DATE DUE

Interlibrary Loan			
GAYLORD			PRINTED IN U.S.A.

GEOLOGICAL SURVEY OF CHINA

V. K. TING AND W. H. WONG DIRECTORS

Palæontologia Sinica

EDITORS:

V. K. TING AND W. H. WONG

Series B. Volume 1

Fascicle 1.

ORDOVICIAN FOSSILS FROM NORTH CHINA

BY

AMADEUS W. GRABAU S. D.

Palæontologist to the Survey and Professor of Palæontology
in the National University, Peking.

PLATES I-IX, 20 TEXT FIGURES

古生物誌

地質調查所

PEKING 1922.

Palæontologia Sinica.

中 國 古 生 物 誌

SERIES A. FOSSIL PLANTS OF CHINA.

VOL. I.

Fascicle 1. Zur alttertiären Flora der südlichen Mandschurei, von Rudolph Florin (Riksmuseum, Stockholm, Sweden) 46 pages text, 1 plate, 3 text-figures. (In press).

Other numbers of this series now in preparation will contain descriptions and illustrations of the Palæozoic and Mesozoic Floras of China by Dr. Th. G. Halle and associates in the Palæobotanical Department of the Riksmuseum Stockholm, Sweden, based on extensive collections made by the Geological Survey and associate collectors.

SERIES B. FOSSIL INVERTEBRATES OF CHINA.

VOL. I.

Fascicle 1. Ordovician Fossils from North China, by A. W. Grabau. 127 pages text, 9 plates, 20 text-figures. Published April 28, 1922. Price $5.00 Mex.

Fascicle II. Devonian Fossils of Yunnan by A. W. Grabau. (In preparation).

VOL. II.

Palæozoic Corals of China, Part I. The Tetraseptata, by A. W. Grabau.

Fascicle 1. Introduction, and descriptions of *Petraiidæ*, *Streptelasmaidæ* and *Cyathaxonidæ* with 1 plate and 74 text-figures. (In press).

Fascicle II. *Zaphrentidæ* and *Cyathophyllidæ*. (In preparation).

SERIES C. FOSSIL VERTEBRATES OF CHINA.

This series will contain descriptions and illustrations of Tertiary and Quaternary vertebrates of China, by Prof. Carl. Wiman of Uppsala, Sweden, Prof. M. Boule of Paris, and others, based on large collections made by Dr. Andersson and others for the Survey and by other organisations and private individuals.

SERIES D. ANCIENT MAN IN CHINA.

VOL. I.

Fascicle 1. The Cave-deposit at Sha-Kuo-T'un in Fengtien (in preparation).
Article 1. Topographic notes and description of artifacts by J. G. Andersson.
Article 2. Human skeletal remains by Davidson Black.

Series B. *Vol. I. Fascicle 1.*

PALÆONTOLOGIA SINICA.

Editors:

V. K. Ting and W. H. Wong

Ordovician Fossils of North China.

BY

AMADEUS W. GRABAU S. D.

Palæontologist to the Survey and Professor of Palæontology in the National University Peking.

With Plates I IX and 20 Text figures

古生物誌

地質調查所

Published by the Geological Survey of China

Peking 1922.

G

PUBLISHED APRIL 28, 1922

Printed by
THE COMMERCIAL PRESS.
PEKING.

CONTENTS:

Pour bien savoir une chose, il faut en savoir les détails.

La Rochefoucauld.

ORDOVICIAN FOSSILS FROM NORTH CHINA.

BY

A. W. GRABAU.

INTRODUCTION.

In his classical work on China, Ferdinand von Richthofen classified the great limestone formations which underlie the coal-bearing series of north China as "Kohlen-kalk" and referred them to the Carboniferous Limestone of Europe. In this he was not altogether wrong, for we now recognize the existence of Lower Carboniferous (Dinantian) limestones in north China, which carry many elements of the Carboniferous Limestone fauna of western Europe.

The greater part of the limestone series here under consideration was expressly excluded by v. Richthofen from his Sinian System which comprised the Cambrian and older rocks. It and a part of the rocks included in the Sinian are now known to be of Ordovician age, as was indeed recognized by Frech, who in the fifth volume of v. Richthofen's monumental work, published in 1911, described two specimens of *Actinoceras*, (*A. richthofeni* Frech) collected by von Richthofen in Manchuria, and correctly referred them to the Upper Ordovician. Frech further recognized that this form was similar to, or even identical with, a species of *Actinoceras* from Canada which was figured by Barrande under the name *Actinoceras richardsoni* Stokes. Frech also described a fragmentary gastropod collected by von Richthofen in the same strata, and referred it tentatively to *Raphistoma æquilaterum* Koken which occurs in the Chasmops-Kalk (Upper Ordovician) of western Europe. He also notes the occurrence of specimens of *Actinoceras* sp. and *Trochoceras* sp, from Shantung, in the British Museum, together with *Dalmanella* cf. *testudinaria* (p. 8).

Previous to the appearance of Frech's monograph, G. C. Crick (1903) had described and figured several specimens of *Actinoceras* obtained by the Rev. Samuel

Couling from the neighborhood of Tsingchou-Fu, Kiaochow, Shantung. Crick however did not identify his specimens specifically, referring to one as closely allied to *Actinoceras* (*Ormoceras*) *tenuifilum* Hall from the Black River formation of New York, and to another as possibly representing the genus *Gonioceras*, a reference which now appears to be probably correct. Besides the cephalopods, Crick mentioned the occurrence of several small brachiopods. According to Buckman "the general appearance suggests *Orthis* (*Dalmanella*) *testudinaria* Dalman, an Ordovician species" *). This is the first published demonstration of the Ordovician age of these limestone in north China. In 1906 Th. Lorenz ** described the following species from the Ordovician of Shantung the first three from Ho-shan the fourth from Santefan.

1. *Asaphus bohmi* Lorenz.
2. *Maclurea logani* Salter.
3. *Hyolithes* sp.
4. *Plectambonites sericeus* (Sowerby).

Frech (in Richthofen V p. 14) referred the first three of these to the Middle Ordovician the fourth to the Upper Ordovician.

In their investigations of the geology of parts of northern China which appeared before Frech's monograph, Bailey Willis and Elliott Blackwelder (in 1903-1904) recognized that the greater part of von Richthofen's Kohlenkalk was to be referred to the Ordovician. Professor Stuart Weller, of the University of Chicago, who studied the fossils collected by Blackwelder, recognized the existence of the cephalopod genus *Orthoceras*, the gastropods *Maclurea?* or *Helicotoma?* and *Lophospira*, the trilobite *Asaphus?*, and the brachiopods *Strophomena* and *Orthis* (*Dalmanella?*) in the Ordovician rocks of Shantung but he was unable to make specific determinations because of the poor state of preservation of the fossils. He however described a number of species collected by Blackwelder in the Yangtze region (south China) *** and recognized their affinities with European Middle Ordovician species. Previously, several authors had described Ordovician fossils from south China among them S. P. Woodward (1856) Kingsmill (1869) and Grieve (1887). The first described the well-known "Pagoda stone" as *Orthoceras* sp. and this was later redescribed by Foord as *Orthoceras chinense* Foord (1888). Kayser and Frech also described a number of Ordovician species from southern China, (v. Richthofen Vols. IV and V) and a number of these have since been redescribed with others by H. Yabe and I. Hayasaka in their work "Palæontology of South China" (1920). Several Ordovician species from south China were also described and recorded

*) Crick loc. cit p. 483.

**) Beiträge zur Geologie und Palæontologie von Ostasien, pt II pp 84-90 pl VI.

***) For stratigraphic studies the Yangtzekiang forms the approximate dividing line between North and South China.

by Martelli (1901) Mansuy (1902) Brown (1913) and G. Pellizzari (1913).

In all these studies however, only one new species was recognized in addition to the *Actinoceras* from the Ordovician of north China, namely *Asaphus bœhmi* Lorenz from Shantung, though a number of generic determinations were made and a few forms identified with European species. *Actinoceras richthofeni* has remained up to the present the only specifically identified cephalopod known from the Ordovician of north China, but this species was definitely known only from Manchuria.

During the progress of investigations carried on by the Geological Survey of China, a considerable number of specimens of *Actinoceras* was obtained from the provinces of Chihli and Shantung. Material was also sent to the Survey by residents in various districts. Only a few other fossils were however obtained. Early in the present year some additional species were obtained from Tangshan in the Kaiping coal basin by Messrs. Fred. K. Morris, Geo. B. Barbour and A. C. Terrill, and later, a survey expedition, in charge of the author, began a systematic study of the stratigraphy of certain parts of the Kaiping basin. The party included Professor George B. Barbour of Yenching college (Peking Christian University) and Messrs. Y. C. Sun and S. C. Chean of the Survey. In the field we were joined by Dr. F. F. Matthieu, Geologist of the Kailan Mining Administration and Mr. Jacques Gerard engineer and geologist of the Chaokouchuang mines and later by Mr. C. H. Huang of the Machiakou mining staff *). The greater part of the fossils from the upper beds herein described was collected at that time.

The discovery of the Lower Ordovician fauna of the Ching-wang-tao region north of the Kaiping basin is to the credit of Dr. F. F. Matthieu who placed the material in my hands for description, and with true scientific spirit has deposited the types and illustrated specimens in the museum of the Survey, where they are accessible to all students and specialists.

The Ordovician species at present known from north China comprise 31 genera

---

*). It gives me great pleasure to acknowledge the uniform courtesy and helpfulness of the officers of the various mines notably M. Alexandre Doquier Chief of Staff Tangshan, M. Maurice Derwiduee Chief engineer of the Chaokouchuang mines and Mr. Ch. P. Huang, Chief engineer of the Machiakou mines. To Messrs. Matthieu, Gerard and C. H. Huang we are also greatly indebted for efficient aid and guidance in our field-work, and to the first for placing at my disposal collections previously and since then made by him, especially in Shantung, and from the Lower Ordovician beds of the Chingwangtao region of east Chihli, this lower fauna having been discovered by him. To Mr. W. S. Nathan president of the Kailan Mining Administration special acknowledgments and thanks are gladly tendered for his courtesy in giving us unlimited opportunity to study the mines and properties in the Kaiping basin under his control, and for putting at our disposal housing accomodations, transportation and mechanical assistance.

and 58 species 45 of these being specifically identified.* All except five of the species are new. Three new genera, and a new family of cephalopods, that of the *Chihlioceratidae* are described.

STRATIGRAPHIC SUMMARY.

Willis and Blackwelder applied the name *Tsinan formation* to the entire Ordovician series of North China, which they regarded as a unit. The name was taken from Tsi-nan-fu in Shantung near which the upper beds of the series are well exposed. It is now known that there are several Ordovician formations in north China, with probably a disconformity between the higher and the lower divisions. The base of the Ordovician has been definitely located in the vicinity of the little hamlet of Yehli, about 9 li or about 3.6 miles east-north-east of Machiakou in the Kaiping Coal Basin. Here the Ordovician beds rest disconformably upon the Upper Cambrian or Cambro-Ordovician transition beds, the *Fêngshan formation*, which carries a fauna recalling the *Ceratopyge* fauna of Europe, including a new species of *Ceratopyge*. The disconformity is marked by an irregular erosion surface of the Fêngshan formation followed by a basal conglomerate which marks the beginning of the Ordovician limestones **).

To the limestone immediately succeeding this basal conglomerate we have given the name *Yehli formation*, and from it the following species have been obtained.

CEPHALOPODA

Sucoceras yehliense Grabau

Sucoceras attenuatum Grabau

Extremely meager as this fauna is, it is sufficient to indicate early Ordovician, but whether it is Lower or early Middle Ordovician must for the present remain undetermined. The limestones of this region have a total thickness, according to the measurements of Mr. H. C. T'an, of approximately 800 meters, but whether this series is continuous or separated into two divisions by a hiatus, has not yet been ascertained.

