

THE CORRELATION OF THE FENGNIAN SYSTEM,  
THE CHINESE LOWER CARBONIFEROUS,  
AS BASED ON CORAL ZONES.

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- I. Introduction.
- II. Distribution of Lower Carboniferous in China.
- III. Correlation of the Lower Carboniferous beds from the different localities of our country.
- IV. Comparison of Chinese Lower Carboniferous Zones with those of Europe.
- V. Description of some index corals of the faunal zones.

I. INTRODUCTION.

Much has been written about the Lower Carboniferous formations of central as well as northern China. Through recent field work and researches we now know that the Lower Carboniferous of former authors was far from being correctly determined and that many true Lower Carboniferous beds have been discovered in different localities.

Before we consider the distribution of the Lower Carboniferous and its faunal succession, let us briefly summarize the formerly supposed Lower Carboniferous—the Taiyuan series of North China and the Chihhsia formation of Central China—in order to clear the confusion.

The term "Taiyuan (太原) Series" was created by Dr. Wong and Prof. Grabau in 1922. It consists of marine intercalations in the lower part of the coal-bearing series, which is so well-known and wide-spread in North China. It was Frech who first considered it to be Lower Carboniferous in age<sup>1</sup>. Later on Willis and Blackwelder put the lower marine beds in Shansi together with the upper coal measures in their Shansi system, which was compared with the Pennsylvanian of North America by Girty<sup>2</sup>. Hayasaka

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1. Richthofen's China, Vol. V, pp. 59-81.

2. Research in China, Vol. III, pp. 297-303.

also believed that the marine beds underlying the coal-bearing series belong to the Upper Carboniferous. In 1922 Prof. Grabau subdivided the coal-bearing series of North China into two parts. The lower part supposed to represent the late Lower Carboniferous was named the Taiyuan series, while the Shansi series of Willis and Blackwelder was restricted to the upper part, and considered to be Permo-Carboniferous<sup>3</sup>. In making this division Professor Grabau recognized the fact that the fauna of the higher beds was of Permian character and different from the fauna of the lower beds. This is especially well brought out in the west Shansi section, where the lower two limestones below the coal are referred to the Taiyuan, but the Paotichou (保德州) limestone and the T'umen (土門) shale are referred to the Shansi series. In the sections further east, the Taiyuan and Shansi disconformity was drawn higher as the faunas were not then fully understood, only the uppermost limestones being placed in the Shansi division. In regard to the classification of the lower division Professor Grabau says\*:

"We might, of course, refer the entire Taiyuan series to the basal part of the Moscovian, but since it marks the culmination of the transgressive movement begun in China in the Visean epoch, whereas the typical Moscovian was in China a period of emergence, it seems more logical to class it as a final stage of the Dinantian, especially since, in its typical development, it carries a preponderating Dinantian element in its fauna. The presence of *Fusulina* in this fauna need not modify this classification, since it is obvious that *Fusulina* could not have arisen suddenly at the beginning of the Moscovian time, it must have had a pre-Moscovian history of some duration during which it developed, probably from some *Enthothyr*a-like ancestor. It is not improbable that this development took place within the Chinese basin during the Taiyuan epoch."

"In any case, the Taiyuan series, if Moscovian, can represent only a very short portion of that period, the greater part of which is unrepresented in China."

When in 1925 the late Mr. Y. T. Chao<sup>4</sup> undertook the study of the *Productidæ* and *Spiriferidæ* of the Taiyuan and Shansi series as formerly defined by Professor Grabau, he reached the conclusion that the Shansi—

3 Stratigraphy of China, Vol. I, p. 253.

\* Stratigraphy of China, Vol. I, p. 241.

4. Bull. Geol. Soc. China, Vol. 4, No. 3-4, pp. 221-227.

Taiyuan disconformity should be drawn much lower in the central Shansi sections although in the west Shansi section it remained where Professor Grabau had drawn it, as it did likewise in the Kaip'ing (開平) section. Finding a typical *Spirifer mosquensis* in the Tangshan (唐山) limestone of the lower series in the Kaip'ing basin, while other characteristic Moscovian fossils were obtained from the other sections he concluded that the lower series was the true representative of the Middle Carboniferous and could not be left in the Lower Carboniferous.

Professor J. S. Lee, who at the same time studied the *Fusulinas*<sup>5</sup> of these beds came to the same conclusion. At the same time he proposed to apply the name *Penchi* (本溪) series to the lower division and restrict the name Taiyuan series to the upper fossiliferous beds. According to the strict rules of priority the lower division should have retained the name Taiyuan and the upper be called the Shansi, but since the upper marine beds are followed by an extensive series of continental beds the name Shansi series is better restricted to these, and in his volume on the *Permian of Mongolia* Professor Grabau has accepted Professor Lee's classification.

The Chihsia formation, named by the Survey after the hill known as Chihsiashan (棲霞山) near Nanking, was considered to be Lower Carboniferous by von Richthofen and Frech.<sup>6</sup> On the basis of Willis' and Blackwelder's collection, Girty has shown<sup>7</sup> that the basal part of the Wushan Limestone at Taningshien (大寧縣), which was proved to be the equivalent of the Chihsia Limestone by Prof. J. S. Lee and Y. T. Chao<sup>8</sup> in 1924, is of Upper Carboniferous age. Hayasaka believed that the Chihsia Limestone was Lower Permian because of the presence of *Verbeekina*. Nevertheless, the majority of Chinese geologists still maintained the assumption made by Frech. In 1927 Y. T. Chao<sup>9</sup> studied some brachiopods from the Chihsia Limestone at Ch'hsiashan and some other localities along the Yangtze Valley and came to the conclusion that the Chihsia Limestone was Upper Carboniferous, being thus in agreement with Girty. Prof. Grabau, however, held the opinion of Hayasaka and referred the Chihsia formation to the Lower Permian. Prof. J. S.

5. Bull. Geol. Soc. China, Vol. 5, No. 2, pp. 113-134.

6. Richthofen's China, Vol. V, p. 67.

7. Research in China, Vol. III, pp. 297-328.

8. Bull. Geol. Soc. China, Vol. 3, No. 3-4, pp. 375-378.

9. Bull. Geol. Soc. China, Vol. 6, No. 2, pp. 83-112.

Lee and Mr. S. Chu<sup>10</sup> of the Geological Institute of the Academia Sinica have recently re-studied the Chihhsia Limestone not far from the type locality of Ch'ihsiashan and found several limestones which they have named as follows:

Chinglung (青龍) Limestone—Middle—Upper Permian

Chuanshan (船山) Limestone—Upper Carboniferous or Permo-Carboniferous or Lower Permian.

Huanglung (黃龍) Limestone—Middle Carboniferous

Upper shale (not named)

Kinling (金陵) Limestone—Lower Carboniferous

Lower shale (not named)

As however the *Verbeekina* Limestone and that containing the brachiopods studied by Chao do occur at the type locality Ch'ihsiashan, it seems that, according to the right of priority, the term Ch'ihhsia should be retained in a restricted sense. In fact V. K. Ting uses the term Chihhsiaian as a systemic name for the limestone of which the uppermost part contains *Verbeekina* and the lowest part rests disconformably on different older formations. Thus the term Ch'ihhsia limestone or Chihhsiaian means the whole of the Lower Permian (if Professor Grabau's determination of the age of that limestone is correct) as distinguished from the overlying coal series and the underlying Carboniferous when the latter is present.

## II. DISTRIBUTION OF LOWER CARBONIFEROUS IN CHINA.

A. In the year 1914 Lower Carboniferous fossils were first collected by V. K. Ting from Chanyi (雲縣) and Chütsing (曲靖) in Yunnan and Weining (威寧) in Kueichow province. The whole collection was sent to the late Dr. Walcott for preliminary determination after which it was sent to a Chinese student at Illinois. In repacking the collection for shipment to China, he unfortunately mixed up the labels and some of the fossils, when returned, no longer correspond to the field sections. For this reason the corals contained therein are not included in the present study.

Recently Mr. Y. L. Wang has been sent by the Geological Survey to these same localities to make new collections which will no doubt enable us to utilise V. K. Ting's old collection.

