33. *Fusulinid Zones in the Carboniferous of Japan.*

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Fusulinid faunal zones proposed by M. L. Thompson¹⁾ are :

1. Zone of *Millerella*
2. Zone of *Profusulinella*
3. Zone of *Fusulinella*
4. Zone of *Fusulina*
5. Zone of *Triticites*
6. Zone of *Pseudoschwagerina*
7. Zone of *Parafusulina*
8. Zone of *Polydiexodina*
9. Zone of *Verbeekina-Neoschwagerina*
10. Zone of *Yabeina*

The Zones 6, 7, 9 and 10 can be followed in Japan ; brief accounts of their development have already been given by the present writer under the title "Neoschwagerininae Dunbar and Condra", in the Proceedings, Vol. XXIV, No. 9, 1948

Some species of the genus *Triticites* have been recorded from several places in Japan, where, the Zone of *Triticites* seems to be lacking just as in the extensive realm north from Manchuria, over Korea, North and South China, south to Indo-China ; throughout this wide area, a stratigraphical hiatus is either recognized or assumed between the younger formation with the *Pseudoschwagerina* fauna characterizing the Zone of *Pseudoschwagerina* and the older formation with the *Fusulina-Fusulinella* fauna characterizing the Zone of *Fusulina*. At some other places the stratigraphical hiatus may be represented by terrestrial deposits.

In the Liaotung Peninsula, this stratigraphical hiatus is inferred by S. Hanzawa on "the upper part of the uppermost limestone in the Penchi series" being "sometimes brecciated consisting of angular blocks of dark gray limestone entombed in the calcareous and buff-coloured matrix", (2) the 5 meters thick basal fire-clay of the overlying Atung formation, with numerous plant fragments and interrupted at its middle by one or two beds abundant in limestone blocks which he regarded as mere calcareous nodules and not blocks derived from the underlying limestones of the Penchi formation, and (3) the wavy boundary plane between the two formations. The limestones interbedded in the Penchi formation

1) M. L. Thompson : Studies of American Fusulinids. Univ. Kansas Publ., Contrib. Pal., Protozoa, Art. I, 1948.

contain *Fusulina cylindrica* Fischer de Waldheim, *F. konnoi* (Ozawa), *F. schellwieni* (Staff), *Fusulinella praesimplex* (Lee), *F. obsoleta* (Schellwien), *Eoschubertella parva* (Lee and Chen), *Ozawainella angulata* (Colani), *Boultonia rawi* Lee, and some others, and those in the Atung *Schwagerina richthofeni* (Schwager), *Quasifusulina longissima* (v. Moller), *Boultonia willsi* Lee, *Pseudoschwagerina glomerosa* (Schwager) and *P. moungtensis* (Deprat).¹⁾

The Penchi and Atung formations constitute the Taizuho group in the Liaotung Peninsula. This group of the Taizuho district in South Manchuria consists of, according to M. Noda²⁾ in descending order,

Tsaichia formation, 489 m. Shales and sandstones, lacking both coal and limestone. (Characterized by *Gigantopteris nicotianaefolia* flora).

Liutang formation (upper coal formation), 170 m. Sandstones, shales and coal; coal seams predominating in the lower part and sandstone beds in the upper; shales become reddish purple toward the top. Rich in plant fossils, (Stephanian flora of Euro-american type, having in addition *Lepidodendron oculisfelis* Abbado and some other characteristic forms).

Huangchi series (lower coal formation), 70 m. Sandstones and shales, with some coal seams; equivalent to the Atung formation of Liaotung Peninsula. (Partly marine³⁾).

Penchi formation, 120 m. Sandstones, shales and limestones, with a few workable coal seams; reddish purple shales in the lower part, interbedding several aluminous shale beds. Limestone rich in foraminifera similar to those in the Penchi formation of Liaotung Peninsula (beside, corals: *Arachnastraea manchurica* Yabe and Hayasaka, *Cystophora manchurica* Yabe and Hayasaka).

1) S. Hanzawa: The Stratigraphical Relation between the Carboniferous and Permian Formations in Manchuria, Korea and Japan Proper. Jap. Jour. Geol. Geogr., Vol. XVIII, No. 3, 1941.

