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THE PERMIAN FORMATIONS OF SOUTHERN CHINA

BY T. K. HUANG

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INTRODUCTION

In the early days Permian formations of southern China used to be considered "Kohlenkalk" or Carboniferous limestone by pioneer geologists, like Richthofen, Loczy, Willis and Blackwelder. It was not until the publication of Frech's work (14)¹ on the palæozoic faunas of China that the existence of typical Permian deposits was firmly established and accepted by foreign stratigraphers. In Frech's time however both the faunas and formations were only insufficiently known, and naturally his correlation and classification were inadequate and in many points incorrect. It was only in recent years, since Chinese geologists undertook explorations in their own country, that the importance of Permian deposits and faunas in southern China was gradually recognized. To-day, all geologists in China agree on the importance of the

1 Hereafter all figures in parenthesis indicate works listed in the Bibliography.

Permian as the most widespread and economically most important geological formation in southern China, and when all the palæontological monographs dealing with the faunas are published, the Chinese Permian will prove to be the richest and best developed record of that period, the individuality of which has recently been doubted by some foreign geologists. As the results set forth in the present contribution are the results of researches of different investigators it is fair to mention them by name.

In the province of Kiangsu, early works were done by V. K. Ting, C. C. Liu, J. C. Chao and Y. C. Sun; later by C. Y. Hsieh, J. S. Lee, C. Li, S. Chu and others. In Anhui, the collections of L. F. Yih, C. Li, C. C. Wang and Y. C. Sun are most important; the recent investigations of members of the Shanghai Institute are quite indispensable. In Chekiang, early explorations were carried out by L. F. Yih, C. C. Liu, J. C. Chao, Y. T. Chao, and T. O. Chu; later by S. S. Yoh, W. P. Shu, S. F. Sheng and others. In Kiangsi, valuable collections were made by C. C. Wang, V. K. Ting, W. H. Wong, C. C. Liu and others. In Fukien, the discovery of fresh water molluscs by S. W. Wang is interesting. In Hupeh, the works of C. Y. Hsieh, J. S. Lee, Y. T. Chao, C. C. Liu are the most indispensable, while the recent works of C. Li, S. Chu, C. C. Yü, W. P. Shu and H. M. Meng are also important. In Hunan, the work of C. C. Tien is the most important. In Szechuan, Y. T. Chao, T. K. Huang, H. C. T'an and C. Y. Lee have all made contributions. In Shensi, Permian strata has been so far only reported by Y. T. Chao and T. K. Huang. In Kueichow, the investigations of S. S. Yoh, V. K. Ting, Y. L. Wang and T. K. Huang have cleared up the complicated Permian stratigraphy of that province. In Yunnan, the early work of V. K. Ting and the recent work of Y. T. Chao, T. K. Huang and Y. L. Wang formed the basis of the present correlation and generalization. In Kwangtung and Kwangsi, the Permian stratigraphy still remains in doubt. Some important palæontological collections however have already been made, including the finding of *Lyttonia* in Tsiensianghsien and of *Gigantopteris* in Chuchianghsien; the authorities thereof are V. K. Ting, S. S. Yoh, T. O. Chu, K. L. Feng and others.

I. THE CHIHsia LIMESTONE

HISTORICAL.¹

The term Chihsia Limestone was first introduced by v. Richthofen, who vaguely applied it to a thick sequence of limestones found in a small hill, Chihsiashan, some 20 kilometers east of Nanking. He did not attempt to give a detailed stratigraphical succession, nor did he delimit the upper and lower boundaries of the formation. He found, however, some corals in it; these were later determined by Frech (14, p. 61) who furnished the following list :

- Hallia gigantea* Mich.
- Lonsdaleia floriiformis* Flem.
- ? *Lonsdaleia papillata* Fisch.
- Zaphrentis spinulosa* E. et H.
- Battersbyia* nov. sp.
- Syringopora ramulosa* Gold.
- Fistulipora minor* M'Coy.

Frech considered the Chihsia Limestone Lower Carboniferous.