UPPER ORDOVICIAN

The upper beds of the Ordovician of the Kaiping basin are well exposed at Machiakou, south-west of Yehli, and from this locality the formation is named the *Machiakou division* or Machiakou formation. This is the typical *Actinoceras limestone*, widely exposed in the Kaiping basin from Chaokouchuang on the east to Tangshan on the west. It is again known by fossils from the Western Hills of Peking, from the Shansi border,

*) This includes two varieties. Two others have been tentatively referred to known species.

**) This will be described by the author in the Bulletin of the Geological Survey.

from south Chihli, from various parts of Shantung and from Manchuria. The fossils so far obtained from it occur in the upper 10 to 15 meters, but it must be clearly understood that over this entire region of its known-exposure it has suffered pre-Carboniferous erosion, and that beds of late Palaeozoic age usually Lower Carboniferous or Dinantian, but sometimes Upper Carboniferous or Uralian and in some cases perhaps Permo-Carboniferous beds rest upon them. Thus the fossiliferous upper beds are probably not always of the same horizon, though it is possible that *Actinoceras* may have only a limited vertical range, in which case the pre-Carboniferous erosion over wide areas was relatively uniform in amount.

FAUNA OF THE MACHIAKOU OR ACTINOCERAS LIMESTONE

The following species have been obtained from the upper part of the Machiakou or Actinoceras limestone *).

BRACHIOPODA

1 *Orthis calligramma* Dalm. var. *orthambonites* (de Vern.), Chihli
* 2 *Orthis?* sp., Shantung (Weller)
* 3 *Dalmanella* cf. *testudinaria* Dalm., Shantung (Crick, Frech)
4 *Strophomena* cf. *incurvata* (Shepard), Chihli
* 5 *Strophomena* sp., Shantung (Weller)
* 6 *Plectambonites sericeus* (Sow.), Shantung (Lorenz)

PELECYPODA

7 *Ctenodonta symmetrica* Grabau, Chihli

GASTROPODA

* 8 *Maclurea?* or *Helicotoma?* sp., Shantung (Weller)
* 9 *Maclurea logani* Salter, Shantung (Lorenz)
10 *Eccyliopterus kushanensis* Grabau, Chihli
11 *Eccyliomphalus tangshanensis* Grabau, Chihli
12 *Lophospira morrisi* Grabau, Chihli
13 *Lophospira pulchelliformis* Grabau, Chihli
14 *Lophospira trochiformis* Grabau, Chihli
15 *Lophospira acuta* Grabau, Chihli
16 *Lophospira gerardi* Grabau, Chihli
17 *Lophospira gerardi* var. *laxa* Grabau, Chihli

---

*). The species proceded by and asterisk are recorded by Crick, Weller, Lorenz, Frech etc. from Shantung and one No. 34, from Manchuria. All of these, except the last, I have not seen.

18 *Lophospira terrassa* Grabau, Chihli
19 *Lophospira obscura* Grabau, Chihli
* 20 *Lophospira* sp., Shantung (Weller)
21 *Pagodispira derwiduii* Grabau, Chihli
22 *Pagodispira dorothea* Grabau, Chihli
23 *Pagodispira dorothea* var. *laxa* Grabau, Chihli
24 *Liospira barbouri* Grabau, Chihli
* 25 *Liospira* sp. (*Raphistoma* cf. *aequilaterum* Koken, Frech), Manchuria (Frech)
26 *Salpingostoma terrilli* Grabau, Chihli

CONULARIDA

* 27 *Hyolithes* sp., Shantung (Lorenz)

CEPHALOPODA

28 *Vaginoceras tsinanense* Grabau, Chihli
* 29 *Orthoceras* sp. (several), Shantung (Weller)
30 *Cycloceras? peitoutzense* Grabau, Chihli
31 *Stereoplasmoceras pseudoseptatum* Grabau, Chihli, Shantung
32 *Stereoplasmoceras machiakouense* Grabau, Chihli, Shantung
33 *Stereoplasmoceras actinoceriforme* Grabau, Chihli
34 *Actinoceras richthofeni* Frech, Chihli, Shantung, Manchuria (Frech)
35 *Actinoceras tani* Grabau, Chihli, Shantung
36 *Actinoceras coulingi* Grabau, Shantung (Crick), Honan, Chihli
37 *Actinoceras suanpanoides* Grabau, Shantung
38 *Actinoceras submarginale* Grabau, Chihli
39 *Actinoceras nanum* Grabau, Chihli
40 *Actinoceras curvatum* Grabau, Shantung
41 *Cyrtactinoceras frechi* Grabau, Chihli, Shantung
42 *Gonioceras shantungense* Grabau, Shantung
* 43 *Trochoceras* sp., Shantung (Frech)

TRILOBITAE

44 *Asaphus bedmi* Lorenz, Shantung (Lorenz), Chihli
45 *Asaphus?* sp. or *Isotelus* sp., Chihli
* 46 *Asaphus?* sp., Shantung (Weller)

A consideration of this fauna clearly shows it to be of early Upper Ordovician age corresponding to the fauna of the Black River limestone of New York and Canada and to the early Trenton beds of the central and eastern United States and Canada. Although no species can be said to be absolutely identical, (except perhaps *Actinoceras richthofeni*, with which is identified a specimen figured by Barrande from Canada *) still the majority are representatives of species occurring in the American early Upper Ordovician formations, and indeed, in some cases these Chinese species are hardly more than geographical varieties of the American forms. As such they indicate a very close correspondence of horizons. The presence in our Chinese fauna, of forms closely analogous to species found in the Stones River or upper Middle Ordovician of North America, indicates that the horizon is to be regarded as at the boundary-line between Middle and Upper Ordovician. Thus it is quite safe to correlate the *Actinoceras* horizon essentially with the Black River formation of North America. How much of the underlying series of limestones represents Middle Ordovician and what part is of Early Ordovician age, cannot at present be determined.

The only European form I have noted in addition to those recorded by Crick, Lorenz and Frech, is *Orthis calligramma* variety *orthambonites*, of the type figured by de Verneuil from Russia.

LOWER ORDOVICIAN.

Undoubted Lower Ordovician fossils were discovered by Dr. F. F. Matthieu in the Shi-mun-chai region northwest of Ching-wang-tao in northeastern Chihli. The stratigraphic succession here is as follows according to Dr. Matthieu.**)

CARBONIFEROUS FORMATION

(Great hiatus and disconformity)

ORDOVICIAN FORMATION

Liangchiashan formation		275 m.
Gray massive more or less dolomitic limestone with fossiliferous horizon (F3) 53 m. below the top.	129 m.	
Limestone conglomerate (intraformational)	1 m.	
Gray massive limestone	118 m.	
Conglomeratic limestone, grayish blue	1 m.	
Pale grayish limestone in thin layers	26 m.	
Shihmunchai formation		155 m.
Interstratified sill	6 m.	

*). The presence in this limestone in Shantung of *Dalmanella* cf *testudinaria* and *Plectambonites sericeus* as recorded by Crick, Lorenz and Frech also suggests early Trenton, while *Maclurea logani* recorded by Lorenz again suggests the Black River, being known from that horizon in Canada as well as from Europe.

**). The stratigraphy of this region will be more fully discussed by Dr. Matthieu in a forthcoming Bulletin of the Survey.

Shales and shaly limestones, yellowish gray to violet...	79 m.
Brownish and red limestone conglomerate	5 m.
Platey limestone	17 m.
Interstratified sill	7 m.
Shales and shaly limestones	22 m.
Limestone	5 m.
Brown shales and calcarenytes	13 m.
Brownish-red limestone conglomerate	1 m.
Peilintze formation (exposed)	95 m.
Oölitic limestone	23 m.
Bluish black massive limestone with fossil horizons F2, 10 meters and F1, 33 meters below the top	72 m.
Base not exposed	
Total exposed thickness of Ordovician	525 m.

The most significant fact revealed by the study of this section is the absence of the Machiakou or Actinoceras limestone, which over such a wide area directly underlies the Carboniferous formations. This indicates a very pronounced pre-Carboniferous erosion in this region and further, a marked irregularity of attitude of the Ordovician strata, for a short distance to the south the higher limestones are present, and they are again found further to the north in Manchuria.

PEILINTZE LIMESTONE.—A noteworthy fact is the apparent entire distinctness of the two faunas found in the limestones of this section. The fauna of the lower or *Peilintze limestone* at present comprises the following species:

ACTINOZOA (?)

1 *Archæocyathus* (*Archæoscyphia*) *chihliense* Grabau

GASTROPODA

2 *Ophileta squamosa* Grabau

3 *Fusispira* sp.

CEPHALOPODA

4 *Protocameroceras matthieui* Grabau

5 *Chihlioceras nathani* Grabau

6 *Chihlioceras chingwangtaoense* Grabau

? 7 *Piloceras platycentrum* Grabau (doubtful from this horizon).

The presence of *Archæocyathus* in this fauna is noteworthy. This genus, and indeed all of the *Archæocyathinæ*, are typical of Cambrian horizons, occurring most commonly in the Lower Cambrian. One species however *A. minganense* Bill. has been obtained from the Lower Ordovician of the Mingan Islands eastern Canada. This species has no inner wall and has been made by Hinde the type of his new genus *Archæoscyphia*. Our species is of the same generic type. The occurrence of this fossil, which appears to be fairly common, is sufficient indication that the Peilintze limestone represents lowest Ordovician. The presence of a *Protocameroceras* very similar to *P. brainardi* of the American Beekmantown, further indicates the correctness of this classification, as does also the presence of *Ophileta*. *Chihlioceras* represents a new type of cephalopod and for it the new family of the *Chihlioceratidæ* is erected. Its nearest relation is *Piloceras*, but it is very distinct from this in its siphuncular structure, which, curiously enough, is much more specialized and complicated than is that of *Piloceras*. The presence in this fauna of the species of the latter genus, characteristic of the higher formation, is open to some doubt, as it is possible that there may have been a mislabeling of specimens in the field. If it really belongs here, it is the only species which the two divisions have in common.

The base of the Peilintze limestone has not yet been found, and its relationship to the older horizons is therefore unknown. All of the material here described comes from the lowest fossiliferous horizon (F 1) except one fragment which contains several specimens of *Ophileta* apparently of the same species as that in the lower horizon, though the material is rather imperfectly preserved. This comes from F 2.

Lianchiashan Limestone.—No fossils have been obtained from the intermediate shales and limestone of the *Shihmunchai formation*. The upper or *Lianchiashan limestones* carry a fossil horizon (F 3) 223 meters above the base. At this level the following species occur.

GASTROPODA

1 *Ophileta plana* Grabau

2 *Hormotoma doquieri* Grabau

CEPHALOPODA

3 *Cameroceras styliforme* Grabau

4 *Piloceras platyventrum* Grabau

This is a small but distinctive fauna, and one confined to this horizon unless the presence of *Piloceras platyventrum* in the lower beds should be substantiated. Both the *Piloceras* and the *Ophileta* indicate Lower Ordovician, or a horizon approximately equivalent to the upper Beekmantown of North America. *Hormotoma* indicates a somewhat higher horizon and the fauna may perhaps represent early Middle Ordovician, but can scarcely be higher so far as the known species permit us to judge.

The relationship of these faunas to the Ordovician faunas of the Kaiping basin farther south, is still obscure. The beds which there rest disconformably upon the Upper Cambrian have so far furnished few fossils only, all of which are entirely unknown in either of the two horizons in the Shih-mun-chai region. Further search may of course bring common species to light, and demonstrate the correspondence of the Yehli limestone series to one or the other of the formations in the more northern region. When such new material is obtained, it will be described in further numbers of this publication.

DESCRIPTION OF SPECIES

Class **ANTHOZOA**

Family **ARCHÆOCYATHINAE**

Genus **ARCHÆOCYATHUS** Billings

(Subgenus Archæoscyphia Hinde)

Archæocyathus (Archæoscyphia) chihliense Grabau (sp. nov.)