2) M. Noda: Stratigraphical Studies on Carboniferous and Permian Formations of Southern Manchoukuo. Central Nat. Mus. Manchoukuo, Bull. I, 1939. The Geological History of the Younger Palaeozoic Formations in Southern Manchoukuo. Proc 5th Pac. Sci. Congr., Vol. I, 1940. On the Boundary between the Carboniferous and Permian Formations in the Taizuho District. Jub. Publ. Prof. H. Yabe's 60th Birthday, Vol. II, 2942. The present writer's additional notes are given in brackets.

3) Noda described *Sphaerodoma renodoi*, S. sp. and *Naticopsis* sp., and R. Toriyama *Orthotetes* cf. *rubra* Frech, *Chonetes* cf. *latisinuata* Schellwien, *C. barusiensis* Davidson, C. sp. and *Marginifera* sp. somewhat resembling *M. loczii* Chao from the Penchi formation of Kansu. M. Noda: On a New Species of *Sphaerodoma* from the Tienhsifu Coalfield, Fengtien Province, Manchoukuo. Bull. Centr. Nat. Mus. Manchoukuo, No. 3. R. Toriyama: Fossil Brachiopods from the Huangchi Series of Penhsifu and Niusintai (in Japanese). Jour. Geol. Soc. Japan, Vol. LII, Nos. 613/615, 1946.

4) H. Yabe and M. Eguchi: Notes on the Upper Palaeozoic Coral Genera *Cystophora* and *Arachnastraea*. The Proceedings, Vol. XX, Nos. 7, 8.

The upper Palaeozoic Heian group of Korea is divided into, in ascending order, Kōten-, Zido, Kobosan and green sandstone formations. The lowest Kōten formation consists of shales, sandstones and conglomerates, reddish in colour, and the overlying Zido of shales and sandstones, gray to black in colour and interbedding anthracite seams. Limestone occurs in small lenses in the Kōten formation and in the lower part of the Zido. The stratigraphical boundary between the two formations is by no means distinct, usually appearing as a gradual transition from one to the other. However, after examination of many samples of fusulinid limestones carefully collected from different horizons, N. Hatae¹⁾ concluded that the Kōten formation has a *Fusulina-Fusulinella* fauna (*Fusulina cylindrica*, *F. konnoi*, *Fusulinella bocki* v. Moller, etc.) and the lower part of the Zido formation a *Schwagerina-Pseudoschwagerina* fauna (*Schwagerina simplex* (Schellwien), *S. complicata* (Schellwien), *Quasifusulina longissima*, *Q. tenuissima* (Schellwien), *Pseudoschwagerina glomerata*, *Boultonia willsi*, among many others). The upper part of the Zido formation has a rich flora similar to that of the Liutang group of Manchuria, and the Kobosan formation has another (*Gigantopteris nicotianaefolia* flora); the writer agrees with Noda in correlating the Kōten formation, the lower part of the Zido formation and its upper part with the Penchi-, Huangchi- and Liutang formations respectively of South Manchuria. Apparently there is no room for the Zone of *Triticites* between the Zone of *Fusulina-Fusulinella* and the Zone of *Pseudoschwagerina* in Korea; nevertheless, it is expected that someday certain evidences for the stratigraphical break between the Kōten- and Zido formations will be found as in Manchuria. In this connection it may be mentioned that the writer once saw in the valley of Tenseiri in Sinso-men, Zyunsen-gun, Heian-nan-do, the lower part of the Zido formation directly resting on Devonian coralline limestones, without intervention of the Kōten formation.

The Taiyuan series of North China and the Chuanshan limestone in the Yangtze valley, both with *Pseudoschwagerina* and *Quasifusulina* represent the Huangchi of South Manchuria and the lower division of the Zido of Korea. The Taiyuan formation is underlain by the Penchi and the Chuanshan by the Huanglung limestone; the formations equivalent to the Chuanshan and Huanglung

1) N. Hatae : Stratigraphical Division of Heian System on Foraminifera (in Japanese, with English abstract). Jub. Publ. Prof. H. Yabe's 60th Birthday, Vol. II, 1939.

2) H. Yabe : Discovery of Devonian Deposits in Korea (in Japanese). Kagaku, Vol. X, No. 3, 1949.