In his "Stratigraphy of China", Grabau (16, p. 446) has not only given a description of the Chihsia Limestone in its type locality but has also enumerated new localities in which this limestone has so far been found. He summarized the Chihsia fauna as follows :

- Girvanella nankingensis* Grabau
- Fusulinella gigas* Mansuy
- Syringopora ramulosa* Gold.
- S. geniculata* Phill.
- Fistulipora minor* M'Coy
- F. waageniana* Girty
- Michelinia favositoides* Girty
- M. favosa* Gold. var.
- Amplexus spinosus* var. *sinensis* Grabau
- Siphonodendron* sp.
- Lonsdaleia chinensis* Girty

¹ See Yoh & Huang : Coral Fauna of the Chihsia Limestone of the Lower Yangtze, Pal. Sinica, Ser. B, Vol. VIII, Fasc. 1.

Pseudolonsdaleia leei Grabau

Zaphrentis delanoui E. et H.

Z. guerangeri E. et H.

Geinitzella chinensis Girty

Spirifer blackwelderi Girty

Grabau, at that time, still believed in the Lower Carboniferous age of the limestone.

In 1924, Hayasaka (24) visited the locality and found additional corals in the limestone, including *Lonsdaleia chinensis* Girty, and species of his newly founded genus *Tetrapora*. On the strength of these fossils, he suggested the Permian age of the Chihsia Limestone.

In describing the brachiopods of the Chihsia Limestone, Y.-T. Chao (3) gave an excellent discussion on its fauna and its distribution. He definitely stated that the fauna is dominated by corals, with *Tetrapora* as the leading genus, and considered the Chihsia Limestone and the *Tetrapora* bed as identical terms. The age of the formation was believed by him to be Upper Carboniferous.

In 1930, Lee and Chu (38) published their detailed investigations of the Permo-Carboniferous strata in the Nanking Hills, in which they applied the term Chihsia Formation to include three limestones, namely, the Huanglung Limestone, the Chuanshan Limestone and the Chinlung Limestone. The age of the Huanglung Limestone is definitely known to be Middle Carboniferous.

Seeing the disagreement in the usage of the term between Lee and Chao, Yoh (63) attempted to redefine it. He included the Chihsia Limestone or *Tetrapora* bed of Chao and the Chuanshan Limestone of Lee in the comprehensive term Chihsia Formation and excluded the Huanglung Limestone therefrom.

In two recent papers Lee (39 & 40) abandoned his former usage of the term and definitely redefined it as a formation beginning from his "lower lydite" and ending at his "upper lydite." He further states that the Chihsia Limestone lies above the zone of *Schellwienia japonica* (Pj), and itself includes three *Fusulina* zones (Pc, Pi, Pm).

DEFINITION

Since the term Chihsia Limestone has been differently used by different authors, it is of importance to trace out its real significance. Let us turn to the type locality, the Chihsiashan, for solution. The limestone series at Chihsiashan is divisible into three parts. The lower part is the Huanglung Limestone of Lee and Chu, which belongs to the Middle Carboniferous. The middle part is the Chuanshan Limestone carrying a Uralian foraminiferan fauna; this limestone has recently been subdivided by Lee into two horizons, the upper is called the Swine Limestone, with the Chuanshan Limestone *sensu stricto* as the lower horizon. Lying immediately above the Chuanshan, is a dark grey, cherty limestone forming the upper part of the whole sequence. It is in this limestone that Sun found, in 1924, the following fossils (Loc. 615):

- Derbya* sp.
- Orithotichia morganiana* mut. *chihsiaensis* Chao
- Tetrapora elegantula* Yabe et Hayasaka
- T. nankingensis* Yoh
- T. halysitiformis* Yoh
- Monilopora dendroides* Yoh
- Michelinia* cf. *placenta* Waagen et Wentzel
- M. microstoma* Yoh (non Yabe et Hayasaka)
- (= *M. marginocystosa* Huang)
- Lonsdaleia chinensis* Girty (= *Polythecalis chinensis* (Girty))
- Fistulipora waageniana* Girty
- F. sinensis* Yoh
- Allotropiophyllum sinense* Grabau
- Fusulinella?* *gigas* Mansuy (= *Staffella inflata* Colani)

Another notable collection from the same hill was made by Liu and Chao (Loc. 605). The species are:

- Spirigerella pentagonalis* Chao
- Schizophoria indica* (Waagen)
- Chonetes* sp.
- Marginifera obscura* Chao

