ON A FUSULINA-LIMESTONE WITH HELICOPRION IN JAPAN.

With a Map and a Plate.

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We have, of course, no right to assume from the present state of our knowledge, that the Palaeozoic limestone of Japan with remains of *Fusulinidae* represents a single horizon. This question can only be settled by carefull investigations both stratigraphical and palaeontological of the said limestone. Particularly interesting is the fact that the limestone of Hanawa, containing *Helicoprion* as mentioned by Mr. E. Sagawa, belongs to the same horizon as that containing *Fusulina japonica* Guembel. But up to this time there is no work giving a full description of the *Fusulina*-limestone of Hanawa and of the region lying to its east.

During a week in the last autumn, I had an opportunity of tracing the extent of the limestone bed in the northern part of Province Shimotsuke and the eastern part of Province Kōzuke, by which I was able to make clear the geological structure of the districts and the age of the limestone.

The works relating to the geology of these districts are not many. It is treated in the explanatory texts to the geological maps, published by the Imperial Geological Survey; namely, by Mr. T. Nasa in his Nikkō Sheet, and by Mr. K. Yamada in his Maebashi Sheet. The late Dr. Toyokichi Harada also gave a very short account of the limestone in question in his 'Japanischen Inseln', (Tōkyō, 1890), mentioning the occurrence of *Bellerophon*, resembling that from Akasaka in Province Mino, together with

fragments of crinoidal stems, corals and *Fusulina* at Nabeyama. Mr. S. Shimizu wrote about the distribution and subdivision of the *Fusulina*-limestone. While the late Mr. Y. Saitō, in his essay on the volcano Nikkō[2] made a reference to the Palaeozoic on the upper course of the Watarasegawa, a note on *Helicoprion* from Hanawa is found in the work of Mr. Sagawa.[3] I myself had also an occasion to write on the *Fusulina* of Tomuro.[4]

As is seen from the distribution of the limestone bed shown on the accompanying map, the bed, in the eastern half of the district, generally constitutes a narrow synclinal trending NEE to SWW., while in the western half, it forms a huge anticlinal with its axis running from NNE to SSW, its crest making a syncline. Besides there are isolated ocurrences of the same rock at Akami and the Ōmama station. It is quarried at several places.

The thickness of the limestone could not be easily ascertained for the other rocks overlying and underlying it are nearly always covered with soil. But its greatest development is at Kuzū where it shows a thickness of more than 60 meters.

The character of the rocks shows marked variation. It is usually thin-bedded in the east, while it is thick-bedded in the west. The colour is white or grey or black with carbonaceous matter; the light grey specimen are the most common. The structure ranges from very compact to coarse crystalline. The, limestone of the eastern part frequently contains, in its middle horizon, numerous black, rarely grey, siliceous masses of irregular form and of various sizes, and enclosing the same fossils as in the rock itself.

The limestone is associated with various rocks; such as clayslate, sandstone, quartzite and schalstein. The order of superposition of these rocks is generally the same throughout the

district.

Near Kuzū, where however no good exposure is found, I determined the following arrangement of rocks in descending order :—

1. A thick alternation of black clayslate, with subordinate layers of sandstone, schalstein and Radiolarian slate.
2. An alternation of schalstein and hornstone.
3. Hornstone or quartzite.
4. ? (Slate ?).
5. Limestone.
6. ?
7. Schalstein.

At Matsuda and Nagusa in the east, as well as in the whole western part, the bed of limestone is found among a thick alternation of slate and quartzite.

At Yamaji, the slate shows in its upper part, a transition to limestcne, and in the limestone there are intercalated layers of slate. At Akami, a comparatively thin limestone bed encloses a lenticular mass of slate with the maximum thickness of about 3 meters. No denudation seems to have taken place between the time of deposition of the limestone and that of the overlying beds. Besides the character of the slates shows no marked difference above and bellow the limestone.

In this rock no important fossils were found besides *Fusulina*, *Helicoprion*, a bivalve resembling *Conocardium*, and two species of *Brachiopoda*. Of these, last two have been unfortunately lost. Dr. Harada mentions a *Bellerophon* as occurring in the same rock, but it has never been seen by myself. Therefore there remain only *Fusulina* and *Helicoprion* which can be taken as a criterion for asserting the age of the rock. Of these two, *Helicoprion* seems o

be an extremely rare fossil, only one cast with its counter-piece having been found there. *Fusulina* is, on the contrary, enclosed in nearly all limestones, though the number of individuals varies considerably. Crinoidal stems are also very common and abundant, but show no characteristic form. However, a segment with a round outline and a cross shaped central canal, as found in the black limestone of Minegishi, attracts our attention.

GENUS FUSULINA.