Plate I Figs. 1-3

Caliculum irregularly sub-conical, apparently expanding in a uniform manner. Basal portion unknown. Adult portion sub-circular to sub-oval in transverse section, the latter possibly accentuated by compression in some specimens. Septate portion (*thecarium*) thick, enclosing a hollow calicular cavity which, in the subcylindrical specimens, has a diameter something over one third the diameter of the entire caliculum. This cavity is well defined by the inner ends of the main septa, which attain a uniform length, but are not bounded by any definite inner wall, or endotheca. Outer wall or exotheca formed by the thickening of the outer ends of the septa, and their irregular confluence, the result being a very porous wall.

Septa thin, formed apparently by a series of small confluent trabeculæ, this resulting in the production of thin radial plates of a very porous nature, so that in transverse section they appear as disconnected trabeculæ, disposed in radial lines. They are very numerous and arranged in groups of three or four each, the groups being separated by interspaces which are about twice as wide as the interspaces between the adjoining septa of a group. Occasionally one of these broader interspaces is occupied by a short septum in the peripheral region.

A section 28 mm. in diameter (Pl I fig. 3), shows about 33 groups of septa, making a total of from 100 to 120 septa. The specimen from which this section is cut appears to have had a somewhat flaring outer edge to its calyx, a section of this showing on one side, because of slight obliquity of the cut. In this outer portion the septa are mostly continuous, very thin, and slightly serrate. They form a pronounced contrast with the inner portions of the septa which, in section, are discontinuous. Occasionally two of the outer septa become confluent.

The following are the measurements of this section:—

Longer diameter, exterior	36 mm.
,, ,, interior	13 ,,
Thickness of thecarium	16 ,,
Thickness on opposite side	7 ,,
Transverse diameter, exterior	28 ,,
,, ,, interior	11 ,,
Thickness of thecarium	8 ,,
Thickness on opposite side	9 ,,

A specimen (Plate I, fig. 2), which evidently has been compressed laterally, has a present maximum diameter on the exposed weathered surface of 80 mm., while the shorter diameter is 40 mm. A series of sections cut across this caliculum 25, 27 and 80 mm. from the exposed surface, and parallel to it, shows so little difference in measurements that we must infer that the caliculum, in this part at least, was subcylindrical. These facts are brought out by a comparison of the following measurements. (Section No. 4 is nearest the top of the caliculum).

SECTION:	Interval between sections	Outside of caliculum		Inside of caliculum	
		Maximum Diameter	Minimum Diameter	Maximum Diameter	Minimum Diameter
1. Weathered surface		80 mm.	40 mm.	45 mm.	20 mm.
	25 mm.				
2. Polished section		85 ,,	37 ,,	50 ,,	14 ,,
	2 ,,				
3. ,, ,,		85 ,,	40 ,,	53 ,,	12 ,,
	53 ,,				
4. ,, ,,		100 ,, +	55 ,,	60 ,,	22 ,,
Rate of tapering in 80 mm.		1 in 4	1 in 5.3	1 in 5.3	1 in 8 *

If the tapering was fairly uniform the length of the specimen must have been between 35 and 40 centimeters; actually it was probably about half that.

A third specimen, the largest obtained (Plate I fig. 1.) shows the following measurements on the exposed weathered surface and in a section 50 mm. below this and parallel to it. The total length was probably 20 cm. or over.

*) In last part only.

SECTION	Interval	Outside of caliculum		Inside of caliculum	
		Maximum Diameter	Minimum Diameter	Maximum Diameter	Minimum Diameter
1. Weathered surface	50 mm.	112 mm.	80 mm.	60 mm.	44 mm.
2. Polished section		90? ,,	70 ,,	42 ,,	30 ,,
Rate of tapering		1 in 2.3	1 in 5	1 in 2.8	1 in 3.57

These measurements clearly indicate the gently tapering character of the caliculum and the variation in the thickness of the wall or thecarium vertically. We have no means at present of determining the length of the caliculum, but that it was very great is shown by the fact, that in one of the specimens there is so little variation in diameters in the known length of nearly 90 mm. It is quite possible that this species grew to be over 30 cm. in length.

There is considerable variation in the thickness of the wall around the periphery as shown in the sections. Measurements at four successive points around the periphery gave for three different specimens:

Section pl. 1 fig. 3	Section pl. 1 fig. 2	Section pl. 1 fig. 1
16	19	37
8	12	16
7	9	15
9	10	20

From the several sections it appears that the form was subcylindrical with the surface of the thecarium scarcely undulating, nor did it exhibit such marked protuberances as characterize *A. minganense*, though scattered tubercles may have existed.

Comparisons. This species agrees with *Archæocyathus minganense* Billings in the absence of the inner wall of the thecarium. Its absence in *A. minganense* has been insisted upon by Hinde (1889) though Billings' figures (1862, figs. 343-344) indicate its presence (see also Roemer 1876, pl. II, fig. 2a, b). Because of the absence of the inner wall, Hinde erected for this species the new genus *Archæoscyphia*. Hinde and subsequent authors (see especially Taylor 1910) were in error in believing *A. minganense* to be a Cambrian species. The Mingan Islands in the Gulf of St. Lawrence north of Anticosti Island, are composed of Ordovician strata, both Beekmantown and Chazy being present, while Potsdam sandstone (possibly only a basal sandy phase of the Beekmantown rather than true Postdam) occurs on the mainland to the north. *A minganense* and *A. chihliense* thus appear to be the last survivors of the Archæocyathinæ, which continued into the Lower Ordovician. Our species has a proportionately thicker thecarium than *A. minganense*, while the arrangement of the septa in groups of 4 or 5 further differentiate it from the American species. The strong annulations and nodes characteristic of the latter, are not developed in the Chinese form, or only slightly so.

Horizon and Locality: This species was collected by Dr. F. F. Mathieu from the Peilintze limestone of Pei-lin-tze, Shih-mun-chai region eastern Chihli province, at horizon No. 1. It is associated with *Ophileta squamosa*, *Cameroceras* and *Chihlioceras*. The age is Lower Ordovician.

Class **BRACHIOPODA**

Order **Protremata** Beecher

Family **ORTHIDÆ** Woodward

Genus **ORTHIS** Dalman

(Emend. Hall and Clarke)

Orthis calligramma Dalm.

var. **orthambonites** von Buch (de Verneuil)

Plate I. Figs. 4a - c, 5a - d

1827 *Orthis calligramma* Dalman, Kon. Vet. Acad. Handl. p. 114, pl. 2 fig. 3.

1845 *Orthis calligramma* de Verneuil, in Murch. De Vern. & Kayserl. Geology of Russia and the Ural Mountains, Vol II, p. 207, plate XIII, figs. 7a - 7f, and var. *orthambonites* von Buch, *ibid.* figs. 8a - 8g.

1868 *Orthis calligramma* Davidson, British Silurian Brachiopoda (Palæontographical Society Monographs), p. 240, pl. XXXV figs. 1 17 (Bibliography and synonymy).

1883 *Orthis calligramma* Kayser, in Richthofen, China Vol. IV, p. 40, pl. III, figs. 10 - 13.

1901 *Orthis calligramma* var. *scrica* Martelli, Boll. della Soc. Geol., Ital. vol. XX, p. 297, pl. 4, figs, 1 - 4; var *davidsoni* Martelli, idem. p. 301, pl. 45, figs. 5 - 6.

1913 *Orthis calligramma* Weller, in Willis, Research in China, vol. III, p. 282, pl. 25, figs, 3 - 6.

Shell small sub-semicircular, wider than high, with the pedicle valve strongly, and the brachial valve more gently convex. Hinge-line forming the greatest width of the shell, cardinal angles rectangular, sides and front regularly rounded.

Pedicle valve somewhat sharply arcuate in transverse section, the greatest elevation between one third and one half the distance forward from the beak, which is elevated and very slightly incurved over the area. Cardinal area high, arched, and of triangular outline, with a median triangular delthyrium which is higher than its basal width.

Brachial valve sub-semicircular, with a slightly salient beak which is not incurved. Cardinal area narrow, about one third as high, in the center, as the pedicle area. Contour depressed-convex, the greatest elevation about one third the length forward from the beak. A very faint median depression towards the front.

Surface of shell marked by strong regular rounded plications, with deep interspaces about equal in width to the plications in the earlier part, but wider towards the front. There are from 19 to 21 of them on the pedicle valve, and a corresponding number on the brachial valve. The plications decrease very gradually in size towards the lateral margins, except on the cardinal extremities where the last three or more are fine and narrow. Growth-lines very fine and rather obscure. In some specimens the plications become rather widely separated near the front, as their own width does not increase in proportion. This gives a very marked character to that part of the shell, as compared with specimens in which the plications thicken more in proportion.

The dimensions of a nearly complete small specimen (pl. I figs. 5a - d) are: height of pedicle valve 6.2 mm., height of brachial valve 5.7 mm., width of shell at hinge area 8.5 mm. Fragments of larger individuals also occur.

The numerous varieties currently classed under this specific name require a thorough revision, when it will probably appear, that there are a number of distinct genetic series. The common Upper Ordovician (Caradocian) form of western Europe illustrated by Davidson in plate XXXV figs. 1 and 2, is strongly biconvex, and belongs probably to the genus *Plectorthis* which is derived from *Orthis* proper by the increase, among other features, of the convexity of the brachial valve, until in that respect it is essentially equal to the pedicle valve. On the other hand, in more primitive mutations (primitive at least, so far as convexity of the brachial valve is concerned) the two valves are very unlike, and to this group our specimens belong. That transitional forms connect the two series does not justify us in uniting them, for transitional forms between species of a genetic series are normal and to be expected. The increase in the size of the plications (or of the interspaces) is characteristic of a distinct evolutional direction, and the increase in number is equally characteristic of another, the two evolutional lines being divergent. Interpreted in terms of mantle growth, which is, after all, the key to the surface features of the shell, the regular increase in size of the plications without intercalation of new striæ, signifies a uniform interstitial growth of the marginal or shell-building mantle-tissues, i. e. a uniform rate, and a uniform distribution of growth. The development of intercalated plications on the other hand, signifies a proportionately more rapid mantle growth of the portions corresponding to the interspaces, and this excess of growth has to be compensated for by a folding of the mantle, and the corresponding formation of plications. In other words, individuals with intercalated plications indicate unequal mantle growth, while those in which new plications are added only at the hinge-margin, indicate relative uniformity of mantle growth. It is evident, that the two groups represent divergent lines of evolution. Our variety belongs to the latter group, and it is the one figured and described by de Verneuil as variety *orthambonites*, and it is to his figures 8b - d, that our form most nearly corresponds.

The variety described by Weller from eastern Szechuan has fine radiating striæ intercalated between the coarser ones, while that described and figured by Kayser from the "Light gray Brachiopod limestone of Kiau-tchang-pa," though larger, agrees in all essentials with the specimens from Chihli.

Horizon and Locality: In the upper part of the Machiakou (Actinoceras) limestone of Chaokouchuang in the Kaiping coal basin, eastern Chihli province. Collected by survey expedition.

Family **STROPHOMENIDAE** King

Genus **STROPHOMENA** Rafinesque

Strophomena cf **incurvata** (Shepard)

Plate I fig. 6.

cf.1893 *Strophomena incurvata* (Shepard), Winchell and Schuchert. Palæontology of Minnesota, Vol. I, (With bibliography and synonymy.)

cf.1909 *Strophomena incurvata* (Shepard), Grabau and Shimer, North American Index Fossils, Vol. I, p. 223, figs. 271, a - d.

cf.1913 *Strophomena* sp. undt. Weller, in Willis. Research in China, Vol. III, p. 281, pl. 25, figs. 1, 2.

At least one species of Strophomenoid shell allied to *S. incurvata* is common in the upper Machiakou limestone. It is of medium size, moderately concavo-convex, with the hingeline forming the greatest width of the shell.