Corwenia chihsiaensis Yoh

Yatsengia kiangsuenensis Yoh

Stylidophyllum volzi (Yabe et Hayasaka)

Tetrapora syringoporoides Yoh

Fusulinella? gigas Mansuy (= *Staffella inflata* Colani)

At first, the writer was not sure as to which horizon the above-said collection came from. Did it come from the cherty limestone or from the Chuanshan Limestone of Lee? After long and careful consideration, he is convinced that Liu's collection was taken not from the Chuanshan but from beds higher up. Three facts are in favor of this interpretation: (1) The Chuanshan Limestone is nowhere known to furnish such a rich coral fauna, (2) The occurrence of *Tetrapora* indicates that the horizon is higher than the Chuanshan, since *Tetrapora* is the index of the higher beds, and (3) *Staffella inflata* has, according to Lee, never been found in the Swine and Chuanshan Limestones.

Now, remembering that both Liu's and Sun's collections came from the cherty limestone which lies above the Swine and Chuanshan Limestone, let us turn to the fossil lists of Frech, Grabau, and Hayasaka. It seems pretty sure, that out of the 7 species listed by Frech, 5 are included in these collections. The writer here attempts to identify Frech's species with those known to-day:

Lonsdaleia floriformis = *Stylidophyllum volzi*

?*Lonsdaleia papillata* = *Corwenia kiangsuenensis*

Zaphrentis spinulosa = *Allotropiophyllum sinense*

Syringopora ramulosa = *Tetrapora elegantula*

Fistulipora minor = *Fistulipora sinensis*

The fossil list of Grabau combines all the species then found in the cherty limestone of the Yangtze Valley, but all these, except the problematical *Girvanella nankingensis*, were undoubtedly found in the beds higher than the Chuanshan Limestone. The fossils collected by Hayasaka also belong to the *Tetrapora* bed.

It appears fairly clear, then, that the fauna of the Chihsia Limestone, that is, the Chihsia Limestone itself, occupies a horizon higher than the Chuanshan and Swine Limestones of Lee. To include both the Huanglung and Chuanshan Limestones in this term, will not only make greater confusion in terminology but will also do injustice to the original authorities. Fortunately, Lee has

revised his old usage of the term and restricted it to that limestone which is delimited by two lydite horizons. It is all the more fortunate that the *Tetrapora* bed of Chao happily coincides with Lee's Chihhsia Limestone in the revised sense. So, following Lee and Chao, let us define it as follows:

The Chihhsia Limestone is a geological formation, mainly consisting of cherty limestones, characterized by a coral fauna which, for simplicity, may be called the *Tetrapora* fauna. In the Nanking Hills, this limestone lies above the zone of *Schellwienia japonica* and is delimited by two lydite horizons.

TYPICAL SECTIONS AND FOSSILIFEROUS LOCALITIES

In the Nanking Hills:—Thanks to the careful investigations of J. S. Lee, the succession of the Chihhsia Limestone and its boundaries in the Nanking Hills region have been clearly worked out. The following summarizes the known facts (see Fig. 13):

Lungtan Series with *Gigantopteris* flora

Chihhsia Limestone

Upper lydite or siliceous shales..... 20 m
S. Chu found *Productus nankingensis*, *P. yangtzeensis*, *Ortholichia morganiana* mut. *chihhsiaensis* and *Plicatifera minor* in this horizon.

Dark blue limestone with bedded flints; *Staffella inflata* occurs in abundance 55 m
This is undoubtedly the horizon from which Sun collected his fossils (Loc. 615).

Cherty limestone alternating with reddish siliceous shale, becoming a well bedded limestone with very few flints towards the upper part 28 m
This is probably the horizon from which Liu and Chao collected their fossils (Loc. 605).

Lower lydite or siliceous shales 18 m
Chuanshan Limestone with *Schwagerina princeps* and *Schellwienia longis-*

sima and with *Schellwienia japonica* at the top (Swine Limestone).
The total thickness amounts to 121 meters.

In South Anhui:—Essentially the same succession has been found in South Anhui, especially in Kueich'ihhsien, where S. Chu (9) has made detailed observations. The succession is as follows:

Lungtan Series with coal seams and *Gigantopteris* flora
Kuhfeng Formation, mostly shales with *Gastrioceras*
Chihsia Limestone

Succession similar to the Nanking Hills; in the upper lydite Chu found *Productus yangtzeensis* and *Linoproductus chianensis*.