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10. Bull. Geol. Soc. China, Vol. 9, No. 1, pp. 37-43.

B. In 1923 Mr. P. L. Yuan of the Geological Survey found at Choniukou (臭牛溝) of Wuweih sien (武威縣), Kansu province, a series of blue and grey limestones and shales, with a total thickness of 68 meters. This he named the Choniukou formation.<sup>11</sup> It is underlaid by a continental formation about 67 meters thick which in turn rests unconformably on the Nanshan series. The Choniukou formation (locality Nos. 515-533) is richly fossiliferous and yields abundant well-preserved brachiopods and corals. The brachiopods have already been determined by Prof. Grabau and Y. T. Chao. The corals which I am now studying are given in the following list.

- Aulina rotiformis* Smith
- Aulina carinata* Yü
- Yuanophyllum kansuense* Yü
- Yuanophyllum kansuense* var.  $\alpha$  Yü
- Yuanophyllum kansuense* var.  $\beta$  Yü
- Lithostrotion mccoynum* Edw. et. Haime
- Lithostrotion portlocki* (Bronn)
- Auloclisia elliptica* Yü
- Auloclisia circularis* Yü
- Auloclisia tenta* Yü
- Arachnolasma cylindricum* var. *longicolumella* Yü
- Arachnolasma synaptatum* Yü
- Dibunophyllum choniukouense* Yü
- Clisiophyllum angulatum* Yü
- Clisiophyllum* sp.

C. In 1928 Dr. V. K. Ting travelled the districts Liuch'eng (柳城), Ch'uanhsien (全縣) and Hsian (興縣) in Kuangsi province. At several localities he collected many well-preserved specimens of corals. A preliminary list is given below:

- a. South of Tap'u (大鋪), Liuch'enghsien (locality number 1601) in a thin-bedded shaly limestone a few meters thick, overlying a thick quartzite.

- Siphonodendron irregulare* Phill. var. *asiatica* Yabe et Hayas.
- Siphonodendron kuangsiense* Yü
- Dibunophyllum tingi* Yü

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11. Bull. Geol. Soc. China, Vol. 4, No. 1, pp. 30-32.

Bull. Geol. Soc. China: Grabau Anniversary Volume

*Dibunophyllum leei* Yü

*Clisiophyllum yentzeensis* Yoh var. *multiseptatum* Yü

*Clisiophyllum anastomosum* Yü

*Arachnolasma irregulare* Yü

*Arachnolasma irregulare* var. *simplex* Yü

- b. At T'outang (頭塘), Liuch'enghsien (locality No. 1602), in the same formation as 1601 but on the other limb of the anticline.

*Cyathophyllum fraternum* Reed

*Siphonodendron kuangsiense* Yü

*Arachnolasma cylindricum* var. *longicolumella* Yü

- c. Near T'outang, Liuch'enghsien, (locality No. 1633) in the same formation as 1602.

*Siphonodendron kuangsiense* Yü

*Siphonodendron kuangsiense* var. *concauum* Yü

- d. At Lanhualing (蘭花嶺), near Wulip'ing (五里坪) Ch'nanhsien, (locality No. 1621 and 1621a), in sandy limestone interbedded with sandstone and shale.

*Lithostrotion mccoynum* Edw. et Haime.

*Siphonodendron rossicum* Stuckenberg

*Siphonodendron petalaxioides* Yü

- e. West of Tatungt'ien (大洞田), Hsinanhsien, (locality No. 1617), in shaly limestone interbedded with sandstone and shale.

*Siphonodendron vesiculotabulatum* Yü

- f. At Chiehshou (界首), Hsinanhsien, (locality No. 1619), in shaly limestone immediately underlying a coal series.

*Pseudouralinia gigantea* Yü

D. In 1928-29 Mr. S. S. Yoh, to whom Dr. Ting communicated his discoveries, revisited locality 1601 near Tap'u. According to the list given by him <sup>12</sup> the species do not seem to be identical with the one given above (a-c).

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12. Annual report of the Geological Survey of Kwangtung and Kwangai, Vol. 2, pt. 2, p. 72.

Perhaps this is due to the preliminary nature of Mr. Yoh's determinations. The question can be settled by comparing the actual specimens.

E. In 1928-29 Lower Carboniferous beds were discovered at Hsiang-hsiang (湘鄉), Hsinhua (新化) and other localities in Hunan province <sup>13</sup> by Mr. C. C. Tien and his colleagues Messrs. H. C. Wang and S. Y. Kuo. The whole system consists of 3 divisions. The lowest formation the Wanloshan (萬羅山) limestone, 250-300 m. in thickness, has yielded from the lower part (loc. No. 267.4) the specimens of *Cystophrentis kolaohoensis*. It is succeeded disconformably by the Tz'ehshui (澗水) coal series, 35-50 m thick without marine fossils. Lastly the Lower Tzemench'iao (梓門橋) limestone, 60-100 m thick, contains a rich fauna of brachiopods and corals. The following all have come from the last named formation:—

- a. At Tzemench'iao (梓門橋), Hsianghsianghsien (Loc. No. Fe).  
*Heterocaninia tholusitabulata* Yabe et Hayas.
- b. At Siangrzechiao (想思橋), Hsianghsianghsien (Loc. No. 260).  
*Lithostrotion porlocki* (Bronn)  
*Auloclisia multiplexa* Yü  
*Heterocaninia concentrica* Yü
- c. At Fengkuanshan (鳳冠山), Hsianghsianghsien (Loc. No. 253)  
*Auloclisia confluentis* Yü
- d. At Hoch'angp'ing (火廠坪), Paoch'inghsien (寶慶) (Loc. No. D<sub>1</sub>)  
*Auloclisia multiplexa* var. *minor* Yü  
*Heterocaninia tholusitabulata* Yabe et Hayas.  
*Heterocaninia concentrica* Yü

F. In 1929-30 Dr. Ting and Mr. Y. L. Wang worked in Kueichow province and collected a great many fossils from the Lower Carboniferous. They have named the whole system Fengninian which is here adopted for the whole of the Chinese Lower Carboniferous. It is divided into an Upper and a Lower division each of which is again subdivided into 2 groups. The lower Fengninian consists of the Kolaoho (獐老河) Limestone, and the T'angpakou

13. In the Bulletin of the Geological Society of China, Vol. 7, No. 1, pp. 61-74 Mr. S. Chu described some Carboniferous corals from the Shihertalung formation at Yaoling, Ch'ensien of South Hunan. But it is not clear whether the said formation belongs to the lower part of the Viséan.

(蜈蚣溝) sandstone, and the upper Fenginian the Chiussu (舊司) sandstone and the Shangssu (上司) limestone, all in the ascending order. The coral specimens are the richest and the most characteristic that have ever been found at any place in this country. The following is a preliminary list:—

- a. Between Chiussu and Liuchai (六寨), Tat'anghsien (大塘).
  - T298 b *Clisiophyllum yengzeensis* Yoh var. *multiseptatum* Yü  
*Depasophyllum* (*Diphyphyllum*) *convexum* Yü
  - T298 *Arachnolasma vesiculare* Yü  
*Kueichouphyllum* (*heishihkuanense*? Yü  
*Siphonodendron petalaxioides* Yü
  - T297 *Depasophyllum* (*Diphyphyllum*) *parallelum* Yü  
*Diphyphyllum suggestum* Yü  
*Arachnolasma equiseptatum* Yü  
*Arachnolasma cylindricum* Yü  
*Arachnolasma sinense* (Yabe et Hayas.)  
*Yuanophyllum kansuense* Yü  
*Kueichouphyllum sinense* var. *gracile* Yü  
*Cyathophyllum stutchburyi* Edw. et Haime var.  
*merophylloides* Yü  
*Caninia plana* Yü
  - T269 d *Kueichouphyllum sinense* Yü  
*Arachnolasma cylindricum* Yü  
*Siphonodendron chachaiense* Yü
  - T296 b *Thysanophyllum pseudovermiculare* (M'Coy) var. *minor* Yü  
*Thysanophyllum asiaticum* Yü  
*Siphonodendron curvatum* Yü  
*Yabeella cyathophylloides* Yü
  - T296 a *Thysanophyllum* sp.
- b. Between Kolacho and Hsiassu (下司), Tushanhsien (獨山).
  - T196 *Kueichouphyllum heishihkuanense* Yü  
*Dibunophyllum minor* Yü
  - T194 *Siphonodendron chachaiense* Yü
  - T190 *Caninia vesicularis* Yü  
*Lithostrotionella kueichouensis* Yü