Pedicle valve gently concave with a well developed hinge area. In some of the specimens the earliest stage of this valve, now forming the beak, is more or less strongly convex but this is usually a very small apical portion, and in some shells this is not shown at all. In consequence these suggest the characters of the brachial valve of a *Rafinesquina*. A specimen of this kind however shows a high hinge area, thus indicating that it is the pedicle valve, and that the generic reference is to *Strophomena*. Only half of the area is shown, but this is enough to show the triangular delthyrium partly covered by a rather short deltidial plate. The contour of the valve varies in different specimens from nearly flat to pronouncedly concave, the greatest concavity being in the anterior third.

Brachial valve strongly convex. No specimen has been observed in which the apical portion is depressed or concave, as is often if not generally the case in the genus. In some specimens the center of the valve is most strongly elevated, the sides being depressed-convex. Such a shell when small, has something of the aspect of a *Dalmanella*. In other specimens, the contour of the valve is regularly arched transversely, while the longitudinal contour shows the greatest convexity somewhat in front of the middle. In a few specimens the longitudinal contour is slightly undulating, due to faint and ill-defined concentric wrinklings, while near the front, the valve tends downward rather abruptly.

Surface marked by rather strong radiating striæ which increase in strength forward, and are multiplied by the intercalation of other striæ. These are at first much finer, but also become strengthened towards the front, while at the same time other fine striæ appear in the widening interspaces. Thus the aspect of the surface is that of strong striæ with from three to five finer ones between each pair of coarser ones. Very fine concentric lines cancellate the striæ and mark the interspaces, where they are strongest. They are very numerous and close-set.

The width of an average specimen is 14 mm. the height 8 mm. or more.

Horizon and Localities: This is a common form in the massive dark-gray calcilutytes of the upper Machiakou limestone series at Chaokouchuang. As a rule the shells are closely crowded, and so much a part of the rock, that it is practically impossible to prepare the specimens, and observations are limited to the fracture exposures. Only in rare cases, where the rock has weathered upon the surface, is the shell visible in relief and preparation with the needle point is possible.

Weller described similar shells as abundant in the Ki-su-ling limestone on the Ta-ning River in eastern Szechuan, where they were collected by Blackwelder. His specimens indicate a somewhat larger size than our form, but appear to be of the same species. The reference of our species to the American *S. incurvata* is tentative, and indeed is probably not warranted. Better material is however necessary before it is possible to make a complete characterization of our form. It will probably be found to be a new species.

S. incurvata is a characteristic and abundant fossil of the Trenton limestone of New York and of the central United States, where it is widely distributed.

Class **PELECYPODA**

Order **Prionodesmacea**

Family **CTENODONTIDÆ** Hall

Genus **CTENODONTA** Salter

Ctenodonta symmetrica Grabau (sp. nov.)

Plate I Fig. 7.

Shell small, transverse, beak subcentral; hinge-line somewhat sharply arcuate, marked with rather strong transverse denticulations; ends subangularly rounded; ventral margin nearly straight. The anterior end is somewhat broader than the posterior, but the difference is not very pronounced. The anterior muscle-scar also appears slightly larger than the posterior, but again the difference is slight. It is however more strongly excavated than the posterior. There is a rather strong though low rounded ridge, extending from the posterior ventral margin of the anterior adductor scar towards the rostral cavity, dying away before it reaches this. Surface characters unknown, but apparently the shell is marked by simple growth-lines.

This small shell has some resemblance to *Ctenodonta logani* Salter of the Black River of Wisconsin and Ontario, but the ends are more nearly equal and the denticulated hinge-line is more arcuate. The muscular impressions also are more pronounced, while the short internal anterior muscular ridge is distinctive. From *C. fecunda* Hall of the Upper Ordovician (Maquoketa shale) it differs in the straight ventral margin, and the strong muscular impressions. It has the character of hinge, and of muscular impressions of *C. pectunculoides* Hall, of the Cincinnati group, but is of less rounded form.

HORIZON AND LOCALITY: In the upper Machiakou (Actinoceras) limestone of Tangshan, associated with *Lophospira, Pagodispira* etc. Collected by Geo. B. Barbour. Only a single right valve of this species is so far known, this showing the interior, while the characters of the exterior are not visible.

The genus *Ctenodonta* is abundant in the Upper Ordovician of North America, where it is represented by many species. From Chinese rocks *Ctenodonta* has heretofore been reported only from the Lower Ordovician of Pupino in western Yunnan (Cowper-Reed) but the species has not been identified.

Class **GASTROPODA** *

Order **Rhipidoglossa** Troschel

Family **EUOMPHALIDÆ** de Koninck

Genus **OPHILETA** Vanuxem

Ophileta plana Grabau (sp. nov.)

Plate II, figs. 1, 2a - b.

Shell with the spire flattened to a plane, except for a faint sub-marginal keel, the effect of which is to give the upper surface of the whorl, i. e. the shoulder, a faint concavity. There are about six volutions in what appears to be an adult specimen, the

---

* It is desirable to define the various terms here used somewhat more precisely, since there is some variation in their use. *Spire* is used in the usual sense for the spirally coiled portion of the shell above the last or *body-whorl*. The angle formed by the convergent sides of the spire is the *apical angle*, the body-whorl being excluded where this enlarges more rapidly, or is separated from the earlier whorls. *Whorl* is used in a general sense for the elements of the spire and for the last or *body-whorl*. *Volution* is used more precisely for a complete coil, indicated by the lines of growth in juxtaposition on the two adjoining whorls. When the number of whorls is given it refers to the number of coils in the shell counted upwards from the body-whorl. In speaking of the first, second, third *volution*, or when the statement is made, that such and such a change occurs at the end of 3 1/2 volutions, or 4 volutions etc. the measurement is always from the apical point or *protoconch* of the shell, the first volution being completed by the line of growth opposite (next below) the apical point. The whorls are separated by the *sutures*. A *sutural shelf* is a flattening of the succeeding whorl below the suture. The *subsutural spiral* or *carina* lies at the upper edge of the next lower whorl, next below the suture. A *sutural canal* is a depression at the suture, a sunken sutural shelf. *Spirals* are fine revolving ridges, a *carina* is a thickened revolving ridge, which may be a single thick spiral or composed of several spirals. It generally forms an *angulation* in the shell whorl. The strong angulation of the whorl next below the suture, is called the *shoulder angle*, and is measured in degrees. It is often emphasized by the *peripheral carina*, and forms commonly the most salient feature of the whorl. The space between the shoulder angle and the suture is the *shoulder* and it is usually flat or gently concave or faintly convex. It may slope upwards as in *Lophospira*, at right angles to the axis of coiling as in *Ophileta* and *Maclurea* or downward, and inwards, when the spire is *depressed*, as in *Eccyliopterus*. The part below the shoulder angle is the *body of the whorl* and it may contain one or more *lower carinæ* each forming as a rule an angulation. They are numbered from the shoulder angle downwards (forwards). *Ribs or costæ* are transverse rounded elevation marking temporary expansions of the whorl followed by an equal contraction. If the expansion is suddenly abandoned, so as to leave an open forward-pointing or flaring portion of lip exposed, this is called a *varix*. It may be spinose, and it may be confined to a single spine at the shoulder angle.

The degree to which the next whorl covers the preceding is called the amount of *embracing* of the whorls. When the amount is small, so that most of the preceding whorl shows, the spire is said to be *loose-coiled*, if much is covered, it is *close-coiled*. If the whorls become separated from the earlier ones they are said to be *laxly coiled*. Lax coiling begins with the formation of a sutural canal or channel. In trochiform shells the embracing extends to the shoulder angle. In a few forms with sunken spire, it may extend above the shoulder angle.

upper surfaces of which all lie at the same level, or are depressed so faintly as to be scarcely noticeable. Side or body of the whorl at first vertical, thus making the shoulder angle 90 degrees. This verticality is most marked in the last or body-whorl of the adult shell, whereas in the young, the contour quickly becomes rounded off inwards, this rounding being progressively more pronounced in the younger portion of the shell. On the under or umbilical side, the inner whorls are probably depressed, though so far only weathered specimens have been obtained, in which the whorls appear entirely flat. In these however the outer whorls are quite evidently worn down to the level of the inner. In a young specimen partly freed from the matrix, this depression of the inner whorls is indicated.

In an adult specimen, (Plate II, fig. 1) the greatest diameter of which is 24 mm. the width of the final whorl (shoulder width) is 6.8 mm. In a young specimen (pl. II. figs. 2a-b) with a maximum diameter of 14 mm., the final whorl has a diameter of 4 mm.

The most characteristic features of this species are: the flat surface of the spire formed by the shoulder, the position of which is at right angles to the axis of the shell, and the submarginal carina. The lines of growth are not sufficiently shown in any of the specimens so far found to indicate whether or not there is a deep notch upon the keel such as characterizes typical species of *Ophileta*. Nevertheless the general characters are such as to make reference to the genus *Ophileta* most reasonable.

Of American species of the genus known to me, the present form comes in many respects near to *O. complanata*, of the Beekmantown (Lower Ordovician). It differs however from that species in the flat spire, and the sunken or depressed umbilical area, which in the American form is flat, while the spire is depressed and the whorls concave. As in the American form, the upper keel is submarginal and the sides of the shell flat and nearly vertical, except in the lower portion, where they curve inwards in the Chinese species.

In general appearance the Chinese species is very like that descriped and figured by de Verneuil as variety A, of *Euomphalus qualteriatus* Salter, in the Palæontological volume of the great work on the Geology of Russia and the Ural Mountains (p. 334, pl. XXII, figs 2a, 2b,), Indeed our form might be considered conspecific with the Russian form (obtained from the Ordovician rocks of St. Petersburg), which is most certainly distinct from Salter's species. The two forms are very similar, except for the absence in the Russian form of the outer keel, which is distinctly shown in the Chinese species, and for the fact that the shoulder angle of the Russian form is less than 90 degress.

Horizon and Locality: This species was collected by F. F. Mathieu, geologist of the Kailan Mining Administration, in the Liangchiashan limestone at Liang-Chia-

Shan, Shih-mun-chai (Shihmenchai) region near Chingwangtao eastern Chihli province (horizon F3). The formation is Lower Ordovician.

Ophileta squamosa Grabau (sp. nov.)

Plate II Figs 3-6

Shell with sunken spire, the whorls nearly in a plane but asymmetrical, gradually enlarging and in contact except, in some cases, in the last part of the final whorl. Umbilicus very large. Whorls with a gently concave, slightly inward sloping shoulder, limited within by a blunt angulation and without by a rather sharp carina or keel, which is however not greatly elevated. Outer surface of whorl regularly convex, in such a manner that seen from above the carina is something less than one third of the width of the whorl within the periphery. Lines of growth curving strongly backwards at the carina, forming a pronounced apertural notch at that point.

On the umbilical side the whorls are gently convex or slightly angular at the center with a pronounced but rounded carina next to the inner margin. On this side the lines of growth are very squamose projecting at regular intervals, in the adult, in the form of small sharp varices. These die away at the outer margin, but continue on the inner carina and along the inside of the whorl to the point of contact with the preceding whorl. Preceding the strongly squamose portion of the final whorl is a part where these squamæ have more the appearance of costæ and are farther apart (plate II fig 4). This condition is still slightly visible on a portion of the preceding whorl.

The largest adult individual of this species found (pl. II fig. 6), has a maximum diameter of 38 mm. It is however a much worn specimen, and little can be added to the characters. The width of the final whorl of the aperture is 15.5 mm., the enlargement being rather rapid in the last stage. The growth lines are strongly squamose projecting about. 0.7 mm. from the shell.

A section of another adult shell has a diameter of 36 mm., but shows only the outer whorl (pl. II. fig. 5), the maximum diameter of which is 12 mm., this being some distance behind the peristome. The outer surface of the shell is regularly rounded, from the keel of the shoulder angle to the margin of the umbilicus which is characterized by a faint rounded keel. The shoulder angle or keel lies about one third the distance in from the periphery of the whorl as seen from above and it forms nearly a right angle. The shoulder slopes strongly inward and is gently concave. The inner side of the whorl is rounded with a very faint suggestion of an impressed zone where it was in contact with the preceding whorl. The growth lines are squamose and crowded.