Chuanshan Limestone.

Chu believes that the Lungtan Series is unconformable with the Kuhfeng Formation.

In the Yangtze Gorges:—The Chihsia Limestone is well represented in the Yangtze Gorges, where the succession is, according to Lee (36) and Chao (27), as follows:

Flinty limestone with *Oldhamina* and *Lyttonia*
Foraminifera limestone with *Neoschwagerina* and *Yabeina*
Chihsia Limestone with *Tetrapora* and *Polythecalis*
Subformation—Silurian sandstones.

The total thickness of the three limestones amounts to 500 m.

In Central Hunan:—Recently C. C. Tien made a detailed columnar section of the Permo-Carboniferous formations of central Hunan, which has been kindly forwarded to the writer (see Pl. I, XX):

Doliolina limestone 100-150 m
Light grey limestone with *Doliolina lepida*, etc.
Chihsia Limestone 250-300 m
Upper limestone with *Caninia liangshanensis*
Lower limestone with *Michelinia multicystosa*
Basal shale about 30 m.

Chuanshan Limestone.

It is to be noted that the succession is essentially the same as the Nanking Hills, except that in the latter section the *Doliolina* limestone is wanting.

In South Shensi:—At Liangshan, Hanchung, Shensi (Fig. 1), the following section has been reported by Chao and Huang (8):

Well-bedded limestones, fossils not found
 Cherty limestone with *Tachylasma* and *Caninia liangshanensis*
 Limestone with *Tetrapora hanchungensis*
 Shales with coal smuts

Disconformity

Subformation—Silurian graptolite beds.

The total thickness of the fossiliferous limestone, the equivalent of the Chihsia Limestone, is no more than 150 m.

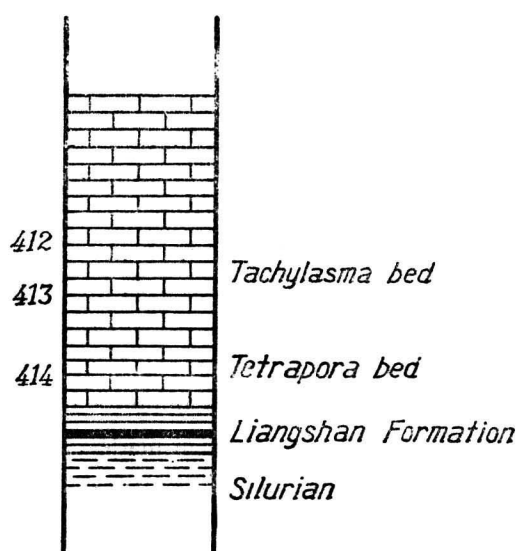


Fig. 1.—Columnar section showing the Permian succession at Liangshan, Hanchung, S. Shensi. Scale 1:20,000.

In Northern Kueichow:—The Chihsia Limestone is well developed in N. Kueichow. Summarizing the works of Yoh, Ting, and Huang, the following succession may be established.

Lyttonia coal series with *Gigantopteris* flora

- (4) Limestone of Shihtzup'u with *Plicatifera minor* — 20 m?
- (3) Tungkungssu limestone with *Doliolina* and *Neoschwagerina*

- (2) Cherty limestone with *Polythecalis*
- (1) Limestone with *Tetrapora*

Disconformity

Subformation — Silurian shales

(1) and (2) undoubtedly correspond to the Chihhsia Limestone at Nanking. (3) is equivalent to the *Doliolina* and *Neoschwagerina* beds of Hupeh and Hunan.

In Southern Kueichow:— Comparing the columnar sections given in Pl. I, Figs. XV—XVII, the succession in southern Kueichow may be given as follows:

- Coal series with *Lophophyllum kayseri*
- (4) Limestone with *Wentzelella subtimorica*
- (3) Limestone at Wengchengh'iao with *Michelinia siyangensis* and *M. microstoma*
- (2) Limestone with *Tetrapora*
- (1) Limestone with *Stylidophyllum volzi*
- Chuanshan Limestone with *Schellwienia minima*

(1), (2) and (3) unquestionably belong to the typical Chihhsia Limestone, but (4) may be equivalent to the *Neoschwagerina* and *Doliolina* beds in other sections. The relation of (2) and (3) is not clearly known, but it is supposed that (2) is slightly lower than (3).