Our knowledge on the Permo-carboniferous *Foraminifera* is largely due to the work of Professor E. Schellwien.[5] He studied those in the Carnic Alps, and found the long accepted separation of the genera, *Fusulina* and *Schwagerina*, to be only of a sub-generic value; and united them under one genus of *Fusulina*. However, it seems to me more natural to subdivide it into four, instead of three sub-genera.

In the diagnoses, I propose the use of the designations, primary secondary and transverse septa. By the primary septa, I mean those marked on the surface as deep longitudinal sutures, as they are commonly called. The secondary septa are those parallel to the former, but not seen on the outside. They are shorter, and not provided with a median lamella, which is always present in the primary septa. The transverse septa (the 'Nebensepta' of Schwager) are those at right angles to the other two, extending from the roof of a volution to its base. When only the basal portion of the transverse septa is developed, making them appear as spiral ridges, they form what are generally called basal skeletons.

Synopsis of the four snb-genera.

(1). FUSULINA s. str. Type: *F. cylindrica* Fischer.

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

(2). SCHWAGERINA. Type: *S. princeps* Ehrenberg.

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

(3). DOLIOLINA. Type: *D. lepida* Schwager.

Shell cylindrical in 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. sub-genus. Type: *N. craticulifera* Schwager.

Shell fusiform to spherical. Septa of three kinds: transverse septa numerous, and 1 to 4 secondary septa being found between two primary ones.

These four sub-genera, however, form quite a continuous series.

The *Fusulina*-limestone of the district is distinguished from the various limestones of Akasaka, by containing less numerous species of *Foraminifera*. In all, except that of Yamada, there are only species of *Fusulina* s. str.

NEOSCHWAGERINA sp. nov.

This species was found in a single slide of the limestone from Yamada. The preservation is not perfect, the matrix being crystalline; but the longitudinal section shows important charac-

teristics. The complete outline of the shell is not known, but it seems to be like that of *N. craticulifera*, from which it differs by being somewhat larger. Shell and septa thin, and remarkably uniform in thickness; volutions close. Primary septa alternating with 1 to 3 secondary septa, which are close to each other, as in *N. craticulifera*. Transverse septa arranged at very regular intervals, closer than in the same. The distinction of our new species from *N. craticulifera* can only be made by examining the longitudinal section, which shows the characteristic form of the space between the transverse septa, either square or transversely elogated, instead of longitudinally as in *N. craticulifera*.

The present species is also found in a limestone from NW. of Lung-chia- ch'ung in Kiang-si, together with *Doliolina Verbeeki*.

A form, nearly intermediate between this and *N. craticulifera*, is found in a *Fusulina*-limestone of Higashi-uwa-gōri, Province yo. This seems, however, to be only a variety of the latter.

FUSULINA JAPONICA GUEMBEL. var.

1883. *Fusulina japonica* Schwager: Carbonische Foraminiferen aus China und Japan. p. 121, pl. xv. figs. 1-11.

Shell rather large; fusiform (showing some variations), always obtusely pointed on the umbilical ends, rarely with a median constriction. Septal furrows on surface distinct, nearly straight in the middle portion, twisted on the umbilical ends. Embryonal chamber large and spherical, with a diameter about 0.4 mm. Volutions close, seven or a little more in number.

Height of the whorl at the end of the	1st.	volution. 0.12 mm.
" " " " " " " " "	2nd.	" 0.20 "
" " " " " " " " "	3rd.	" 0.24 "

Height of the whorl at the end of the 4th. volution. 0.28 mm.
" " " " " " " " " 5th. " 0.33 "
" " " " " " " " " 6th. " 0.36 "

Septa numerous, about 37 in the 5th. volution, strongly and regularly folded, folds united together along their lower halves. Secondary chambers small. Thickness of the shell wall, which is either equal to or a little greater than that of the septa, increases very slowly, being about 0.085 mm. at the end of the 5th. volution. Average diameter of the pores in the 5th. volution about 0.009 mm. Height of the orifice about a half of that of the whorl.

Dimensions of the three examples measured are as follows :—

	Length.	Breadth.	Ratio of length to breadth.
(1)	12.0 mm.	5.5 mm.	100 : 45
(2)	9.0 mm.	4.0 mm.	100 : 44
(3)	12.5 mm.	4.9 mm.	100 : 32

Most of the individuals of *Fusulina* in our collection[6] belong to the present species, and are, in form and size, nearly same as those described by Guembel and Schwager, from the limestone of Akasaka, and showing also a similar variation in its external form, and a slight structural difference which is, however, of no specific value. Thus, our form shows the septa somewhat thiner and more strongly folded, and the orifice higher. It approaches, therefore, to *F. Richthofeni* Schwager, which however shows more numerous septa and a different external form. But by the arrangement of the septa and the mode of growth of the shell, I believe I am entitled to refer the present form to *F. japonica*.

In some slides of the limestone, I found, besides, longitudinal sections of a form exactly like those of the typical *F. japonica*, but the form can not be determined as such, until the rcoss

section through the embryonal chamber is examined.