This species is of the type of *Ophileta bella* Billings which is found in the Beekmantown (Div P) of Newfoundland. The upper carina is however nearer to the outer margin in the Chinese species and the shoulder more regularly concave. Again, the lines of growth are not squamose on the upper surface of the Chinese species, as they are in the Newfoundland form. On the umbilical side, the Chinese species is marked by a rounded carina near the inner margin, this being absent in the Newfoundland species. On this side too, the growth lines are much more strongly squamose in the Chinese than in the Newfoundland form. Though related, these two forms are markedly distinct.

HORIZON AND LOCALITY: This species was obtained by Dr. F. F. Mathieu from the Peilintze or lower limestone of the Lower Ordovician, at Pei-Lin-Tze, Shihmunchai, province of Chihli. It is not an uncommon form.

Genus **ECCYLIOPTERUS** Remele

Eccyliopterus kushanensis Grabau (sp. nov.)

Plate II Figs 7a - c.

Shell of medium size consisting of about four volutions, which enlarge gradually and regularly. Spire sunken; umbilical side nearly flat. Whorls of sub-rhomboidal section, the shoulder sloping inward, with a sharp shoulder angle, which was scarcely elevated into the marginal "collar". Shoulder angle of the inner whorls somewhat greater than that of the outer ones, the shoulder itself sloping inward to a lesser degree than in the adult, and being flat, whereas that of the outer whorls becomes slightly concave. The successive whorls embrace to within a very short distance of the shoulder angle, which, however, projects slightly in each whorl. Outer surfaces of the whorls very gently convex, less so in the adult than in the earlier whorls, but not actually flattened. Towards the umbilical side the whorls become regularly rounded, and separated by depressed sutures. On this side the whorls are only very slightly depressed, so that a very large and very shallow umbilicus results.

This species is related to *Eccyliopterus sinensis* (Frech) (*Raphistoma sinense* Frech) from southern China. Comparison with a characteristic specimen from Hupeh, (Pl. II, fig. 8) shows it to be a flatter as well as larger shell. The whorls of the present species are not so high laterally as in *E. sinensis*, and the shoulder angle is somewhat less pronounced. The sides of the Hupeh form too are less convex, becoming almost flat in the last whorl, and the umbilicus is more depressed than in the northern species. In *E. sinensis* too, the embracing is much more pronounced so that each outer whorl rises, on its inner margin, above the shoulder angle of the preceding whorl, whereas in *E. kushanensis* the shoulder of the outer whorl meets the whorl next within, a very short distance below the shoulder angle. This is shown in the sections on plate II. of which fig. 7c represents the whorls of *E. kushanensis* and 8d those of *E. sinensis*.

Horizon and Locality: The only specimen so far known comes from the Måchiakou limestone of Ku-Shan, in Huo-Luh-Hsien western Chihli. This region has also furnished *Actinoceras richthofeni* from apparently the same horizon.

Genus **ECCYLIOMPHALUS** Portlock

Eccyliomphalus tangshanensis Grabau (sp. nov.)

Plate II Fig. 9.

Shell large, laxly coiled, whorls not in contact, coiling essentially in a plane. Whorls rather rapidly enlarging from about 10 mm. at the beginning, to 25 mm. at the end of the final volution in the type specimen, in which only about one and a half volutions are preserved. Earliest whorls unknown. Under side broadly rounded, inner angle sharp and rectangular outer angle rounded. Upper surface unknown.

The specimen exposes only the lower side of the whorls which is partly worn. Its large size (maximum diameter about 75 mm.) and rapidly enlarging whorls are however very characteristic features. A section of a second specimen shows nearly two complete volutions but the final portion is crushed inward giving the shell a smaller proportional diameter. The diameter of the final volution is only about 18 mm. at the end, and 7 mm. at the beginning, giving about the same rate of enlargement. This specimen is worn down from the upper side. A comparison of the two specimens suggests an ovate-triangular cross-section of the whorls. Only a portion of the shell is preserved on the under side and this shows indistinct regular lines of growth. In general form and character, and in the rate of enlargement this shell suggests *Eccyliomphalus undulatus* Hall from the Stones River (late Middle Ordovician) of the central United States. It is however a much larger shell than any member of that species with which I am acquainted.

Horizon and Localities; In the upper beds of the Machiakou or Actinoceras limestone, at Tangshan in the Kaiping Coal Basin, Chihli province, T. C. Wang coll. Also in the same formation at Huo-Luh, (Hwo-Luh) Chihli, Miss Clarke, coll.

Family **PLEUROTOMARIIDÆ** d'Orbigny

Genus **LOPHOSPIRA** Whitfield

Lophospira morrisi Grabau (sp. nov.)

Plate III Figs. 1, 2a, b.

Shell of medium size for the genus. Spire consisting of about five angular whorls which embrace to within a very short distance of the peripheral carina. Apical angle 57 58 degrees. Whorls with flat or very gently concave shoulder, pronounced peripheral carina, obtuse shoulder angle, and faint lower carina. In well-preserved specimens, the shoulder angle is marked by a sharply rounded carnia with a narrow peripheral band on the outer edge of the shoulder, delimited by the peripheral carina and a fainter spiral above it. Lines of growth fine and sharp, beginning at the suture, where the shoulder is sometimes thickened as by a faint subsutural carina. From this point the lines of growth bend backwards, at first very gently, then, as they approach the band, move abruptly, crossing the band with a distinct semilunar curve. In this respect the growth-lines and band are very similar to those of *Liospira barbouri* from the same horizon. They evidently indicate a rather pronounced supra-marginal notch, a feature not usual in the genus *Lophospira* where the notch is generally at the peripheral carina.

The lower carina is faint and scarcely affects the contour of the body of the whorl; it may indeed be absent altogether.

Aperture sub-rhomboidal, the inner lip slightly reflected and covering the umbilicus.

Length of a perfect specimen (Plate III fig. 1), 17.5 mm., greatest diameter of body whorl, 12.5 mm.

This species is very similar to *Lophospira medialis* Ulrich and Scofield, from the Trenton limestones of New York and the central United States, the chief difference being the pronounced marginal band on the shoulder of the Chinese species, and its somewhat sharper peripheral carina. In other respects the two species are closely allied, and somewhat worn specimens of the Chinese species might readily be taken for the American form.

Horizon and Locality: A nearly perfect specimen was obtained by Messrs. Morris, Barbour and Terrill in the upper quarry beds of the Machiakou or Actinoceras limestone at Tangshan in the Kaiping coal basin eastern Chihli province. This specimen was associated in the same slab with *Salpingostoma terrilli* and *Actinoceras tani*. Another specimen, obtained by Mr. Geo. B. Barbour, from the same locality and horizon, is associated with *Lophospira pulchelliformis* and *Pagodispira dewiduii*. These specimens are deposited in the Museum of the Survey. The specific name is given in honor of Frederick K. Morris, Professor of Geology in Peiyang University Tientsin, in recognition of his active interest in the stratigraphic and structural problems of this country.

Lophospira pulchelliformis Grabau (sp. nov.)

Plate III Figs. 3, 4.

Spire elevated, the apical angle about 60°, whorls embracing only to the lower carina which is strong and occupies the middle of the body of the whorl.

Shoulder flat or very gently concave, the shoulder angle about 90°, and marked by a rounded, well defined, peripheral band which occupies the apex of the angle, and is defined by an impressed line on either side. Lower part of whorl divided into two parts by the strong body carina which is rounded and nearly equal in strength to the shoulder angle. This carina is partly shown just above the suture in the earlier whorls. That part of the whorl between the shoulder angle and the lower carina is concave, while that below the carina is gently concave near the carina but becomes gently convex towards the umbilicus, which is narrow. Lines of growth deflected backwards on the periphery, where they indicate a notch of moderate depth.

This species is the Chinese analogue of the North American *L. pulchella* Ulrich and Scofield, which is found in the Black River horizon of the central States. The apical angle of our species is somewhat larger, being 60° as against 50° to 56° in the American form. The lower carina in our species is also somewhat lower down on the whorl than in the American form. Nevertheless the two are very much alike.

Horizon and Localities: In the upper part of the Actinoceras or Machiakou limestone at Tangshan, several specimens, collected by Survey expedition; also one from the same section collected by Geo. B. Barbour.

Lophospira trochiformis Grabau (sp. nov.)

Plate III Figs. 5a, 5b.

Shell with trochiform spire, the whorls embracing to the peripheral angulation. Shoulder concave, the periphery formed by a round band delimited by linear depressions above and below. Body of whorl without carina, concave below the peripheral band but convex for the greater portion; umbilicus small. Apical angle about 75^0, shoulder angle 100^0.

This species resembles *L. morrisi*, but is more strongly embracing, so as to entirely cover the preceding whorl. There is, further, no indication of an accessory carina on the body of the whorl.

Horizon and Locality: In the upper part of the Actinoceras or Machiakou limestone at Tangshan.

Lophospira acuta Grabau (sp. nov.)

Plate III Figs. 6.

Shell small, high-spired, apical angle about 57 degrees, whorls embracing to lower carina, which is pronounced and sharp. Shoulder concave, characterized by revolving spirals, and forming an acute angle with the body of the whorl. Shoulder angle sharp. There are indications of rather sharply pronounced growth-lines which cancellate the spirals. Umbilicus minute.

This species differs from *L. pulchelliformis*, in the more acute shoulder angle, and in the sharp peripheral and lower carina. The apical angle is also somewhat smaller in *L. acuta* than in *L. pulchelliformis*.

This species resembles in form, acuteness of whorl, and sharpness of carinæ the American *L. acuminata* (Ulrich and Scofield) from the Upper Ordovician (Richmond) of the central United States, and like that form, appears to have strong growth lamellæ. Our species is however characterized by a minute umbilicus, which is absent in the American species.

Horizon and Locality: This species was collected by the Survey party in the upper Actinoceras limestone (Machiakou limestone) near Chaokouchuang, province of Chihli (Kaiping coal basin). Its age is early Upper Ordovician. Cat. Mus. Geol. Survey Nos 47 and 48.

Lophospira gerardi Grabau (sp. nov.)

Plate III, Fig. 7.

Shell of less than medium size, with an apical angle of 65 to 70 degrees. Whorls embracing to a point about midway between the two carinæ, exposing the lower portion of the whorl for an amount equal to about half the shoulder width. Shoulder flat to very gently concave, with a well-marked peripheral carina, bordered above and below by a distinct spiral line. The upper of these spiral lines is separated from the median carina by a distance about twice that between the carina and the lower bordering spiral, producing the appearance of a peripheral band on the margin of the shoulder. Shoulder angle about 95°. Lower carination generally well marked, its distance from the periphery being somewhat less than the width of the shoulder. The space between the two carinations is gently concave or nearly flat, while below the lower carina, the whorl slopes rather abruptly to the umbilical region. Aperture subquadrate; umbilicus not observed.

Lophospira gerardi has many of the characters of *L. perangulata* Hall, from the Stones River and Lowville-Black River groups, of the central United States, New York, and Canada, the chief differences being the greater apical angle of our species. In the American form the final whorl is also often laxly coiled, and the peripheral carina is trilineate.

Horizon and Locality: This species and its variety were found by the Survey expedition in the Machiakou or Actinoceras limestone of the Chaokouchuang region in the Kaiping coal basin. The specific name is given in honor of M. Jaques Gérard, geologist and engineer of the Chaokouchuang mines of the Kailan Mining Administration.

Lophospira gerardi

variety **laxa** Grabau (var. nov.)

Plate III, Fig. 8.

This is a gerontic mutation of *L. gerardi*. The early whorls are slightly more embracing than in the normal form, making a greater apical angle (nearly 80 degrees), but the later whorls become slightly separated, producing a lax-coiling adult. This results in a pronounced sutural channel, bounded without by the sharp upper angle of the shoulder. The shoulder itself at the same time becomes more pronouncedly concave, and the peripheral carina becomes more prominent. The trispiralled character of the peripheral carina is still maintained, with the median spiral thickest, but the lower spiral becomes more distant, so that the space between it and the median one is slightly wider than that between the median and upper spirals. The space between the peripheral and lower carinæ has also become more pronouncedly concave. Umbilicus not observed.