- Kueichouphyllum jugum* Yü  
*Kueichouphyllum heishihkuanense* Yü  
 T188 *Pseudouralinia irregularis* Yü  
 T185 *Pseudouralinia gigantea* Yü  
*Pseudouralinia irregularis* Yü  
 T184 *Pseudouralinia simplex* Yü  
*Pseudouralinia tangpakouensis* Yü  
*Lophophyllum ashfellenae* Garwood var. *regulare* Yü  
 T181 *Cystophrentis kolaohoensis* Yü  
*Cystophrentis pinnatea* Yü
- c. Near Maochai (茅寨), west of Tushanhsien.  
 T282 *Dibunophyllum changchaiense* Yü  
*Aspidophyllum maochaiense* Yü  
*Siphonodendron* cf. *irregulare* Phillips  
*Lophophyllum* sp.  
*Caninia* sp.  
 T181 *Pseudouralinia tangpakouense* Yü  
 T280a *Cystophrentis kolaohoensis* Yü
- d. W. of Lanmuch'iao (爛木橋), Tingfanghsien (定番).  
 T301 *Depasophyllum* (*Diphyphyllum*) cf. *parallelum* Yü  
 T302b *Kueichouphyllum sinense* var. *gracile* Yü
- e. West of Weichai (韋寨), Lip'ohsien (荔波)  
 T249 *Pseudouralinia tangpakouensis* Yü
- f. At Chi'aotzushih (橋子石), Kueiyanghsien (貴陽), collected by Mr. Y. L. Wang alone from a limestone 130 m. thick, regarded as the equivalent of the Shangssu limestone, and overlaid by a massive limestone containing Middle Carboniferous fossils.  
 TW 52b *Aspidophyllum maochaiense* Yü  
 TW 53 *Heterocanina lahopoensis* Yü  
 TW 52 *Clisiophyllum wangi* Yü

G. In 1930 Prof. J. S. Lee and Mr. S. Chu separated the Kinling Limestone of Lower Carboniferous age from the lower part of what was formerly called the Chihsia formation, in the neighbourhood of Chihsiasan.

Later Messrs. C. Li and S. Chu discovered another bed of Lower Carboniferous age, the Hochow (和州) Limestone, 5-15 m. in thickness, at Hochow, Anhwei province, and Lungtan, Kiangsu province. They collected from these beds a number of corals which now have come to hand except those from the Kinling Limestone. In April of this year Messrs. Huang, Chi and I collected some specimens of corals from the Kinling Ls. (Loc. No. LS. 8-10) at Chinlungshan (青龍山) near Tangshan (湯山). Although they are not well preserved, these specimens may be satisfactorily compared with *Pseudouralinia tangpakouensis*. The corals from the Hochow Limestone are well-preserved. They have been partly identified by Mr. S. Chu. The list is given below:

a. At Hochow, Anhwei (Loc. No. S)

*Yuanophyllum kansuense* Yü

*Lithostrotion portlocki* (Bronn)

*Lithostrotion mccoynum* Edw. et Haime

*Siphonodendron irregulare* Phill. var. *asiatica* Yabe et Hayas.

*Aulina* cf. *carinata* Yü

b. At Lungtan, Kiangsu (Loc. No. US)

*Yuanophyllum kansuense* Yü

*Lithostrotion portlocki* (Bronn).

### III. CORRELATION OF THE LOWER CARBONIFEROUS BEDS.

Although many Lower Carboniferous fossils have been collected by different geologists, especially by Dr. Ting, none of the sections are really complete. There are however two sections in Kueichow province, each of which gives a fairly good representation of one of the two different divisions of this period. The one at Tat'ang, (Pl. I Section 2) represents the Upper and the other to the south of Tushan (Pl. I Section 1a), the Lower Fengninian. The apparent disagreement between the upper portion of the latter and the former is no doubt due partly to discontinuous collecting, and partly to changes in facies, corals being only found in limy sediments. We will therefore discuss these 2 sections in some detail and try to correlate with them all the other sections.

A. Section 2.—This can be divided into 2 zones. The higher beds T298b—T297 yielded the genera *Depasophyllum*, *Yuanophyllum*, *Arachnolasma* etc. *Depasophyllum* was named by Prof. Grabau in 1927. It practically

belongs to the type of *Diphyphyllum*  $\beta$ , which, as stated by Dr. S. Smith<sup>14</sup>, is only known from the higher part of the zone (D<sub>1</sub> and D<sub>2</sub>). This forms the first zone. The bed 296d is characterized by *Kueichouphyllum sinense* which occurs very abundantly. *Kueichouphyllum sinense* is remarkably large in size and closely resembles *Palæosmilia purchisoni* of Europe, but can be distinguished from it by certain definite characters. So far this species has not been found either in the beds above or below. It may, in reality, constitute another zone. Because of the fact that the collection was made in a reconnaissance trip therefore necessarily incomplete, and that this form has not been met with in any other locality, it is thought preferable to put bed T296d provisionally into the first zone until further researches prove it to be deserving a separate one. The corals collected from beds T296a and T296b include the typical form *Thysanophyllum asiaticum* consisting of a columella, and some other species of *Thysanophyllum* which form the second zone. Throughout the whole section the genus *Siphonodendron* is present, which suggests that in this section at least the beds from T296a upwards are to be correlated with the European Viséan.

B. Section 1 a-b—So far beds T181—T188 have yielded no *Siphonodendron* at all. If this is substantiated, these horizons should be correlated with the Tournaisian. Bed T181, the lowest in the section, is characterized by the genus *Cystophrentis* which assumes the *Zaphrentis* form in the young but becomes vesicular in the outer margin at the full-grown stage. The different species of the genus *Pseudouralinia*, which is somewhat related to the form *Caninia cylindrica* (Scouler), prevails in the beds T184—T188. Lithologically the beds from T181 to T184 represent a single unit, and bed T184 should be grouped with T181 as one division. Nevertheless, the genus *Pseudouralinia*, so far as we know, has not been found below bed T184, therefore T174 is here included in the *Pseudouralinia* zone which thus overlaps the upper part of Dr. Ting's Kolaoho limestone. Bed T190 contains many large, well preserved specimens of *Kueichouphyllum heishihkuangense*. From the palæontological point of view this bed ought to be compared with bed T298 in the columnar section 2, for the latter yields the same species of *Kueichouphyllum* as in the bed T190. But according to the field observations of Dr. Ting, T190 should

14. Ann. and Mag. Nat. Hist. Ser. 10th, Vol. 1, p. 119.

correspond to T296d. In any case the bed T190 may be regarded as the equivalent of the beds T296d-T298. Between bed T188 containing *Pseudouralinia* and T190, there is a considerable thickness of sediments from which no fossil other than *Syringopora* was found. This may represent the *Thysanophyllum* zone in section 2. The exact position of T192, T194, T196 etc. is not certain; it may be equivalent to T190 since T196 contains also *Kueichouphyllum heishihkuanense*, but it may also be higher.

C. Section 3.—In bed T280a specimens of *Cystophrentis* were collected, while in bed T281 *Pseudouralinia tangpakouensis* was found. It is a matter of course that these beds correspond respectively to the beds T181 and T184. In the upper limestone only, bed T282 contains such corals as *Siphonodendron* cf. *irregulare* Phillips, *Dibunophyllum changchaiense* Yü, *Aspidophyllum maochaiense* Yü, etc. Since these forms can hardly be correlated with any species from the two standard sections, we can only conclude that this horizon is probably the correlative of the higher Viséan, because of the presence of *Siphonodendron* cf. *irregulare* Phill. and the genera *Dibunophyllum*, *Aspidophyllum*, the latter one being also a closely allied form of *Dibunophyllum*. So this bed may probably be compared with T297 of the section 2 or it may be a little lower.