In the same limestone from Tomuro, there was found one detached specimen of another form occurring together with the present variety of *F. japonica*, from which it differs in its cylindrical form, rounded on the umbilical ends. Between these two, no transitional forms were yet found. However I am not in a position to forward any opinion on this specimen.

HELICOPRION BESSONOWI KARPINSKY.

PL. II.

1899. *Helicoprion Bessonowi* Karpinsky: Ueber die Reste von Edestiden und die neue Gattung *Helicoprion*

Among the Palaeozoic fossils of Japan, there is none more interesting than this fossil, (plate II.) It shows an unmistakable affinity with the Karpinsky's specimen from the Ural, regarded by him as a powerful weapon placed above the snout of a selachian fish on its median line. But several other explanations have been given, among which may be mentioned that of A. S. Woodward and C. R. Eastman, who have taken it as symphyseal teeth of a *Cestracionitidae* fused into whorls.

Our specimen consists for the greater part, of a black impression, with only a small number of preserved segments. A piece of grey limestone with this fossil shows many small faultings, making exact measurements difficult.

It consists of two volutions and a quarter, coiled in a plane, laterally compressed, broadest at the base and gradually sharpened towards the periphery. The outer volution has 43 segments, the inner 42, and the remaining quarter 10.

Periphery butressed prominently. Coronal apices showing an acute angle,(about 50°), and sharpened margins; but the serrations are not preserved in our specimen. Enamel, covering the lateral surface, forms stripes, just as in the specimens from the Ural; and their lower portions are abruptly bent and attenuated suddenly downward from the base of the middle portion. They are broadest at the base of the corona, and are slightly broader than in the Uralian specimens.

The basal portion of the volution is well developed and better preserved in ours, and shows a median, longitudinal deep groove.

The enamel-stripes bear an apparent indication of numerous striae, as in fig. 9, Pl. III. in the Karpinsky's work. The basal portion of the spiral shows also fine irregular and discontinuous striae parallel to the volution.

The following measurements have been made:

Diameter of the outer volution.	12.cm.
" " " inner "	10.0
Maximum height of the outer volution	6.0
Height of the middle part of the outer volution	4.0
Maximum height of the inner volution	2.8
Height of the middle part of the inner volution	about 2.0
Thickness of the basal portion of the outer volution.	about 1.0
Distance between the lower end of the enamel-stripe of the outer volution and the coronal apex of the inner.	1.5
Height of enamel-stripe.	5.0
Maximum breadth of the stripe.	1.3
Height of the corona.	1.4
Height of the middle portion of the stripe.	2.3
Breadth of the base of the middle portion.	1.0
Length of the lower portion of the stripe.	2.2

Height of the basal portion. 0.8

So far about the external form of our specimen, as observed without breaking it. Nearly all of the characters given above agreeing with those of the Uralian form, I believe that they belong to one and the same species, the only difference lying in the basal portion of the spiral which is somewhat higher in ours. But we must bear in mind that the basal portion, which is distinctly seen in ours is not so in the specimens from the Ural.

The Carboniferous age of the *Fusulina*-limestone has been hitherto maintained by geologists, both in and abroad. Conrad Schwager[8] regarded the limestone fo Mino as Upper Carboniferous, after the study of the Richthofen's collection. The late Wilhelm Waagen,[9] as well as Fritz Frech[10] and Gothard Fliegel[11] essentially followed his example. L. v. Loczy,[12] however, has assigned the Permo-carboniferous age of our limestone, and after the discovery of *Lyttonia* in the Palaeozoic of Rikuzen,[12] our geologists also began to put in the Permo-carboniferous or in the uppermost part of the Carboniferous. However only after the determination of our *Helicoprion* as such, we were convinced that a trace of Permian is found in Japan Very recently Schellwien[14] discussed the age of the *Doliolina*-limestone, so widely distributed along the coast of the Pacific, and in Central Asia, as corresponding to the greater part of the Permian in other parts of the world. Mr. Sagawa's opinion that the limestone of Hanawa is Permo-carboniferous and that of the district lying to the south of the town is Carboniferous, seems not to be based on any strong ground, as he simply compares the relation of our *Fusulina*-limestone with that containing *Helicoprion* to that existing between the *Fusulina*-limestone and the Artinsk stage of Russia.

The paucity of other fossils than *Foraminifera* in the *Doliolina*-limestone, as already pointed out by Schellwien, has led many geologists to entertain very diverse opinions respecting its age, just as was the case with the Japanese *Fusulina*-limestones.

Even from Akasaka which is known as a locality with very numerous fossils, only the following forms were mentioned by C. Gottsche[15] : *Favosites*, *Cyathophyllum*, *Pleurotomaria*, *Murchisonia*, *Bellerophon*, (aff. *hiulcus*). Recently, however, the list of fossils was enlarged by addition of *Lonsdaleia*, *Ostrea*, another large bivalve, *Dentalium*, two species of *Naticopsis*, and *Loxonema*.

