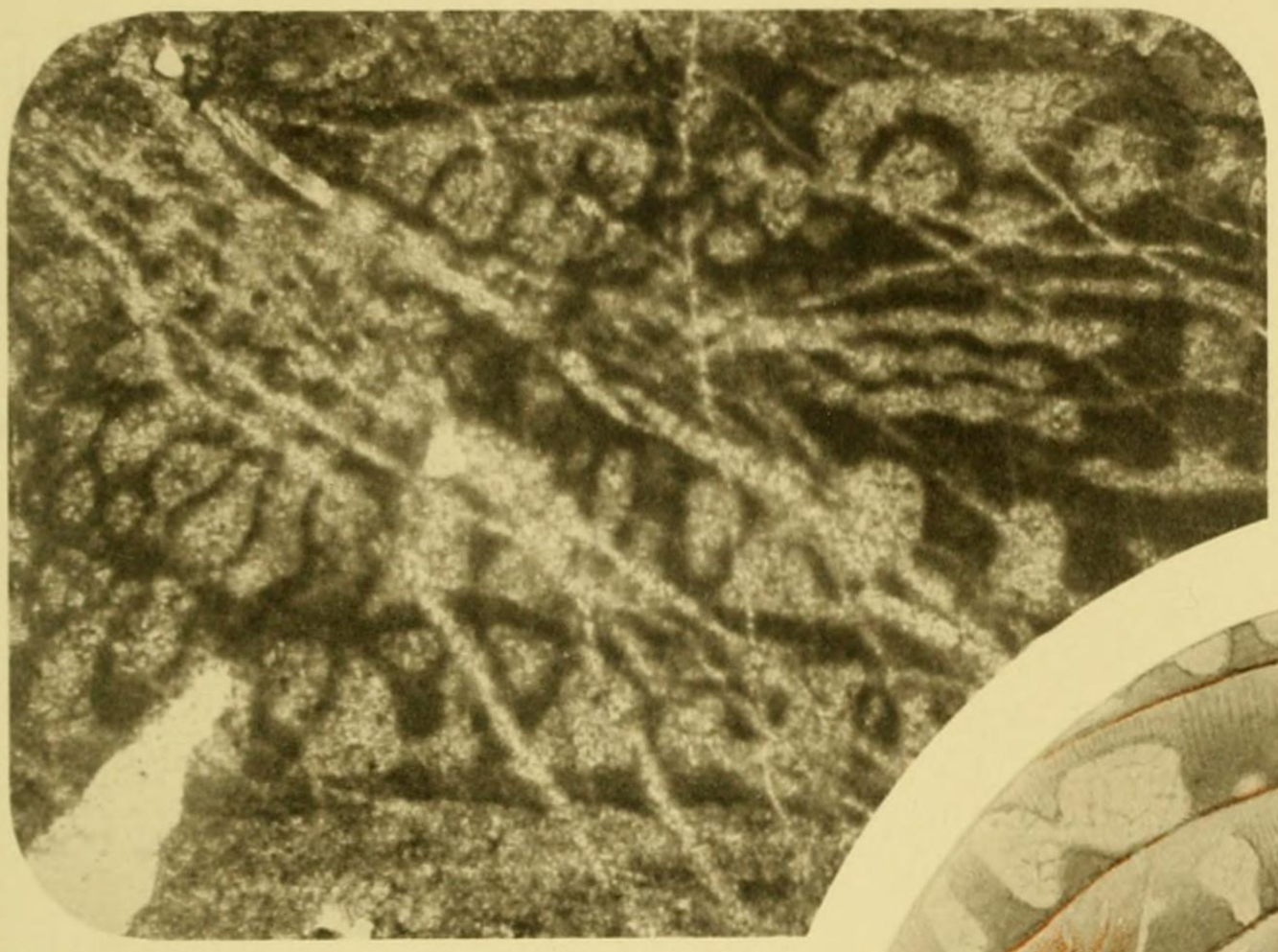

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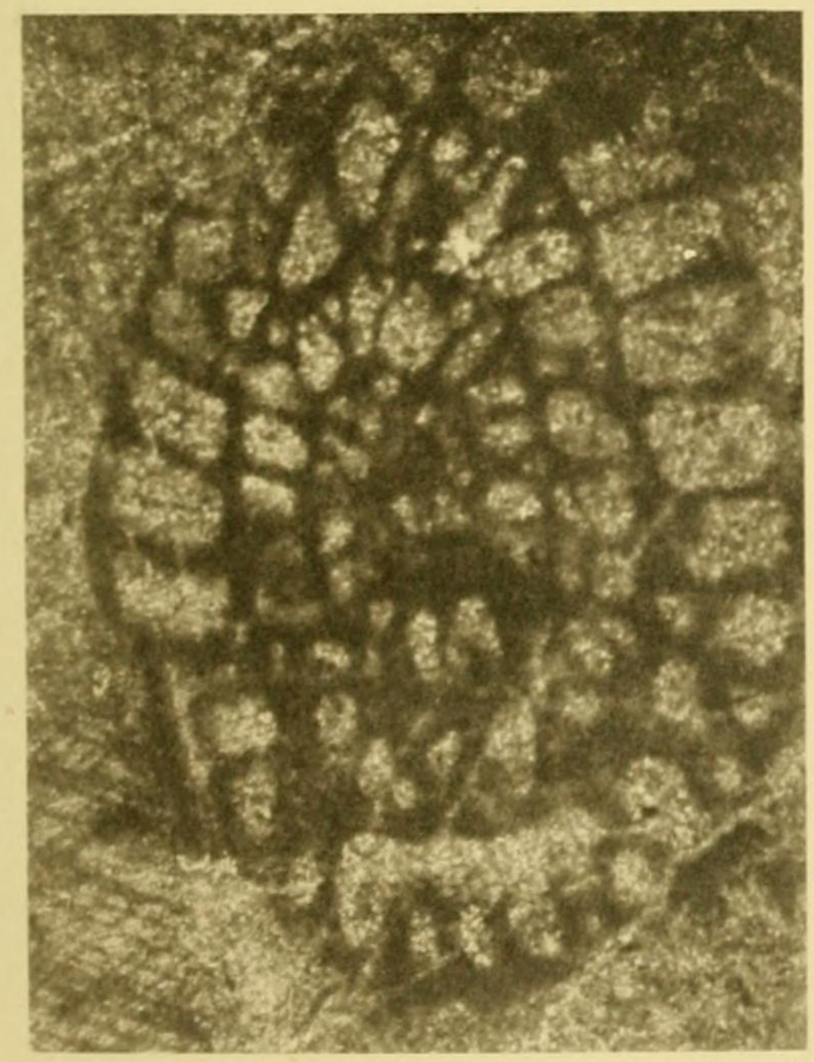