D. Other localities in Kueichow Province.—A specimen of *Pseudouralinia tangpakouensis* was obtained from bed T249, which, of course, may be considered as the equivalent of the bed T184 of section 1.

From Tingfan (T301 & T302b) a few corals were collected. The species *Depasophyllum* (*Diphyphyllum*) cf. *parallelum* Yü comes from the upper, while *Kueichouphyllum sinense* var. *gracile* Yü comes from the lower bed. From the palæontological point of view these beds undoubtedly belong to the first zone.

Bed TW 52b may be correlated with T282 of the section 3, for both of them have furnished the same species, *Aspidophyllum maochiaense*, but stratigraphically it is higher and the occurrence of *Heterocaninia tahopoensis* contained in bed TW 53 below suggests also a higher position in the scale.

E. The Choniukou formation in Kansu.—This formation carries abundant specimens of *Yuanophyllum kansuense*. In association with this, the characteristic forms, *Aulina rotiformis* Smith, *Lithostrotion portlocki* (Bronn) and several species of *Auloclesia*, *Dibunophyllum* and *Clisiophyllum* etc. were also found. In

England *Aulina, rotiformis* Smith occurs in three beds<sup>15</sup>—the Fell Top Limestone, the Botany Beds and a high horizon in the Yoredale Series ( $D_1$ - $D_2$ ). From this, the Kansu bed may probably be regarded as not lower than the corresponding bed  $D_2$  of Europe. Though the genus *Aulocisia*, according to Lewis' statement<sup>16</sup>, is known from the bed  $D_1$  in Europe, the Chinese form is not conspecific with it. So far the Kansu forms are not found in Kueichow province except *Yuanophyllum kansuense* which occurs in bed T297 of section 2. In any case the Choniukou formation may probably represent the highest bed of the Fengninian system in China or may at least correspond to the first zone (T298b-T297) of section 2. The lower part of the Fengninian deposits of Kansu is of continental facies, and contains no fauna at all.

F. The Fengninian of Hunan.—In central Hunan many small horn-shaped corals were found in the lower part of Wanloshan Limestone. Thin sections show the structures of *Cystophrentis* as found in bed Tr8r of section 1a. The lower part of Wanloshan limestone therefore undoubtedly correspond to the Kolaoho limestone, the lowest member of the Fengninian. From the upper limestone, the so-called Lower Tzemench'iao limestone, very beautiful and well-preserved corals have been collected from different localities in central Hunan as already listed above. The majority of corals belongs to *Heterocaninia tholusitabulata* Yabe et Hayas. *Lithostrotion portlocki* (Bronn), *Yuanophyllum kansuense*, and several species of *Aulocisia* etc. Compared with the Kansu fauna, *Aulocisia* is seen to be of different species, while *Aulina rotiformis* Smith is entirely absent, being replaced by typical specimens of *Heterocaninia*. Because of the presence of the typical forms *Yuanophyllum kansuense* and *Lithostrotion portlocki*, the lower Tzemench'iao Limestone should correspond to the Choniukou formation, or it may be of a somewhat lower horizon. The Tz'ehshui series, in the middle part, contains coal seams and no marine fossils have been found therein. Mr. Tien himself regards it as lying disconformably over the Wanloshan limestone, because he finds that the Tangpakou brachiopod fauna is absent.

G. The Kinling Limestone and Hochow Limestone in Kiangsu and Anhwei provinces:—The Kinling Limestone may be correlated with bed Tr84 of section 1a in Kueichow province, for it contains also the form of *Pseudouralinia* cf. *tangpakouensis*. The Hochow Limestone, is entirely equivalent to the

15. Ann. & Mag. Nat. Hist. Ser. 9th, Vol. 16, pp. 487-490.

16. Proc. Yorks. Geol. Soc. Vol. XXI, p. 30.

Choniukou formation in horizon because of the presence of *Yuanophyllum kansuense*, *Lithostrotion portlocki*, *Aulina* cf. *carinata* etc. which are nearly of the same types as the Kansu forms.

H. The Fengninian of Kuangsi—The beds 1601, 1602 and 1633 belong to the same horizon, all containing the typical species of *Siphonodendron kuangsiense*. In these beds neither *Aulina rotiformis* Smith nor any species of *Auloclesia* and *Heterocarinia* are present, but *Arachnolasma cylindricum* var. *longicolumella* in 1602 and *Siphonodendron irregulare* Phill. var. *asiatica* in 1601 are conspecific with those from the Choniukou formation and Hochow Limestone respectively. On the whole, however, they appear to belong to a somewhat lower horizon than the Lower Tzemench'iao Limestone of central Hunan. From bed 1601 many species of *Dibunophyllum* and another *Arachnolasma* were obtained. So far the latter genus is only known from beds above T296d of section 2, so it can not be regarded as lower than that horizon. The absence of *Kueichouphyllum* is also to be noted. The beds 1621 and 1621a are considered to be a little higher than 1601, for they yield the species *Siphonodendron petaloxioides* which is also found in the higher bed T298 of section 2.

Thus the Fengninian beds of Kuangsi all belong to the middle of the Shangssu limestone. But bed 1619 found at Chiehshou below a coal series, yields a large coral with an outer vesicular zone. It has been identified as *Pseudouralinia gigantea*. The bed is undoubtedly the equivalent to T185 of section 1a.

From the above considerations we may recognize that the Fengninian system may be roughly subdivided into 4 different zones, as given below in ascending order:

- a. CYSTOPHRENTIS ZONE: This zone is characterized by *Cystophrentis kolaohoensis*, which is small in size and curved in form, being found in T181 of section 1a, T280a of section 3, and the lower part of Wanloshan Limestone in Hunan.
- b. PSEUDOURALINIA ZONE: *Pseudouralinia tangpakouensis* is the dominant form of this zone. Many other species of the same genus are also present. The beds T184, T185 and T188 of section 1a, T281 of section 3, T249, 1619 and Kinling Limestone in Kiangsu and Anhwei all belong to this zone.
- c. THYSANOPHYLLUM ZONE: Several species of this genus have been

found in section 2. One of them is named *Thysanophyllum asiaticum* which consists of the characteristic columella. Part of the beds between T188 and 190 in section 1a, those between T281 and T282 in section 3 and the Tz'ehshui series of Hunan may represent this zone.

- d. **YUANOPHYLLUM ZONE:** This zone is considered to be the uppermost zone of the Fengninian. It is characterized by *Yuanophyllum kansuense*, which is found in Kweichow, Hunan, Kansu, Kiangsu, and Anhwei provinces, being especially abundant in the Choniukou formation of Kansu province. In this zone some other typical types are also obtained such as *Aulina rotiformis* Smith, *Lithostrotion portlocki* (Bronn), *Siphonodendron* (*Lithostrotion*) *irregularis* Phill. var. *asiatica* Yabe et Hayas., *Heterocarinia tholusitabulata* Yabe et Hayas., *Kueichouphyllum heishihkuanense* Yü, *Arachnolasma sinense* (Yabe et Hayas.) and many different species of the genera *Auloclisia*, *Depasophyllum* etc. Owing to discontinuous collecting in some sections this zone can hardly be subdivided in detail. Nevertheless, it may be provisionally again separated into 3 subdivisions. The uppermost division is characterized by the genus *Aulina* which occurs in Choniukou formation of Kansu and Hochow Limestone of Kiangsu and Anhwei. In the next division *Heterocarinia tholusitabulata* Yabe et Hayas. is a very remarkable form, being abundant in the Lower Tzemenchiao Limestone of central Hunan. Bed T297 of section 2 forms the third division which has yielded *Arachnolasma sinense* (Yabe et Hayas.). Moreover, in the type section 2 bed T296d contains abundantly the typical species *Kueichouphyllum sinense* which is curved and very large, usually attaining a length of about 20 cm. This may form the lowest subdivision of this zone. The results of correlation may be summarized in the table on the page 17.