Fusulina japonica, *Neoschwagerina craticulifera* and *Doliolina lepida* are found together in the lower division of the limestones of Akasaka while *Lonsdaleia akasakensis*,[17] allied to *L. indica* of the Upper and Middle *Productus*-limestone, and to *L. virgalensis* from the latter of the Salt-range, are met with in the upper horizon, together associated with *Neoschwagerina globosa* sp. nov., which is again very rarely associated with *Doliolina Verbeeki*.

K. Futterer saw no unconformity between the *Doliolina*-limestone and the limestone with *Xenodiscus tanguticus* Schellwien, in the Semenow-gebirge in NE. Tibet; this fact was taken by Schellwien as an indication of the Permian age of the *Doliolina*-limestone.

Although the limestone of Kōzuke and Shimotsuke, here in consideration, does not contain several fossil species, yet its *Helicoprion* as above refered to, seems to be identical with a form found in the Artinsk stage of the Ural.[18] *Therefore, the association of F. japonica with Neoschwagerina craticulifera on one side, and with Helicoprion on the other, seems to be a strong evidence of the Permian age of the limestone with F. japonica.* By the limestone with *F. japonica*, I do not mean all the limestones of our Upper Chichibu system, nor all the limestones containing *Fusulina* in Japan, but

only that of *F. japonica*. Whether these limestones all belong to the same age or not, can only be settled by a carefull study of their palaeontological contents.

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1) S. Shimizu : Localities of *Fusulina* in the Province Shimotsuke. Journ. Geol. Soc. Tōkyō, Vol. III. No. 31. 1896.
2) Y. Saitō : On the Geology of the Volcanoes of the Nikkō Group. 1899. Publication of the Earthquake Investigation Committee.
3) E. Sagawa's Note. Journ. of Geography, Tōkyō. Vol. XII. No. 133
4) H. Yabe : On *Fusulina japonica* Schwager, from Tomuro, Prov. Shimotsuke. Journ. Geol. Soc. Tōkyō. Vol. VI. No. 658 1899.
5) E. Schellwien : Die Fauna des Karnischen Fusulinenkalkes. Theil II. *Foraminifera*. Palaeontographica. Bd. XLIV. 1897.
6) This species is quite abundantly found, in a quarry at Tomuro, being detached from the matrix by weathering.
7) Vide : C. R. Eastman : on *Campyloprion* a new Form of *Edestes*-like Dentition. Geol Mag. No. 454. 1902. Also. H. Klaatsch : Zur Deutung von *Helicoprion* Karp. Centralb f. M. G. u. P. 1901. No. 14. Th. Fuchs : Ueber die Natur der Edestiden mit besonderer Rücksicht auf die Gattung *Helicoprion*. 1902.
8) C. Schwager : Carbonische Foraminiferen aus China und Japan. 1883.
9) W. Waagen : Salt-range Fossils Geological Result. 1891.
10) F. Frech: Die Steinkohlenformation. 1899.
11) G. Fliegel : Die Verbreitung des Marinen Obercarbon in Süd- und Ostasien. Zeitschrift d. deut. Geol. Ges. Bd. L.

1898. Ueber Obercarbonische Faunen aus Ost- und Südasien. Palaeontographica. Bd. XLVIII. 1901.

12) L. V. Loczy: Die Fossile Fauna. Palaeontologische und Stratigraphische Ergebnisse. Die Wissenschaftliche Ergebnisse der Reise der Grafen B. Szechenyi in Ostasien. Bd. III. 1899.

13) H. Yabe: On the Brachiopoda *Lyttonia* from Japan. Journ. Geol. Soc. Tōkyō. Vol. VII. No. 179.

14) E. Schellwien: Trias, Perm und Carbon in China. Schriften d. Physik.—Oekonom. Gesellschaft zu Königsberg. 1902.

15) C. Gottsche: Ueber Japanisches Carbon. Zeitschrift d. deut. Geol. Gesell. Bd. XXXVI. 1884.

16) Hence the supposition of E Schellwien of the Carboniferous age of the limestone with *Fusulina japonica* in Sa-men-quan-Pass in Ta-tya-schan, South Kan-su, seems not to be congruent with the facts observed in Akasaka.

17) H. Yabe: Materials for a Knowledge of the Anthracolitic Fauna of Japan. I. Journ. Geol. Soc. Tōkyō. Vol. IX. No. 104. 1902.

18) *Helicoprion* has been also found in the Upper *Productus*-limestone of Chidru, Himalaya. E. Koken: *Helicoprion* im *Productns*-kalk der Salt-range. Centralb. f. M. G. u. P. 1901.