Fig. 5.

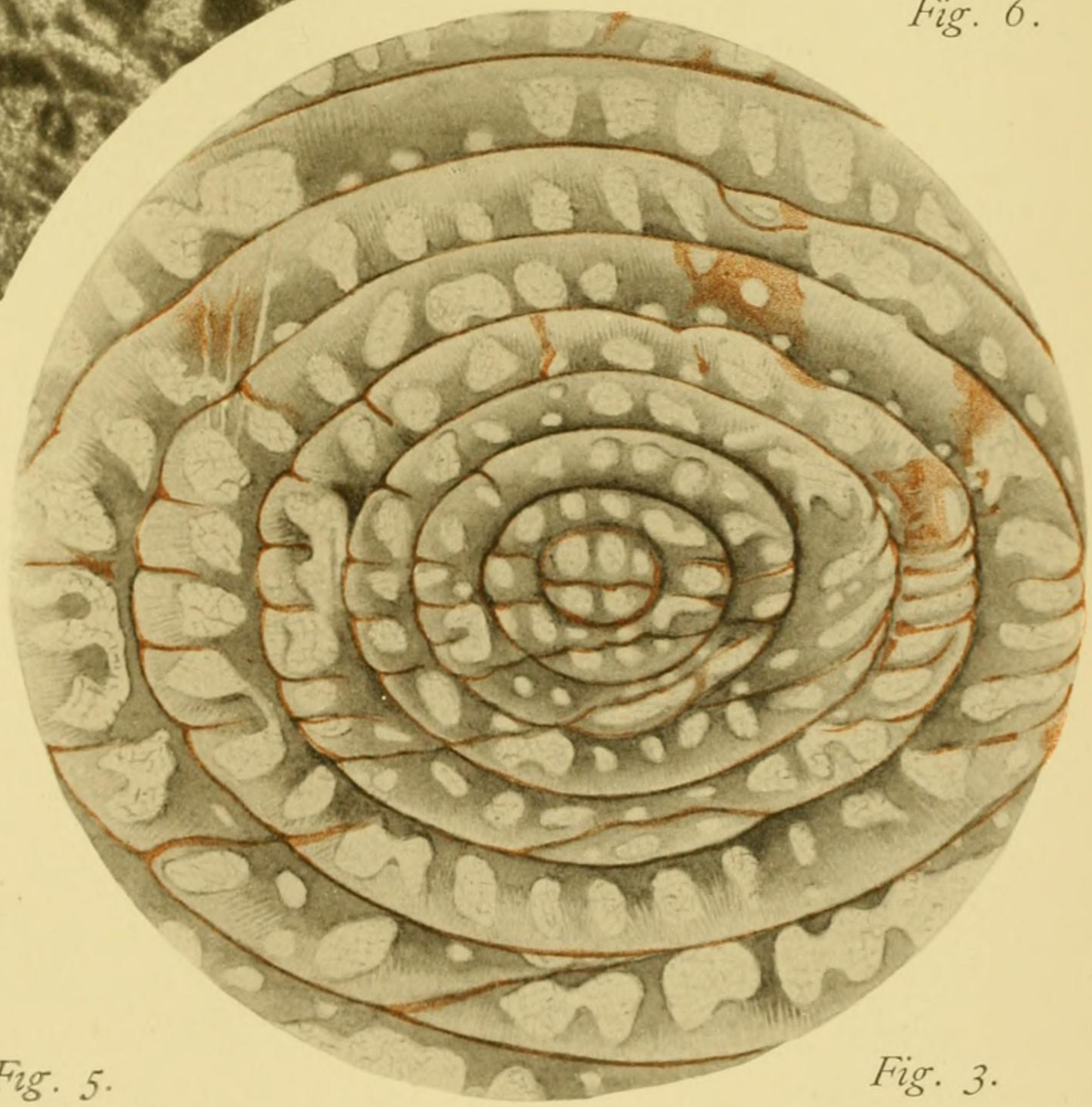

Fig. 3.

東京帝國大學紀要

理科

第貳拾壹冊

THE JOURNAL

OF THE

COLLEGE OF SCIENCE,

IMPERIAL UNIVERSITY OF TŌKYŌ,

JAPAN.

VOL. XXI.

東京帝國大學印行

PUBLISHED BY THE UNIVERSITY.

TŌKYŌ, JAPAN.

1906—1907.

MEIJI XXXIX—XL.

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PRINTED AT THE "TOKYO TSUKIJI TYPE FOUNDRY."