#### IV. COMPARISON OF CHINESE LOWER CARBONIFEROUS ZONES WITH THOSE OF EUROPE.

The Chinese Fengninian corals are closely related to the European Lower Carboniferous forms. In England the Avonian zones were first differentiated by A. Vaughan in 1905 as follows:



Avonian	Viséan . . . . .	Dibunophyllum zone . . . . .	{ D <sub>2</sub> D <sub>1</sub>
		Seminula zone . . . . .	{ S <sub>2</sub> S <sub>1</sub>
	Tournaisian . . . . .	Syringothyris zone . . . . .	{ C*
		Zaphrentis zone . . . . .	{ Z <sub>2</sub> Z <sub>1</sub>
		Cleistopora zone . . . . .	{ K <sub>2</sub> K <sub>1</sub>
		Modiola phase . . . . .	{ M

Since then, the zoning work has been carried on by several English and Belgian Palæontologists. The *Modiola* phase and the *Cleistopora* zone are regarded by the Belgian geologist as the equivalent of Famennian (Upper Devonian). In 1925 another new zonal name "Yoredalian" was proposed by the Committee of the British Association for the Advancement of Science as a subdivision higher than the Viséan of Belgium, in the northern English and Midland Province. The base of Yoredalian is said to be taken as the top of D<sub>2</sub> (i. e. upper D<sub>2</sub>). According to the address<sup>17</sup> of S. H. Reynolds in 1926, the *Girvanella* nodular bed forms an admirable datum line for the base of D<sub>2</sub> and the Yoredalian commences at the base of the *Orionastraea* level. All between *Orionastraea* level and the *Girvanella* bed are included in D<sub>2</sub>. The expression D<sub>2</sub> will be no more needed.

As all the Chinese Fengninian faunas have been collected only in rapid exploration trips, the work on the faunal zones can hardly be made in detail. Moreover, the Chinese forms are not wholly identical with the European species. The comparison between them has only reached the preliminary stage. In general the *Cystophrentis* zone and the *Pseudouralinia* zone would correspond to the European Tournaisian, and the *Thysanophyllum* zone, and *Yuanophyllum* zone to the Viséan, for the genus *Siphonodendron* prevails in the latter two zones but is not found at all in the former two zones. The young stage of *Cystophrentis kolaohensis*, a typical form of the *Cystophrentis* zone, is rather similar to *Zaphrentis konincki* E & H., Carruthers, which, according to S. H. Reynolds and A. Vaughan<sup>18</sup> is very abundant in Z<sub>2</sub> of the Avonian of Burrington Combe. The *Pseudouralinia* zone contains very typical forms of *Pseudouralinia* which resembles *Caninia cylindrica* (Scouler)

\* Later on Vaughan held that the dividing line of the Viséan from the Tournaisian should be drawn at the upper part of C<sub>2</sub>. (Q. J. G. S. Vol. 71, pp. 32 and 33.)

17. Report of the British Association for the Advancement of Science, 1926, pp. 65-85.

18. Q. J. G. S. Vol. 67, pp. 342-390.



Table of correlation of the Chinese Fengninian

Location	Tat'an, Kueichow	S. Tu- shan, Kueichow	W. Tu- shan, Kueichow	Tingfan, Kueichow	Lip'o Kueichow	Kuei- yang, Kueichow	Tap'u etc. Kuangai	Tzemenchiao etc. Hunan	Wuwel, Kansu	Langtan etc. Kiangsu	Hochow, Anhui
Yunno- phyllum Zone	T298b	T190	T282	T301 T302b		Tw 52b Tw 53 Tw 52	1617 1621, 1621a 1601, 1602, 1633	Pe, 260, 253, D <sub>1</sub> (L. Tzemen- chiao La.)	515-533 (Chonlukou La.)	us (Hochow La.)	8 (Hochow La.)
	T298	T192									
	T297										
	T296d										
Thysano- phyllum Zone	T296b										
	T296a										
Pseudourallina Zone		T188 T185	T281		T249		1619				
		T184									
			T280a								
Cystoph- rentis Zone		T181						267.4 (Lower part of Wanloshan La.)		Kinling La. Kinling La.	

Salée of  $C_1$  to some extent. The higher zone  $D_1$  of Europe is characterized by *Cyathophyllum murchisoni* E. and H., which, recently, has been renamed *Palzowskia murchisoni* E. and H. It bears much resemblance to the Chinese *Kueichouphyllum sinense*. So far the European characteristic forms of  $D_1$ , such as *Lonsdaleia floriformis* and *Lonsdaleia duplicata* have not been found in this country. The *Yuanophyllum* zone, however, may correspond to it because of the presence of *Aulina rotiformis* Smith, *Depasophyllum* etc. *Depasophyllum* really belongs to the type of *Diphyphyllum*  $\beta^{19}$  which is only known from  $D_1$ . In England *Aulina rotiformis* has been collected from three beds<sup>20</sup>: (1) Fell Top Limestone, only a few feet below the Millstone Grit; (2) the Botany Beds, about 200 ft. above the base of the Millstone Grit; (3) Higher horizon in the Yoredale Series ( $D_1$ - $D_2$ ). So this zone should correspond to the beds from  $D_1$  to the higher beds of the Yoredalian. A thick series of beds which lies under T296d,—the *Kueichouphyllum sinense* bed, and contains some specimens of *Thysanophyllum* etc. will probably be found to be the equivalent of S. The Chinese faunal zone, as based on the corals, may be compared with the European as follows:

The Tatang Group Upper Fengninian (Viséan)	{	Shangssu Limestone....	<i>Yuanophyllum</i> Zone .....	$D_1$ —Y
		Chiussu sandstone.....	<i>Thysanophyllum</i> zone .....	S
The Aikuan Group Lower Fengninian (Tournaisian)	{	Tangpakou sandstone...	<i>Pseudouralinia</i> zone .....	C
		Kolaohe limestone.....	<i>Cystophrentis</i> zone .....	Z

#### VI. DESCRIPTION OF SOME INDEX CORALS OF THE FAUNAL ZONES

##### Genus CYSTOPHRENTIS Yü (gen. nov.)

Corallum simple, curved, conical in young stage and sub-cylindrical toward the distal end. It is usually small in size. The epitheca is rather thick and covered with the longitudinal ridges which are again traversed by the annulations of growth. Calyx moderately deep with a very prominent fossula lying on the convex side. In the young stage it shows the typical *Zaphrentis* characters. All the septa are much thickened and retain the pinnate arrangement, the quadripartite feature being clearly shown. The longer septa reach the centre. No minor septa. A very prominent fossula is completely fringed

19. Ann. and Mag. Nat. Hist. Ser. 10th, Vol. 1, p. 119, 1928.

20. Ann. and Mag. Nat. Hist. Ser. 9th, Vol. 16, p. 489, 1925.

at the two sides by the inner ends of the septa in the cardinal quadrants, extending in the same width from the outer margin to the centre. Cardinal septum very short. When it grows larger, it assumes a very peculiar form. The septa gradually retreat toward the centre and the outer margin is replaced by the cystose structure. The septa in the cardinal quadrants, especially near the fossula, retreat inwards from the periphery much later than those in any other part. The outer zone consists of the unequal elongate vesicles, on which the discontinuous septal ridges are usually shown. The counter quadrants are much accelerated, and the septa become much thinner. But in the cardinal quadrants the septa are still much thickened and their inner ends still surround the fossula throughout the later stages. A longitudinal section, either along the concavo-convex side or the crossed direction shows that the interior is wholly filled with unequal, elongate vesicles, which slope downwards and inwards from all sides toward the centre and become nearly horizontal at the very narrow central part of the visceral chamber.

OBSERVATIONS:—This genus is somewhat related to *Uralinia* Stuckenberg,<sup>21</sup> but differs from it in having a *Zaphrentis* shape in the young, a very prominent fossula wholly surrounded by the septal ends, the septa in the cardinal quadrants much thickened throughout the whole stages, and the visceral chamber wholly occupied by the elongate vesicles. The above characters can also serve to distinguish the present form from *Caninia cylindrica* (Sculer) Salée.<sup>22</sup>

GENOTYPE:—CYSTOPHRENTIS KOLAOHOENSIS (sp. nov.)

CYSTOPHRENTIS KOLAOHOENSIS Yü (sp. nov.)