HORIZON AND LOCALITY: Occurs with the preceding.

Lophospira terrassa Grabau (sp. nov.)

Plate III, Fig. 9.

Shell of medium size, and somewhat robust aspect; apical angle about 62 degrees. Earliest whorls not preserved. Neanic whorls with a shoulder angle of about 95° which in the adult becomes between 100 and 110°. Whorls moderately embracing, leaving the body exposed to a height equalling about half the shoulder width, or somewhat less. Shoulder moderately convave, with a broad and rather ill-defined upper (subsutural) carina and a well-defined sutural shelf or terrace, which is flat or may slope slightly inwards. Shoulder angle marked by a rounded carina bounded by impressed lines. Body of whorl, below shoulder-angle, gently convex, without lower carina. Lines of growth sharp and crowded, bending at first gently backwards on the shoulder, and then crossing the periphery with a pronounced backward curve. After crossing the periphery, they bend forward, and then more abruptly downwards. They thus indicate a pronounced peripheral notch. Axis with a minute median hollow, as seen in the broken apex. Diameter of final whorl 15 mm.

This species differs from *L. gerardi* in the absence of the lower carina, and in the terrassiform sutural shelf. From *L. morrisi* it differs in the presence of this shelf, and the lesser amount of embracing. It is closely related to *Lophospira ampla* Ulrich of the Lorraine and Richmond (Upper Ordovician) of the central United States, but that species has a less developed subsutural shelf, and the whorls embrace somewhat more, giving the shell a slightly greater apical angle. The two species are however very similar.

HORIZON AND LOCALITY: In the Machiakou limestone of Tangshan, Chihli. Survey collection.

Lophospira obscura Grabau (sp. nov.)

Plate III Fig. 10

Shell turreted, consisting of about 5 whorls which expand rapidly and are angulated by a pronounced shoulder angle and a less marked lower carina. Apical angle about 60 degrees. Shoulder flat, bounded below by a heavy carina and embracing to the lower carina of the preceding whorl. Exposed part of the body of the preceding whorl somewhat less than the width of the shoulder. Shoulder angle about 115 degrees, characterized by a rather strong rounded carina or keel. Lower carina moderately strong, the surface of the whorl between it and the shoulder angle being flat or slightly concave. Below the lower carina the whorl is rounded. Umbilicus apparently closed. Surface characters not ascertained.

In its general form and character this species resembles *L. bicincta* of the Stones River and Trenton groups of the central United States, but it is without the marked carina near the upper end of the shoulder. That is however faint in some cases in the American species. It differs from *L. gerardi* in the greater shoulder angle, smaller apical angle and less degree of embracing.

The mold of the interior of our species presents rounded outlines owing to the thickening of the shell on the interior.

HORIZON AND LOCALITY: In the Actinoceras beds of the Machiakou limestone at Tangshan. Collected by Survey expedition.

Genus **PAGODISPIRA** Grabau (gen. nov.)

Shell with comparatively small apical angle and subrectangular whorls, giving the shell a pagodiform aspect. Whorls without slit, but bearing a peripheral carina like that of *Lophospira*. One or more additional carinæ may be present. Aperture subquadrangular to trapezoid, generally with a faint anterior emargination. Umbilicus generally covered by the reflexed inner lip.

This genus is closely related to *Lophospira* from which it differs primarily in the much drawn-out form of the spire, and the resultant small apical angle. It may indeed be regarded as a more primitive branch of the *Lophospira* series in which the whorls embrace only to a very small degree, or better as a lateral branch from the ancestral stock, in which the embracing of the whorls remains in the primitive state. This is suggested by the fact, that in other gastropod series the more specialized members show a larger amount of embracing, while further, members of a degenerating series, show a tendency towards a decreasing amount of embracing in the adult, which in certain cases is followed by a loosening or laxness of the coil.

Genotype: Pagodispira derwiduii Grabau, Ordovician.

Of foreign species referable to this genus, we may mention *Pagodispira bowdeni* (Safford) from the Upper Ordovician of North America. So far as known the genus is confined to the Ordovician.

Pagodispira derwiduii Grabau (sp. nov.)

Plate III Fig. 11.

Shell slender, with the apical angle varying from 28 to 32 degrees; whorls 8 to 10 (at least 9 in the holotype) angular, and divided near the center of the exposed part by a sharp peripheral carination which consists of a median strong rounded spiral, closely flanked by a fainter and much weaker spiral on each side. Shoulder gently concave, apparently smooth, though there is a suggestion of faint spiral lines. Shoulder angle varying from about 95 degrees in the young, or in more retarded individuals, to about 112 degrees in the adult. Exposed portion of whorl below the shoulder angle of the same width as the shoulder, and like that gently concave. A lower carina, situated just below the suture of the whorls is present at least in the adult portion, where it is of moderate strength on the body-whorl. Umbilicus covered by reflexed inner lip. Length of holotype about 35 mm. (the apex is imperfect), diameter of last whorl 14 mm.

This species differs from the American *P. bowdeni* (Safford) (*Lophospira bowdeni* Ulrich and Scofield) from the Lorraine and Richmond of the central United States, in the sharper shoulder angle (that of *P. bowdeni* being from 122 to 125 degrees) and in the more strongly concave shoulder, that of *P. bowdeni* becoming convex near the suture, forming an obscure carina. The whorls of our species also embrace to a lesser degree than is the case in *P. bowdeni*, where the part below the periphery is only about two thirds as wide as the shoulder. Finally the Chinese species has a sharper peripheral carina and a stronger lower carina, the latter in *P. bowdeni* being faint or absent. From *P. dorothea* Grabau, it differs in the sharper shoulder angle and peripheral carina and the lesser degree of embracing.

Horizon and Localities: In the Machiakou or Actinoceras limestone near Chaokouchuang in the Kaiping coal basin, Chihli province. Collected by the Survey expedition. Also in the same horizon at Tangshan, collected by George B. Barbour.

The specific name is given in honor of M. Maurice Derwiduee, chief of the Chaokouchuang mines, whose interest in, and recognition of the practical value of geological and palæontological science, has contributed not a little to the distinguished success of the great mining operations under his charge, and who gave us every facility and aid in his power, in our investigation of the stratigraphy and paleontology of the Chaokouchuang region.

Pagodispira dorothea Grabau (sp. nov.)

Plate III Fig. 12

High spired, with apical angle of about 24 degrees; consisting of about 8 angular whorls. Shoulder flat or very gently concave, without change of slope at suture; shoulder angle in the young whorls about 90 or 95 degrees, increasing in the adult to 117 degrees. Exposed portion below peripheral carina, about two thirds as wide as the shoulder in the adult, apparently more nearly equal to it in the young; flat, or appearing slightly concave because of the strong peripheral carina, which is somewhat thickened. Lower carina strong, situated at the suture, and exposed in the penultimate whorl, because of the slight separation of the final whorl.

The species differs from *P. derwiduii* in the greater shoulder angle and more pronounced embracing of the adult whorls, as well as in the laxity in growth of the final whorl. From *P. bowdeni* it differs in the character of the shoulder and in the sharper peripheral, and stronger lower carinæ.

HORIZON AND LOCALITY: In the upper Machiakou or Actinoceras limestone of Tangshan. The specific name is given in honor of Mrs. Dorothy Dickinson Barbour, wife of Prof. George B. Barbour the discoverer of the holotype, and by whom it was presented to the museum of the Survey.

Pagodispira dorothea var. **laxa** Grabau (var. nov.)

Plate III Fig. 13

This variety differs from the species in the laxness of coiling characteristic of the whorls. This is shown in the submature whorls by the fact that the lower carina shows above the suture and in the last whorl by actual looseness of the whorl. The apical angle is about 18 degrees. The lower carina is strong.

The earlier whorls, some of which are shown on the same rock fragment, have the normal character of the young of *P. dorothea,* which is also essentially like that of the adult *P. derwiduii.*

Horizon and Locality: This variety occurs in the upper beds of the Machiakou or Actinoceras limestone of Chaokouchuang, where it was collected by the Survey party.

Genus **LIOSPIRA** Ulrich & Scofield

Liospira barbouri Grabau (sp. nov.)

Plate III, Figs. 14a, b., 15a - c.

Shell of medium size but somewhat higher spired than in the majority of species of that genus. Height of spire somewhat variable, the apical angle ranging from 110^0 in the lowest to 95^0 in the highest spired individual. Whorls subrhomboidal, with a gently concave shoulder and a sharp shoulder angle which varies from 60^0 in the more strongly conical to 55^0 in the more depressed forms. Lower part of the whorl very gently convex or almost flat; with a sharp angle at the rather large umbilicus.

Peripheral band on the outer margin of the shoulder fairly well defined by a low but sharp carina or spiral, the succeeding whorl embracing to the outer edge of the peripheral band, i. e. to the shoulder angle, so that the suture is not depressed. Lines of growth nearly vertical or slightly oblique backwards in the upper half of the shoulder, after which they are strongly deflected backward to the peripheral band which they cross with a definite curve, producing a pronounced marginal notch (Plate III, Fig. 15c). Aperture not fully preserved in the known specimens.

This species has the rather flat base and subtrochoidal form of a *Euconia,* but the sharp shoulder augulation, the usual concavity of the shoulder, the large umbilicus with angular margins, and the slightly defined band on the peripheral margin of the shoulder, indicate its relationship to the genus *Liospira.* The character and position of the peripheral band, and the deep notch are features also suggestive of *Euconia.*

I am not acquainted with any American or European species with which this species is likely to be confounded. It has many of the characters of *L. vitruvia* (Billings) of the Middle and early Upper Ordovician (Stones River to Trenton) of Canada and the United States, but the spire is higher and the apical angle therefore less, in our species, while the shoulder angle of our form is also sharper and the lower part of the whorl flatter.

MEASUREMENTS. The following are the measurements of the types:

	Height	Diameter of body-whorl	Diameter of umbilicus
1.	(Fig 14), 12. 5 mm.	19. 5 mm.	5.5
2.	(Fig 15), 11. 5 mm. (approx.)	20. 0 mm. ±	6.

HORIZON AND LOCALITY: In the upper portion of the Actinoceras or Machiakou limestone at Tangshan, province of Chihli. Collected by George B. Barbour, Professor of Geology in Peking Christian University, in whose honor the shell is named. Also Survey collection.

Family **MURCHISONIDÆ** Koken

Genus **HORMOTOMA** Salter

Hormotoma doquieri Grabau (sp. nov.)

Plate III Figs. 16a-b

Shell small, high spired with 7 or more whorls (the apex is imperfect), which embrace very slightly, leaving the larger part of the preceding whorls exposed. Apical angle about 16°. Shoulder flat or gently convex. Shoulder angle obtuse, characterized by a revolving band, which is bordered by a spiral on either side. Lower part of whorl rounded, and broader than the shoulder. Lines of growth prominent, producing a subdued surface ornamentation. Aperture not fully shown, but apparently with an anterior notch.

This shell has the general character of *Hormotoma gracilis* Hall. from the Chazy and Stones River, and the Trenton of North America, but the shoulder is flatter in the Chinese form and the lower exposed part of the whorl proportionately higher than in the American species. The lines of growth are also more prominent in the Chinese form.

HORIZON AND LOCALITY: In the Liangchiashan limestone of the Shih-Mun-Chai region, eastern Chihli province, collected by F. F. Mathieu. The specific name is given in honor of M. Alexandre Doquier chief of mines of the Kailan Mining Administration.

Family **BUCANIDÆ** Ulrich & Scofield

Genus **SALPINGOSTOMA** Roemer

Salpingostoma terrilli Grabau (sp. nov.)