3) J. S. Lee, S. Chen, and S. Chu : The Huanglung Limestone and its Fauna. Mem. Nat. Res. Inst., Geol., No. IX, 1930, p. 89. J. S. Lee and S. Chu : A Geological Guide to the Lungtan District, Nanking, 1932, pp. 17, 18. J. S. Lee : Geology of China, 1939, p. 139.

are extensively distributed in South China. The stratigraphical relation of these younger and older formations are usually simple, apparently being conformable. But Lee¹⁾ who once carefully observed a pronounced erosion surface between the Chuanshan and Huanglung limestones in the Chuangshan area of the Nanking Hills, that signs of epeirogenic movement at that time were widely noticed; only in Yunnan as in the adjacent Indo-China the older formation were more or less intensely disturbed prior to the deposition of the younger: Lee's Kunming movement. In northern Honan the Taiyuan formation overrides the Penchi and rests on the Ordovician limestone, and in the Yangtze valley the Chuanshan limestone sometimes overlies formations older than the Huanglung, as in Korea. A good summary of this stratigraphical relation in China has already been given many years ago by V. K. Ting and A. W. Grabau.

Likewise in Japan, the *Pseudoschwagerina-Quasifusulina* limestone usually co-exist with the *Fusulina-Fusulinella* limestone without intervention of rocks with the typical *Triticites* fauna, for instance in the Akiyosi and Ohuku plateaux (Yamaguti prefecture), Taisyaku plateau (Hirosima prefecture), Suzuka mountains; Akasaka (Gifu prefecture), Kwanto and Kitakami mountainlands.

Of late a pronounced unconformity was traced between the *Pseudoschwagerina-Quasifusulina* zone and the *Fusulina-Fusulinella* zone in the southern Kitakami mountainland, the best area for the stratigraphical and palaeontological studies of the Palaeozoic deposits in Japan, the evidence being, as first reported by Hanzawa³⁾ on the information given to him by Y. Inai and the late T. Sugiyama, that the Sakamotozawa conglomerate basal to the lower Lower Permian Sakamotozawa formation rests on the *Fusulinella* limestone at Nagaiwa and several other places, on the Visean coral limestone at Siroisi and Honoki passes, and even on Tournaisian rocks at the east of Hitokabe. At nearly the same time, the late T. Nagao and M. Minato⁴⁾ independently came to the same conclusion, and this stratigraphical relation was more critically discussed by the latter author⁵⁾ in another paper written in Japanese.

The Carboniferous deposits of the southern Kitakami mountainland are now divided by M. Minato as follows:

1) V. K. Ting and A. W. Grabau: The Carboniferous of China and its Bearing on the Classification of the Mississippian and Pennsylvanian. Rep. XVI Internat. Geol. Congr., Washington, 1933 (extract, p. 13).

3) S. Hanzawa: Op. cit., p. 108.

3) T. Nagao and M. Minato: Ueber eine bedeutende Diskordanz im jungeren Palaeozoikum des Kitakami-Gebirges in nordlichen Honsyū, Japan. Jour. Fac. Sci., Hokkaidō Imp. Univ., Ser. IV, Vol. VII, No. 1, 1943.

4) M. Minato: Unconformity of the Pre-Sakamotozawa (Pre-Sakmarian) Stage in the Kitakami Mountainland. Jour. Geol. Soc. Japan, Vol. XLIX, No. 581, 1942.

Lower Division of the Lower Permian Sakamotozawa Series
Pronounced unconformity

Nagaiwa series : sandstone and limestone. 300m.

Chaetetes, *Fusulinella*

Apparently conformable, but precise nature still unknown

Onimaru series : coral limestone. 300m.

Stylidophyllum, *Siphonodendron*, *Diphyphyllum*,
Dibunophyllum, *Yuanophyllum*, *Kueichouphyllum* etc.

Unconformity

Odaira series :

V. Mostly sandstone. 550m.

Lophophyllidium etc.

IV. Schalstein. 230m.

III. Clayslate. 510m.

Amplexus, *Spirifer*, *Productus* semireticulati etc.

Spirifer verneuili from the lowest horizon.