Corallum simple, curved and small in size. The thick epitheca is covered with both the transverse wrinkles and the longitudinal interseptal ridges. In the young stage (Fig. 1 b), the septa are 40 in number where the diameter of the section measures 10 mm. All the three primary septa (two alar septa and the counter) nearly reach the centre except the cardinal septum which is very short. There are eight secondary septa in each of the cardinal quadrants and ten in each of the counter quadrants. The septa are so much thickened that they are either fused with one another, or leave a very narrow space

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21. Mem. Com. Geol. Vol. X, No. 3, pp. 103, and 104.

22. A. Salée: 'Le Genre Caninia', Bruxelles, 1910, pp. 27-39, pls. II-IV.

between them. A very remarkable fossula is present, extending directly from the margin to the centre. It is wholly surrounded by the inner ends of the septa in the cardinal quadrants. The tertiary septa are absent. Up to a point about 20 mm from the lower section along the convex side, the septa in the counter quadrants first retreat and become thinner toward the center, and the outer margin is replaced by unequal elongated vesicles. Higher up towards

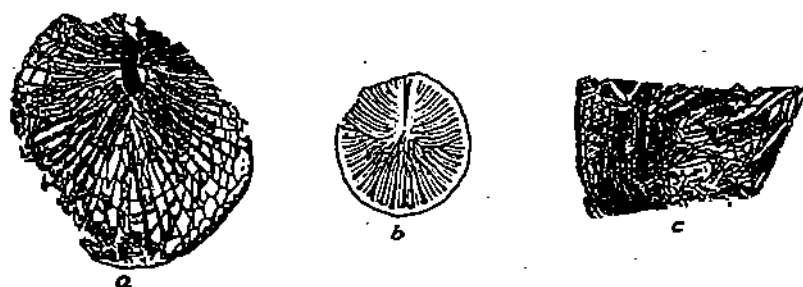


Fig. 1. *Cystophrentis kolaohensis* gen. et sp. nov.  $\times 2$ : a, cross section of full grown stage; b, cross section of young stage; c, longitudinal section along the concavo-convex direction.

the more mature stage (Fig. 1 a), all septa are enclosed by the vesicular zone and the counter quadrants are much more accelerated in development. The septa in the larger quadrants become much thinner throughout the whole length and the majority extend to the centre, while the septa in the opposite quadrants are still much thickened and border the prominent fossula with their distal ends. The counter septum remains prominent and long, and several secondaries next to it are often short. On the convex side of the vesicles the disconnected septal ridges are often shown. In the longitudinal section taken along the concavo-convex direction the unequal, elongated vesicles, which are not found in the young stage, slope downward from the concave side of the corallum towards the center with their convex side pointing inwards and upwards. As the other half at the convex side is occupied by the thickened septa, the vesicles are only seen in a few rows at the margin. When the section is made across the dorso-ventral direction, both sides are seen to be occupied by the obliquely overlapping vesicles, which are arranged nearly horizontally at the very narrow central part.

LOCALITIES: Found to the south of Kolaoho, west of Maochai of Tushanhsien, Kueichou province by Dr. V. K. Ting and at Wanloshan in

Sianghsianghsien, Hunan province by Messrs. C. C. Tien, H. C. Wang and S. Y. Kuo.

Genus URALINIA Stuckenberg

Subgenus PSEUDOURALINIA Yü (subgen. nov.)

Corallum simple, large, conico-cylindrical, curved, and slightly turbinate. The calice is rather deep. Its bottom is flat and its outer margin, thin. The epitheca is thin and encircled by the annulations of growth and concentric striæ. In the very young stage the septa are flexuous and much thickened in the cardinal quadrants. With increase in growth, the vesicular structure first appears at the outer margin of the counter quadrants, and later in the cardinal quadrants. The vesicles are always of very small size, forming two or three rows at the outer margin, but becoming larger toward the inner area. The septa in the cardinal quadrants are very short, flexuous, much thickened at the proximal ends and very thin at the distal. They are widely spaced, but sometimes are fused together because of the great thickening by stereoplasm. The counter quadrants are more accelerated. In these quadrants the septa are thin and usually prolonged beyond the centre of the section to meet the inner ends of the septa in the opposite quadrants. Sometimes only the traces of discontinuous septa are shown in the counter quadrants. Minor septa usually absent. No interseptal dissepiments are present. A cardinal fossula is usually recognizable in the more mature stage. It is flanked by the two major septa, and lies on the convex side of the corallum.

The longitudinal section shows the dissepimental vesicles restricted to the sides, while the visceral chamber is occupied by tabulæ which are either flat or convex, and coalesce with one another. They are also slightly flexuous in some specimens. When the section is made in the concavo-convex plane, the tabulæ are usually seen to rise toward the concave side. If the section is made in the transverse direction, the tabulæ are horizontal, or slightly concave at the central part and gradually ascending toward the sides. On the tabulæ the cut edges of the septa are often observed.

OBSERVATIONS:— This form resembles to a certain degree *Caninia cylindrica* (Scouler) Salée<sup>23</sup> but in Salée's specimen, a siphonofossula is present, the minor septa and the dissepiments are observed, the numerous uniform tabulæ

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23. Loc. cit.

extend nearly horizontally across the tabulate area, and both the cardinal and the counter quadrants are equally developed, which features are quite different from those of our specimen. The present form may also be distinguished from *Cystophrentis*, for the latter assumes a *Zaphrentis* type in the young stage and has a fossula completely surrounded by the inner ends of major septa. The Chinese specimen agrees with *Uralinia*<sup>24</sup> in every respect, but only differs from it in having a few rows of very small cysts always occurring at the outer margin of the vesicular zone, a fossula which is not funnel-shaped, and the tabulæ ascending toward the concave side. These characters are quite sufficient to separate it as a subgenus of the Russian form.

GENOTYPE:—*PSEUDOURALINIA TANGPAKOUENSIS* Yü (sp. nov.)

*PSEUDOURALINIA TANGPAKOUENSIS* Yü (sp. nov.)

Corallum simple, large, curved and turbinate in form. The epitheca is marked by the annulations of growth and the longitudinal striæ. The calyx is deep, and thin at its margin. At the section of 10 mm in diameter there are 13

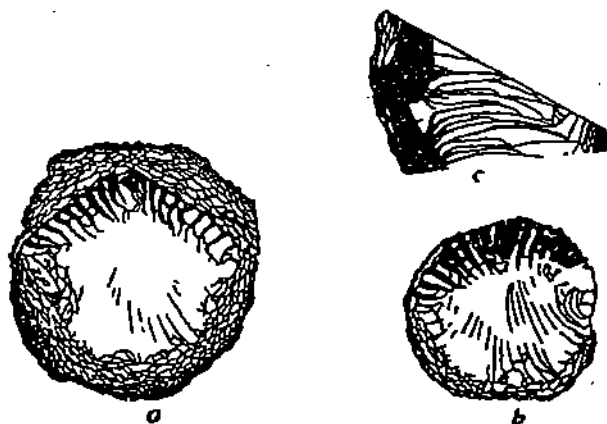


Fig. 2. *Pseudouralinia tangpakouensis* subgenus et sp. nov. x 1: a, cross section of the adult stage; b, cross section of the mature stage; c, longitudinal section.

septa in the cardinal quadrants and 17 in the counter. The septa in the cardinal quadrants are much thickened by stereoplasmic deposit, while those in the opposite quadrants are very thin. All the septa fall short of the centre. The minor

<sup>24</sup>. Loc. cit.

septa are absent. Up to the stage in which the corallum has a diameter of about 20 mm, 15 major septa occur in the cardinal quadrants and 19 in the opposite quadrants. In the minor quadrants the septa are very short, flexuous, and much thickened. They all extend outwards to the epitheca. The thin septa in the larger quadrants are first replaced by the vesicles at the outer margin and stretch centrally to connect with the distal ends of the thickening septa at the opposite side. At the point where the section is 26 mm in diameter, the septa in the cardinal quadrants also begin to withdraw from the margin. From this stage upwards, the major septa are completely restricted to the inner area. The vesicular zone consists of nearly equal, elongate vesicles and always begins with a few rows of very small vesicles at the outer margin throughout the whole stages. Moreover, the characters of the thickened short flexuous septa in the cardinal quadrants and the thin long septa at the opposite side also remain almost constant. But in some specimens of the same species the septa in the counter quadrants are not even observed, being wholly replaced by the cut edges of tabulae which transversely cross the open space.