Plate II, Figs. 10a - c

Shell bellerophontoid with rather rapidly enlarging whorls, coiled in a single plane; the earlier whorls embraced by the later, so as to produce a rather small and deep umbilicus. Outer contour of whorls rounded, except where this is interrupted by the pronounced slit, the sides of which are slightly elevated. Apertural portion suddenly and flaringly expanded into a broad bellerophontoid lip, which extends on all sides of the whorl, and closes the slit in front. Surface markings not preserved.

The only specimen so far known is crushed on one side and on the front, but shows all the essential characters of the genus. The slit is wider than is usually the case in this genus and its borders are somewhat thickened. How much of this is due to silicification cannot be stated.

Compared with other species of this genus, the whorls of this form expand more rapidly and embrace more closely, thus giving a much smaller and deeper umbilicus than is usually found in this shell. The lip also appears to be broader and more extended than in other species. This genus is well represented in the Stones River (Chazy), and Black River formations of interior North America and in the Trenton of New York and Canada. It also extends into the Richmond group of the highest American Ordovician. The genus is further well represented in the Upper Ordovician of Esthonia (formations C1, C2 and F1)

Our species is more nearly of the type of those found in the Echinosphaerites limestone (C1) of Europe and those of the Trenton limestone of America, but is distinct from all of these forms.

Horizon and Locality: Associated with *Lophospira morrisi* and *Actinoceras tani* in the upper Machiakou or Actinoceras limestone of Tangshan, province of Chihli. At present represented by only one specimen. Collected by Messrs. Morris, Terrill and Barbour.

Holotype in the collection of the Chinese Geological Survey, Cat. No 32. Named after Mr. Arthur C. Terrill, Professor of mining in Peiyang University, the discoverer of the specimen,

Order **Ctenobranchiata** Schweigger

Family **PYRAMIDELLIDÆ** Gray

Genus **FUSISPIRA** Hall

Fusispira sp.

Plate III, Figs. 17, 18.

Among the material collected by M. Mathieu from the Peilintze limestone, are two specimens of a gastropod, which, from the general form of the spire and the contour of the whorls, is referable to the genus *Fusispira*. The apical angle is 11 or 12 degrees, and the shell consists of about 10 whorls if not more, the apical portion of both specimens being imperfect. The whorls are of somewhat greater diameter than their length, uniformly rounded, and gradually enlarging. The amount of embracing is slight, producing a loose-coiled shell, with a deep suture, which is very oblique, and forms an angle of 51 to 57 degrees with the axis of the shell. Character of aperture and nature of surface markings not ascertained.

This shell has the general form and proportions of *Fusispira angusta* Ulrich and Scofield, from the Trenton of the central United States, but the apical angle of the Chinese species is smaller by perhaps 5 degrees, the whorls shorter, and the suture deeper.

Horizon and Locality: In the Peilintze limestone of the Shih-Mun-Chai region, associated with *Ophileta squamosa*. Collected by F. F. Mathieu.

Class **CEPHALOPODA**

Order **NAUTILOIDEA** Zittel

Suborder **Holochoanites** Hyatt

Family **ENDOCERATIDÆ** Hyatt

Genus **PROTEROCAMEROCERAS** Ruedemann

Proterocameroceras mathieui Grabau (sp. nov.)

Plate IV, Figs. 1-3

Orthoceracones of unknown size, represented so far only by fragments, which suggest that the shell had a length of a foot, and probably much more. Moreover the fragments may represent only the earlier part of the conch.

Shell oval in section, the largest fragment known having a derso-ventral diameter of 23 mm., while the transverse diameter is something over 30 mm. At the same point the siphuncle has a diameter of 12 and 15 mm. respectively, thus being at this stage about one half the size of the shell. The ventral side is distinctly flattened, this being shown both in the shell and in the siphuncle, which lies in close juxtaposition to the flat ventral side of the shell. The thickness of the shell-wall at this point is half a millimetre. The cameræ average 3 mm. apart at this stage, and their concavity, as nearly as can be ascertained, is equal to about twice their distance apart at the center, or a little more.

Siphuncle distinctly flattened on the ventral side where it is in contact with the shell, the flattened part in the apical portion of the largest specimen being 9 mm. It tapers at the rate of about 1 mm. in 16. There is a well-defined and distinct wall, which encloses the siphuncle (*endosipholining* of Ruedemann). This siphuncular wall or inner shell is obliquely annulated by the edges of the siphonal necks, which are slightly but distinctly constricted just before reaching the next lower septum. The suture forms a distinct ventral saddle on the flattened surface of the shell. The anterior empty portion of the siphuncle (the *endosiphocylinder* of Ruedemann, i. e. the inner living-chamber) is broken away to the edge of the last-formed endosipbosheath (inner conical septum). The depth and apical angle of the endosiphocone, delimited by this last sheath, cannot be ascertained, but the former is at least 20 or 25 mm. which would make the latter about 25^{0}. The interior of the siphuncle below this cone is filled by crystalline calcite which has a distinct radial structure as in belemnites. In its center or nearly so, lies the subtriangular *endosiphocoleon*, flattened on the ventral side to correspond to the flat ventral face of the siphuncle. Its ventral diameter at the lower end of the specimen is about 2.5 mm.

Another specimen (Plate IV fig 2a-c) shows an earlier portion of the shell, apparently of a different individual. The shell is strongly oval, the maximum transverse diameter being 18 mm. while the dorso-ventral diameter is only 11 mm., though the shell appears to be somewhat crushed dorsally. The corresponding diameters of the siphuncle are 8 and 7 mm. respectively.

The septa are a little over 1 mm. apart. The siphuncle is in close juxtaposition to the flat surface of the shell, which is about 6 mm. wide. The sides of the siphuncle are obliquely annulated by the septal necks, which form an angle of 70^{0} with the ventral surface of the siphuncle, this being essentially the angle formed by them in the larger specimen. The endosiphocoleon lies somewhat dorsad of the center. Rate of tapering of siphuncle 1 mm. in 26.

On the exterior of the shell there appear to be broad very shallow and ill-defined concentric constrictions, but these are observed only on the ventral side, the rest of the shell not being visible.

Three fragments of the collection appear to represent parts of a single siphuncle of this species (Plate IV fig 3a-c). This is long and slender, but its entire length is not known, though the fragments preserved indicate a length of over 80 mm. At the smallest end preserved, the diameter is 6.5 mm., at the largest 9 mm. The rate of tapering is about 1 mm. in 25. The youngest fragment is slightly flattened ventrally and shows broad ill-defined undulations. It has a sub-central endosiphuncle, and the organic lime-filling (stereoplasm) of the remainder is obscurely radiate. In the larger fragments, the shell is circular in section, and appears entirely smooth, and is half a millimeter in thickness. In certain positions, however, very faint oblique lines are visible, suggesting septation. Within it, is at least one well-defined thick-walled conical sheath, tapering at the rate of 1 mm. in 10. Around this the crystalline lime has a radiating structure. The interior of the cone, formed by the sheath, is also filled with crystalline calcite, except at the larger end (3b), where an open semilunar cavity exists, due to removal of softer filling. At the upper end of the largest fragment this has a vertical diameter of 1.6 mm. and a basal width of 4.8 mm. On the other side of the fragment, which is 20 mm. long, this semilunar tube, here still retaining its filling, has been reduced to about half these dimensions. The structure of the interior filling of calcium carbonate is also radiate. The presence of three other sheaths is indicated by concentric tubular interruptions of the crystalline (generally radiate) lime-filling, but these were exceedingly thin walled, possibly membranous. *

Except for the very faintly indicated oblique ridges these siphuncular fragments suggest the preseptate apical end of *Proterocameroceras*, and for such they were at first taken. This is also suggested by the circular cross-section, but on the other hand, their size agrees with that of the siphuncle of the species where still surrounded by the camerae (Plate IV fig 2).

Horizon and Locality: This species occurs in the Lower Ordovician Peilintze limestone of Pei-lin-tze, Shih-Mun-Chai region near Chingwangtao eastern Chihli. It is associated with *Chihlioceras*, *Archaeocyathus* etc. Collected by F. F. Mathieu, in whose honor the specific name is given.

---

* This supports Ruedemann's contention that endosheaths are present in *Cameroceras* (including *Proterocameroceras*), below the final thick-walled sheath of the adult living-chamber. At least one of these in the present specimen, is thick-walled and of well defined character.

Genus **CAMEROCERAS** Conrad (emend. Hyatt)

Cameroceras styliforme Grabau (sp. nov.)

Plate IV Figs. 4-6

A small slender siphuncle of *Cameroceras* occurs in the upper or Liangchiashan beds but no portion of the shell remains in the specimens so far obtained.

A specimen (Plate IV fig. 4) measuring 30 mm. in length, and of suboval section, measures 3.5 mm. in transverse, and 2.5 mm. in dorso-vental diameter at the lower end. The corresponding measurements at the upper end are 6.6 mm. and 4.8 mm. respectively. The vental side is distinctly flattened. The siphuncle was evidently enclosed by cameræ. Their distance apart near the upper end, as shown by the annulations, was 2.2 mm. and the angle which these annulations form with the ventral line of the siphuncle is about 68 degrees. Wall of siphuncle of moderate thickness; interior filled with crystalline calcite, but showing in the center, at the smaller end of the siphuncle, an empty endosiphocoleon of semi-lunar section, its flat base corresponding to the flat side of the siphuncle. The width of this side is 1.3 mm. while its dorso-ventral diameter is 0.5 mm. (Plate IV fig. 4b). There are three other lumens irregularly placed around the periphery, but equi-distant from the outer wall, indicating that they represent part of an endosiphosheath. *

Another fragment (Plate IV, figs. 5a-c) representing a larger portion of the siphuncle, measures 7.3 and 5.9 mm. respectively in lateral and dorso-ventral diameters. The ventral side is not so much flattened, but is more broadly rounded than the dorsal. The siphuncle at this point was not absolutely in contact with the shell, for the septal edges form a distinct, broad, rounded saddle upon the ventral side. Septa 2.2 mm. apart. Siphuncular wall (silicified) rather thick, the interior filled with crystalline calcite, except for a central sheath of similar section as that of the wall of the siphuncle, and like that, silicified. Its diameters, at the upper end are: lateral, 5 mm., dorso-ventral, 3 mm., the dimensions of the siphuncle at this end being 7.3 and 5.9 mm. respectively. At the other end, 8 mm. distant, where the dimensions of the siphuncle are 6 and 5 mm. the inner tube measures 3 and 1.8 mm. respectively. Thus, while the lateral tapering of the siphuncle is 1.64 mm. in 1 mm. and the dorso-ventral tapering 1.12 mm. in 1 mm., that of the inner tube is 2.5 and 1.5 in 1, respectively.

A third specimen (Plate IV figs. 6a-c) represents a still larger portion of the siphuncle of apparently the same species. Its length is 13 mm., while the diameters at

---

* See the foot-note on p. 38

the larger end are 10 and 9 mm., and the corresponding measurements at the smaller end 8.2 and 8 mm. respectively. The corresponding measurements of the endosiphuncle are:—upper end, 5.7 mm. and 4.7 mm., lower end, 2.5 mm. and 2 mm., respectively. Although somewhat compressed, there is no flattening of the siphuncle and the septal ends, which still adhere to the silicifield siphuncle, form only a very gentle obliquity with its axis. This indicates that the siphuncle at this stage was no longer in contact with the wall of the shell, but had been surrounded by the cameræ on all sides, including the ventral. This is further shown by the fact that the ends of the septa still remaining, are stronger on the ventral side (side of forward convergence) than elsewhere. The septa average about 2 mm. apart.

In spite of the variations here shown, I am disposed to think that we are dealing with one species only. This is however quite distinct from the species found in the lower horizon (i. e. *Proterocameroceras mathieui*).

Horizon and Locality: A number of fragments were obtained by Dr. F. F. Mathieu from the upper or Liangchiashan limestone of Liang-Chia-Shan, near Chingwangtao, eastern Chihli. The age is late Lower or perhaps early Middle Ordovician. Geol. Survey collection cat. nos. 103 to 107.