Summary of Fossiliferous Localities

The important localities in which typical Chihhsia fossils have been found are given below.

Kiangsu Province.

In this province the collections made by C. C. Liu and J. C. Chao and by Y. C. Sun, as mentioned in a preceding page, are most important. The finding of *Productus nankingensis*, *P. yangtzeensis*, *Plicatifera minor* and *Orthotichia morganiana* mut. *chihhsiaensis* by S. Chu in the upper lydite horizon is also noteworthy. Other localities were given on p. 6 of Yoh and Huang's monograph (63).

Chekiang Province.

Chiuyaoshan, Hangchow (杭州九曜山), Coll. S. F. Sheng

Upper Feilaifeng Limestone

Corwenia chiuyaoshanensis Huang
C. parachihsiaensis Huang
Yatsengia hangchowensis Huang
Bradyphyllum caninoides Huang
Hapsiphyllum shengi Huang
Productus inflatiformis var. *pauciplicatus* Grabau
 (probably a variety of *P. yangtzeensis*)
Athyris bicincta Grabau

Middle Feilaifeng Limestone

Michelinia marginocystosa Huang
M. aff. siyangensis Reed
Lophophyllum cf. *multiseptum* Grabau

Nankao, Changhsinghsien (長興縣南高), Coll. C. C. Liu and J. C. Chao

Stylidophyllum chaoi Huang
Polythecalis yangtzeensis var. *hochowensis* Huang

Hsiashipu, Chühsien (衢縣下石埠), Coll. S. S. Yoh

Tetrapora elegantula Yabe et Hayasaka

Fengkeng & T'anshihssu, Chiangshanhsien (江山縣風根及潭石寺), Coll. S. S. Yoh

Tetrapora elegantula Yabe et Hayasaka

Anhui Province.

Chilungshan, Hohsien (和縣雞籠山), Coll. Y. C. Sun (Loc. 721)

Tetrapora elegantula Yabe et Hayasaka
T. nankingensis Yoh
T. halysitiformis Yoh
Monilopora dendroides Yoh
Michelinia cf. *placenta* Waagen et Wentzel
M. marginocystosa Huang
Polythecalis chinensis (Girty)
P. rosiformis Huang
P. yangtzeensis var. *hochowensis* Huang
Allotropiophyllum sinense Grabau

Fistulipora waageniana Girty

Kiangsiella pectiniformis var. *nankingensis* Grabau

Schizophoria indica (Waagen)

Productus nankingensis (Frech)

Staffella inflata Colani

Yehshanch'ung, T'unglinghsien (銅陵縣叶山冲) Coll. Yih & Li (Loc. 722)

Tetrapora nankingensis Yoh

Michelinia marginocystosa Huang

Yangershan, T'unglinghsien (銅陵縣羊兒山) Coll. H. M. Meng

Tetrapora elegantula Yabe et Hayasaka

T. nankingensis Yoh

T. sp.

Monilopora dendroides Yoh

Michelinia marginocystosa Huang

Polythecalis multicystosis Huang

P. yangtzeensis var. *hochowensis* Huang

Lophophyllum pendulum var. *simplex* Huang

Allotropiophyllum cf. *sinense* Grabau

Geinitzella sp.

T'aoch'ung, Fanchanghsien (繁昌縣桃冲) Coll. I. Hayasaka

Tetrapora elegantula Yabe et Hayasaka

Yentzuling, Chinhhsien (涇縣燕子嶺) Coll. Yih & Li (Loc. 725)

Tetrapora laxa Yoh

7 li S. of Hsienshanhsien (含山縣南) Coll. Yih & Li (Loc. 733)

Tetrapora halysitiformis Yoh

Hupei Province

Sintan, Ichang (宜昌新灘) Coll. Lee & Chao

Tetrapora sp.

Michelinia microstoma Yabe et Hayasaka

Polythecalis chinensis (Girty)

Fusulinella multivoluta Lee

F. verbeekinoidea Lee

F. sphaerica Abich