In the longitudinal section taken along the concavo-convex direction, the dissepimental vesicles are arranged at the sides, and the slightly convex tabulae extend nearly horizontally across the tabulate area. The tabulae are irregularly spaced and often coalesce with one another. On the whole the convex tabulae often rise toward the concave side.

LOCALITIES:—This species was collected from the region 1.5 li south of Kolaoho Bridge, and the region 2 li west of Maochai, Tushan, Kueichow province. Collected by V. K. Ting

Genus *PALÆOSMILIA* Edw. and Hai.

Subgenus *KUEICHOUPHYLLUM* Yü (subgen. nov.)

Corallum simple, very [large, conico-cylindrical, curved and turbinate. The epitheca is thin and covered with the encircling striae and the annulations of accretion. The calice is not clearly observed. The cross section of the corallum appears to be circular in form. The septa are very numerous, being about 100 in each cycle when the longer diameter is about 50 mm. The major septa mainly fall short of the centre. The minor septa are well-developed, attaining a length of  $1/3 - 1/2$  that of the major septa. The dissepiments are regularly

and concentrically arranged and rather crowded. All the septa are thin at the extrathecal region and become thicker at the intrathecal area. In some forms the septa are much thickened at the intrathecal area of the cardinal quadrants. A very remarkable fossula is present. In the longitudinal section the sides are occupied by a broad zone of vesicular tissue, which is composed of 10-26 rows of convex cells facing inwards and upwards. At the inner area the tabulæ turn into the arched vesicles and all rise toward the centre with their convex side upwards and outwards.

**OBSERVATIONS:**—As shown in the transverse section there are two bands lying essentially on opposite sides of the centre. Their position is quite variable, occupying either the position of the alar septa or assuming other locations. Close examination shows that the bands are entirely composed of the crowded septa which have been much shattered into small broken fragments. This feature is probably due to the fact that the septa are very thin<sup>25</sup> so that they can be easily deformed by any compression of the fossiliferous beds.

As to the generic characters the present form is distinguished from either *Cyathophyllum* Goldfuss or *Strephodes* M'Coy in having small vesicular tabulæ, the stereoplastic thickening of the septa at the intrathecal region, more numerous septa, and a more prominent fossula. Our form may be compared with *Caninophyllum* Lewis<sup>26</sup> in some respects, but the latter form has the uniform horizontal tabulæ at the tabulate area, the less numerous septa and some other characters which are quite different from those of the Chinese specimen. The only form nearest to ours is *Palæosmilæa* Edw. and Haime<sup>27</sup>. But the present specimen also differs from it in the thickening of the septa in the intrathecal area, the vesicular tabulæ which ascend markedly toward the centre, the more numerous septa, and a more prominent fossula. These features are sufficient to differentiate it as a new subgenus of *Palæosmilæa*.

**GENOTYPE:**—*KUEICHOUPHYLLUM SINENSE* Yü (sp. nov.)

*KUEICHOUPHYLLUM SINENSE* Yü (sp. nov.)

Corallum simple, conico-cylindrical, curved and slightly turbinate. It is very large, measuring more than 20 cm. along the convex side. The epitheca

25. Benson and Smith also stated that the septa and epitheca are thin in the forms having numerous septa. Q. J. G. S. Vol. 79, p. 163, foot note 2.

26. Ann. and Mag. Nat. Hist. Ser. 10th, Vol. III, pp. 456-467, pls. XI and XII.

27. Edwards and Haime; Ann. Sc. Nat. 3me Serie, Vol. X, p. 467, 1848.



is not very thin and encircled by the striæ and annulations of growth. The section is commonly deformed into sub-elliptical shape and is usually marked by two bundles of very crowded shattered septa at the two ends along the direction of the longer diameter. The septa are very numerous, about 108 in each cycle at a section of 56 mm. in longer diameter. The majority of them reach the centre. All the septa are very slender and sometimes slightly flexuous in the extrathecal region and thickened by stereoplasm in the intrathecal area. The septa are much thickened especially in the cardinal quadrants and nearly fused with one another. The outer zone is very broad. The dissepiments are regularly spaced and more crowded toward the theca, forming about 26 concentric rings in the same section. The minor septa are much longer, about  $\frac{1}{2}$ - $\frac{3}{4}$  the length of the major septa, and always extend for a short distance

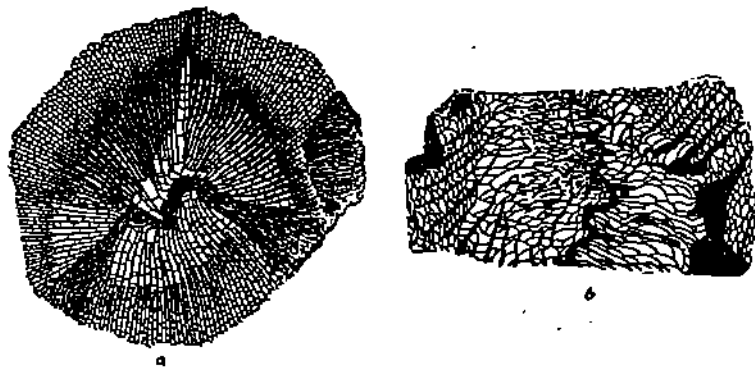


Fig. 3. *Kuelichouphyllum sinense* subgenus et sp. nov.  $\times 1$ ; a, cross section of the more mature stage; b, longitudinal section.

into the intrathecal area. A very prominent fossula is present. In the longitudinal section the dissepimental zone is occupied by nearly equal vesicles and the tabulate area by the tabulae which have wholly changed into the elongate arched cells. These vesicular tabulae are arranged nearly horizontally at the intermediate area of the section and become ascending toward the central imaginary axis at the central portion.

OBSERVATIONS:— *Cyathophyllum sorrowinum* as described by Reed (Palæozoic and Mesozoic Fossils from Yunnan, p. 30, pl. v, figs. 4 and 4a) is quite congeneric with the present type but not conspecific, for in the latter form the tabulæ are highly arched and rising toward the centre, and the major septa are more than 100 at a section of 50 mm. in diameter, while Reed's specimen has only about 60 major septa in a diameter of 45-50 mm. and nearly horizontal and scarcely arched dissepiments inside the outer zone.

LOCALITY: 3 li W. of Jungtung, Tingfan, Kueichow province. Coll. V. K. Ting.

Genus YUANOPHYLLUM Yü (gen. nov.)

Corallum simple, large, curved and slightly turbinate. In some specimens it is cornute proximally and cylindrical distally. The calyx is deep with a small projection at the centre of its base. The major septa are commonly thickened within the intrathecal region, especially in the cardinal quadrants. The counter septum is always prolonged to the centre to form a columella. It is usually flexuous, slightly thickened at the centre and often twisted with some other longer septa. The minor septa are very short. The dissepiments are arranged mainly angulo-concentrically. The dissepimental zone is rather broad, attaining a thickness of about  $\frac{1}{2}$  the major septa at the adult stage of some specimens. A very distinct fossula is present. The inner ends of the major septa often turn aside in one direction. The pseudocolumella in the longitudinal section is usually flexuous vertically and also discontinuous in some specimens. The central part of the visceral chamber is wholly filled with vesicular tabulæ

OBSERVATIONS:— This genus may be compared with *Heterocaninia* Yabe and Hayasaka,<sup>28</sup> but in the latter the major septa are much more numerous, the counter septum does not extend to the centre as a pseudo-columella, and the corallum is much larger. It also resembles *Koninckophyllum* Thomson and Nicholson<sup>29</sup> in many respects, but the pseudo-columella in our form is simply the prolongation of the counter septum and has never been separated as a styliform pseudo-columella as in *Koninckophyllum*. Furthermore, in *Koninckophyllum* the septa always fall short of the centre by a considerable space, and

28. Palæontology of Southern China, pl. XI, figs. 2a-d.

29. Ann. & Mag. Nat. Hist. Ser. 4th., vol. XVII, pp. 297-300.

are not greatly thickened at the intrathecal area of the cardinal quadrants, while the reverse is the condition in the present type.