II. Schalstein. 135m.

I. Clayslate. 30m.

Minato is probably correct in separating the Nagaiwa formation from the Onimaru to which the former was originally included by Y. Onuki. The Nagaiwa is usually regarded as Moscovian, as it contains *Fusulinella* and *Chaetetes*, of which the latter is indistinguishable from a *Chaetetes* of the Penchi formation but this correlation needs further confirmation. If it is really Moscovian in age, an unconformity is expected beneath its base. The coral limestone of the Onimaru formation called *Dibunophyllum* limestone by Minato, often abounds in corals; *Hexaphyllia* and *Heterophyllia* once dealt with by T. Sugiyama and the writer are also from this horizon. Beneath this limestone is another line of unconformity by which the limestone is separated from the older Odaira formation. While the *Dibunophyllum* limestone is Upper Viséan and contemporaneous with the Upper *Yuanophyllum* zone of the Fengningian system in South China and the *Dibunophyllum* zone in Europe, the Odaira formation ranges from Tournaisian down to Etroeungian or even to the uppermost Devonian; this view of Minato does not much differ from that of the late Sugiyama.

The lack of *Triticites* fauna representing the Zone of *Triticites* in Japan, and more in general way over the extensive area of eastern Asia, is a significant geological feature for which there are two plausible interpretations: 1. the deposition of the Zone of *Triticites* (or its equivalent marine formation in different faunal facies) did not taken place over this wide area, or 2, it did and later the deposits were entirely taken off by subaerial denudation indicated

1) M. Minato: On the Lower Carboniferous Deposits at Setamai, Kesen-gōri, Iwate Prefecture. Jour. Geol. Soc. Japan, Vol. XLVIII, No. 577, 1941.

by the erosion surface beneath the Sakamotozawa formation of the Lower Permian in Japan and that beneath the contemporaneous deposits in the adjacent lands. Minato¹⁾ who once discussed in length this problem tended to accept the first interpretation, but still without absolutely denying the tenability of the second interpretation.

For a long time the present writer also was in doubt about that which of the two interpretations should be reasonable and many years ago urged H. Huzimoto to take a work of finding if possible evidences in support of the second interpretation ; not withstanding his great and constant effort to this direction, he does not seem to have been successful and the writer is now more positive than Minato in believing the truth of the first assumption and hold the view in accordance with that of V. K. Ting and A. W. Grabau²⁾, who expressed that the marine Upper Pennsylvanian is lacking in China.

Thompson recognized three fusulinid zones in the Middle Pennsylvanian the Zone of *Fusulina*, Zone of *Fusulinella* and Zone of *Profusulinella*. In Japan material at disposal in this respect is still very scanty and does not serve for undertaking such fine division; for a while one must satisfy himself with a single Zone of *Fusulina-Fusulinella*. In China, Lee distinguished the younger fauna with *Fusulina cylindrica* and *F. quasicylindrica* from the older without them and having only minute fusulinids in both the Penchi formation in North China and the Huanglung formation in South China.

Thompson's Zone of *Millerella* occupies the whole Lower Pennsylvanian and extends downwards to the late Mississippian. In another paper³⁾ the writer reported on a find of *Millerella* in the coral limestone of the Onimaru formation, Upper Viséan, that is to say, the late Mississippian in age. Thompson referred to the occurrence of *Millerella* in the Huanglung.

In Nanking Hills, this limestone, 100m thick, is disconformably underlain by the Houchou limestone, a few meters to 10 m thick ; this having *Yuanophyllum kansuensis* Yu, *Siphonodendron irregulare* (Phill.) var. *asiatica* (Yabe and Hayasaka), *Lithostrotion portlocki* (Bronn), *L. maccoyanum* Edw. & H. and *Aulina* cf. *carinata* Yu is an example of the Zone of *Yuanophyllum* C. C. Yu's to which Minato correlated the coral limestone of the Onimaru formation, his

1) M. Minato : Op. cit., 1949

2) V. K. Ting and A. M. Grabau : Op. cit.

3) J. S. Lee : The Geology of China, 1939, p. 138.

4) H. Yabe : The Zone of *Millerella* in Japan. See the foregoing article of the present number of the Proceedings.

5) C.C. Yü : The Correlation of the Fengninian System, the Chinese Lower Carboniferous. Bull. Geol. Soc. China, Vol. X, 1931, p. 10.

Dibunophyllum limestone. The Hochou limestone contains numerous foraminifera, particularly *Endothyra* and *Orobias* in its upper part ; it may likewise represent the early part of the Zone of *Millerella*. While the Onimaru formation is separated by a stratigraphical break from the underlying Odaira formation, Etroeungtian to Tournaisian in age, the Hochou limestone is underlain by the Kaoliu formation of continental origin with yellowish sandstone and shale, occasionally purple shale and also argillaceous limestone lenses and having a *Lepidodendron* flora.