GENOTYPE:—*YUANOPHYLLUM KANSUENSE* Yü (sp. nov.)

*YUANOPHYLLUM KANSUENSE* Yü (sp. nov.)

Corallum simple, conical and slightly turbinate in the young stage and tending to be cylindrical distally. The epitheca is moderately thick. The striae and many strong annulations of growth are observed upon its surface. The calice is rather deep and its floor is occupied by a small projection at the centre. A fossular depression is often seen at its edge on the convex side. In the earlier stage a pseudo-columella, which is the prolongation of the counter septum, is much thickened at the centre and connected with the cardinal septum. All the septa are also very thick and extent to the pseudo-columella. On increasing somewhat in size, the pseudo-columella is reduced in thickness and becomes separated from the cardinal septum. The other septa also retreat from the centre, and become thinner, especially at their inner ends in the counter quadrants. In the mature stage the major septa mostly stop short of the centre and their distal ends all turn aside in one direction. They are about 42 in number at a diameter of 23 mm. The counter septum is still prolonged centrally

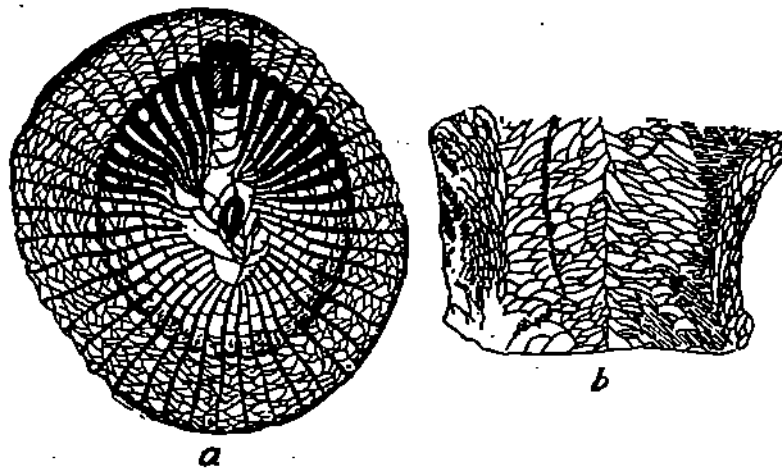


Fig. 4. *Yuanophyllum kansuense* gen. et sp. nov.  $\times 2$ : a, cross section of more mature stage; b, longitudinal section.

as a pseudo-columella. It is slightly thickened and usually flexuous, being sometimes twisted with some other major septa which also extend to the centre. The

minor septa are very short. The dissepimental zone is broad, about half the length of the major septa. It consists of the crowded dissepiments in herring-bone arrangement. The septa are very thin at the outer margin of the extrathecal area and slightly thickened by the stereoplasm toward the theca. When they come within the intrathecal region, all of them are much thickened, especially in the cardinal quadrants. A prominent fossula occurs on the convex side. The pseudo-columella as shown in the longitudinal section is usually straight in the earlier stage and zigzag in the mature stage. The vesicular tabulæ are disposed horizontally, or very slightly ascending toward the pseudo-columella. The outer zone consists of the convex dissepimental vesicles, with their convexity pointing upwards and inwards at the margin, and nearly inwards near the theca.

**OBSERVATIONS:**—The longitudinal section shows that the pseudo-columella is sometimes discontinuous or slightly shifting aside for a short distance in some places. This feature is probably due to the fact that the prolongation of the counter septum is flexuous not only horizontally, but also vertically.

**LOCALITIES:**—This species is very abundant in the Choniukou formation at Wu-wei-hsien in Kansu province. Coll. P. L. Yuan. It was also found by V. K. Ting in Kueichou, C. C. Tien in Hunan and J. S. Lee and S. Chu in Kiangsu and Anhwei respectively.

Genus *HETEROCANINIA* Yabe and Hayasaka.

Corallum simple, large, curved, cornute in the earlier stage and greatly expanding toward the superior end. The epitheca is marked by the annulations of accretion. It is very thin. When it is not preserved, the pinnate arrangement of septa is clearly shown on the outside of the corallum. As examined on the transverse section a very prominent fossula is present and lies on the convex side of the corallum. The septa are very numerous about 115 in each cycle at a diameter of 46 mm. The major septa are straight, but become somewhat flexuous at their distal ends. They stop usually short of the centre, but some of them extend centrally to meet with one another. The minor septa are commonly not preserved. In a well-preserved specimen they are shown to be of very slight length. In the extrathecal region the dissepiments are arranged concentrically and angulo-concentrically. The dissepimental zone

is very narrow near the fossula and becomes broad toward the opposite side. All the septa are thin in the extrathecal area, but thickened within the intrathecal region. In the cardinal quadrants the major septa are always much thickened by stereoplasm at the intermediate zone. They are nearly fused together and only very narrow slits are seen between them.

In the longitudinal section the outer zone is crowded with many rows of unequal vesicles, their convex surface pointing inwards and slightly upwards. The central part of the visceral chamber is wholly occupied by the vesicular tabulæ which rise strongly toward the central imaginary axis.

OBSERVATIONS.—This genus was created in 1920 by Yabe and Hayasaka. Only one species was figured in the Palæontology of Southern China, Pl. XI, but it has not previously been described. Mr. C. C. Tien has also collected, from Hunan, many specimens of a coral congeneric with Yabe and Hayasaka's specimen. Among these there is one form exactly the same in every respect as that figured by Yabe and Hayasaka. It will be regarded as the genolectotype of the present genus. This genus is characterized by the much more numerous septa, the longer major septa meeting at the centre, the very short minor septa and the arched tabulæ ascending toward the centre throughout all the stages. The above characters distinguish this genus from the closely allied genera *Caninophyllum* Lewis,<sup>30</sup> *Pseudocaninia* Stuckenberg<sup>31</sup> and *Kucichouphyllum* Yü.

GENOLECTOTYPE:—*HETEROCANINIA THOLUSITABULATA* Yabe and Hayasaka.

*HETEROCANINIA THOLUSITABULATA* Yabe and Hayasaka.

1920. *Heterocaninia tholusitabulata* Yabe and Hayasaka, Palæontology of Southern China, Pl. XI, Figs. 2a-d.

Corallum simple, curved, conical in the young stage and enlarging upwards very rapidly. It measures about 90 mm. along the convex side. The thin epitheca, on which only the annulations of accretion are seen, is often not preserved and the pinnate arrangement of the septa is clearly shown at the cardinal and alar sides on the surface of the corallum. In an adult stage 113 major septa are counted at a diameter of 45 mm. The minor septa are very short and only observed in the well-preserved specimens. The extrathecal

30. Ann. & Mag. Nat. Hist. Ser. 10th., vol. III, p. 456, 1929.

31. Ann. & Mag. Nat. Hist. Ser. 10th., vol. VII, p. 225, 1931.



Fig. 5. *Heterocaninia tholusitabulata* Yabe et Hayasaka.  $\times 1$ : a, cross section of adult stage; b, longitudinal section.

zone is composed of the dissepiments in herring-bone and concentric arrangement. They are more crowded toward the theca. The dissepimental zone is variable in thickness, being very narrow at the fossula and broadest in the opposite quadrants near the alar septa. In general the concentric dissepiments are arranged in from 5-20 rings. The septa are thin in the extrathecal region and thickened in the intrathecal area. But in the cardinal quadrants they are always much thickened at the intermediate zone and only very narrow slits are left between them. The major septa are straight and usually stop some distance from the centre. But some of them are long and flexuous at their distal ends, and extend to meet one another in the central part of the section. In longitudinal section the dissepimental vesicles of unequal size accumulate at the sides and the elongate vesicular tabulae in the central area. The latter rise steeply toward the centre which appears to be very vesicular.

LOCALITIES: From the Lower Tzemenchiao Limestone at Ho-ch'ang-ping, Pao-ching-hsien and Tze-men-chiao, Siang-hsiang-hsien, Hunan province. Coll. C. C. Tien.