Genus **SUECOCERAS** Holm

Suecoceras yehliense Grabau (sp. nov.)

Plat IV, Figs. 7a, b.

Represented only by the apical portion of the endosiphuncle which shows the slight but distinct inflation characteristic of the genus. The most perfectly preserved specimen (Plate IV, fig. 7), has a length of about 40 mm. Its apex is pointed and its diameter increases rapidly at first, then more slowly, until at a point about 20 mm. from the apex, it has a diameter of 13.2 mm. Then it decreases slowly, its diameter at the upper end of the specimen being 12.5 mm. A second specimen shows a maximum diameter of 11.3 mm. at a point about 20 mm. above the apex and then decreases to 10.5 mm. at a distances of about 28 mm. from the apex.

Neither specimen has the surface well preserved, but on the larger one the oblique septal lines are indicated in the apical portion. At first they are 1.5 mm. apart, this distance increasing to nearly 2 mm. shortly after. The obliquity of the septal lines, with reference to the axis of the shell, is 55 degrees.

Horizon and Locality: In the lower Yehli limestone of Lower Ordovician age, at Yeh-li, northern rim of Kaiping coal basin. (Y. C. Sun coll.).

Suecoceras attenuatum Grabau (sp. nov.)

Plate IV, Figs. 8, 9.

Like the preceding, this is known only from the siphuncle, which clearly shows it to be a more slender form, and one which never reaches the siphuncular diameter of the preceding species.

The siphuncle (in fig. 8) gradually increases in diameter from the initial point, reaching its maximum of 9 mm. at a point distant about 20 mm. from the apex. After that it decreases again, until at the uppermost preserved end, it is 7.5 mm., this being about 40 mm. from the apex. In another specimen, the greatest diameter is 9.3 mm. at a point about 25 mm. from the apex, narrowing subsequently to 8.9 mm.

In one specimen, apparently of this species, the diameter of the siphuncle is 9.8 mm. at the upper end, this being the aperture of the endosiphocone or uppermost one of the conical fillings (endosiphosheaths) of the siphuncle (see Plate IV fig. 9). The position of the endosiphosheaths in the siphuncle seems to be oblique, their axis not coinciding with the median line of the siphuncle as a whole.

Horizon and Locality: In the lower beds of the Yehli limestone near Yeh-li northern border of the Kaiping coal field, Chihli. (Y. C. Sun coll.).

Genus **VAGINOCERAS** Hyatt

Vaginoceras tsinanense Grabau (sp. nov.)

Plate IV, Figs. 10a, b.

Represented at present only by the siphuncle, which however has certain very definite characters from which some of the other characters of the shell can be deduced.

The form of the siphuncle is sub-cylindrical, increasing from 9.6 mm. at the lower preserved end, to 10.8 mm. at the upper, the distance being 40 mm. This gives a rate of tapering of 1 mm. in a length of 33 1/3 mm.

The siphuncle is filled solidly with the endosiphosheaths but these have been converted into crystalline lime. The upper portion of the specimen however shows the endosiphocone or funnel-like prolongation of the living-chamber into the siphuncle, bounded by the last endosiphosheath. This part of the specimen is partly filled with the lime matrix in which the shell is embedded. Endosiphuncle unknown.

The sides of the siphuncle are distinctly marked by the necks of the septa, and these show that the later ones extend beyond the upper edge of the preceding one, thus showing that the shell belongs to the genus *Vaginoceras*. The direction of the septal lines is strongly oblique, forming an angle of about 50° with the axis of the siphuncle and meeting on the ventral side in an angle of about 70°. This indicates that the siphuncle is subventran in position. The septa average about 3.3 mm. apart.

The subcylindrical character of this siphuncle is its most marked feature, and this together with the obliquity of the septal lines, and their relative closeness, serve to differentiate this species from others found in the Ordovician beds of China.* In the characters noted, our species is not unlike the early stages of *Vaginoceras oppletum* Ruedemann, from the Chazy beds of the Lake Champlain region of the eastern United States, but there is no indication that the Chinese species ever reached the size of the adult American form.

Horizon and Locality: In the upper quarry beds of the Machiakou limestone, associated with *Actinoceras*, *Lophospira* etc., Cement quarry Tangshan. Survey expedition coll.

Family **PILOCERATIDÆ** Hyatt

Genus **PILOCERAS** Salter

Piloceras platyventrum Grabau (sp. nov.)

Plate IV, Figs. 11 a-c, 12 a-c. Text figures 1 a-e.

Siphuncle with broadly subconical apex with endosiphuncular scar or slightly protruding endosiphuncle; enlarging rapidly until at a point 15 mm. from the apex (in one specimen fig 11), it has reached a diameter of 21 mm., after which it enlarges more gradually at the rate of about 15 mm. in 10 of length, while later on it appears to be subcylindrical. The apical portion of the siphuncle (for about 35 mm. in the only specimen showing this part) appears smooth, this part ending in a faint broad but

---

* Several species occur in the Ordovician rocks of south China. These will be described in a future number of this publication.

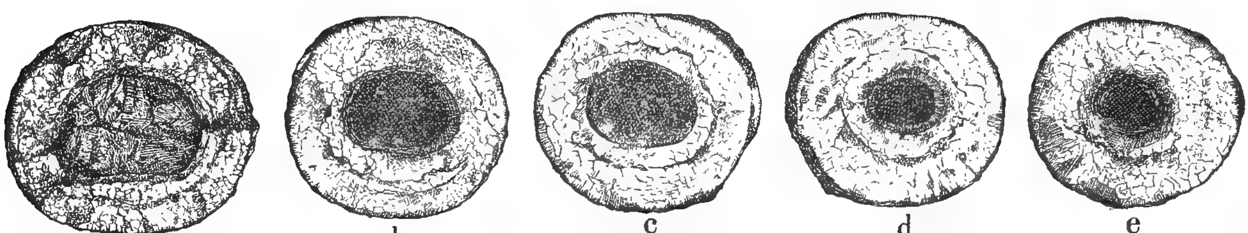
unmistakable constriction, after which the expanding shell of the siphuncle becomes annulated. This suggests that the apical portion of the siphuncle was not enclosed by cameræ. The annulations (shown well in specimen fig. 12) are oblique, forming on the side an angle of about 60° with the axis of the siphuncle. They become fainter on the ventral side, meeting in a broadly rounded forward curve or saddle. About five of these annulations occur in the space of 20 mm.

In transverse section, the siphuncle appears slightly broader than high, the ventral surface being somewhat flattened.

Interior of siphuncle with endosyphosheaths and crystalline lime-filling between them. Two or possibly more of these older endosheaths are indicated. The endocone formed by the final (last-formed) sheath of the most mature individual seen (fig. 12c), is of subcircular section in the upper part, with the ventral surface slightly flattened. In the lower part, or at least in the earlier sheaths, this ventral surface becomes strongly flattened and the greater part of the endocone lies dorsad of the center (fig. 11c). It is continued posteriory in the dorso-ventrally compressed endosiphuncle. The thickness of the last endosheath (the wall of the endocone) is about equal to that of the wall of the siphuncle.

In the specimen shown in fig. 11, the dorso-ventral diameter is 31 mm., the corresponding diameter of the endocone is 11.5 mm., the space between it and the ventral surface being 11.5 mm., while that between its dorsal surface and the corresponding surface of the siphuncle is 8 mm. This point is about 13 mm. from the apex of the endocone.

A series of sections of another specimen shows the following relationship. (Text figs. 1a-e).



Figs 1 a-e. Succesive cross-sections of the siphuncle of *Piloceras platyventrum* (For distances apart, and measurements see table p. 44); 1a, largest section preserved; 1e, last section before end of endocone. Natural size.

Section No.	Distances between Sections	Dorso-ventral diameters of Siphuncle	Dorso-ventral diameters of Endocone	Distances between ventral surfaces of siphuncle & endocone	Lateral diameters of Siphuncle	Lateral diameters of Endocone
a		27.5 mm.	15.3 mm.	8.5 mm.	32. mm.	21.5 mm.
	15 mm.					
b		26.8 ,,	10.5 ,,	9.3 ,,	30. ,,	13.2 ,,
	2 mm.					
c		26.6 ,,	9.5 ,,	10. ,,	29.5 ,,	12.3 ,,
	6 mm.					
d		26. ,,	6. ,,	11. ,,	28.5 ,,	8. ,,
	2 mm.					
e		25.5 ,,	5.5 ,,	11.3 ,,	28. ,,	7. ,,
	6 mm.					
f		23.7 ,,	—	—	26. ,,	—

In the specimen from which these sections are taken, the annulations of the shell of the siphuncle are finer, there being 5 in the space of 10 mm. This specimen is recorded as from the lower horizon, the Peilintze limestone, whereas the others occur in the upper or Liangchiashan limestone of the Shih-Mun-Chai district. The specimen in question may represent a distinct species.

Horizons and Locality: Two specimens of this species were obtained by Dr. F. F. Mathieu from the Liangchiashan limestone at Liang-Chia-Shan, Shih-Mun-Chai near Chingwangtao, eastern Chihli province. Another specimen with finer annulations and siphuncle less flattened ventrally, was obtained from the *Chihlioceras* or Peilintze limestone of the same region (this may possibly be a case of mislabelling). The former horizon is the upper part of the Lower Ordovician.

Family **CHIHLIOCERATIDÆ** Grabau (fam. nov.)

Genus **Chihlioceras** Grabau (gen. nov.)

Text Figures 2-16

Breviconic orthoceracones with large and stout siphuncle, which is surrounded by a definite wall or siphuncular shell; with rounded apical end, the center of which is marked by a mammillary elevation with a circular scar, representing the beginning of the endosiphuncle. Siphuncle filled with endosheaths and organically deposited mineral matter as in *Piloceras*. Endosheaths flattened ventrally, at least in the adult. In the final one, this flat face is produced anteriorly in the form of a blade-like prolongation, which is either flat or slightly arched inwards with depressed sides. In its general form and character the final endosheath suggests the conotheca of the Belemnite which is prolonged forward into the delicate blade-like proöstracum, or the similar blade of the odern cuttle-fish. This blade-like prolongation slopes ventrad until it apparently joins the wall of the siphuncle on the ventral side. On the dorsal side, the blade may have been covered by the shell of the siphuncle, but of this there is no positive evidence. Indeed the sections negative it, although it is of course conceivable that the shell was broken away before burial.

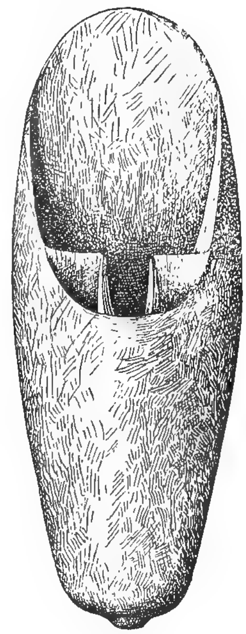


Fig. 2.

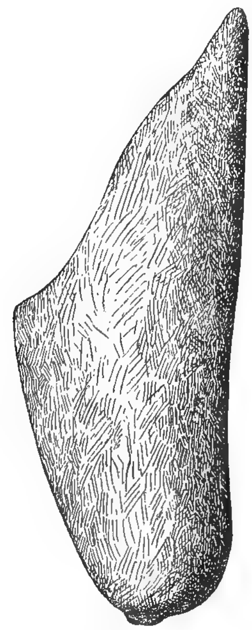


Fig. 3.

Fig. 2. *Chihlioceras nathani.* Dorsal view of a model of the siphuncle of this species with the compound endocone in place. Two thirds natural size.

Fig. 3. *Chihlioceras nathani.* Side view of the same. (The annulations of the surface are not represented.)

The endocone is triple in character. In the genotype the main part has a sub-quadrangular to sub-crescentric cross-section, but appears to taper into a more or less flattened conical alveolus towards the apex. On the ventral side, where the wall of the endocone is prolonged into the blade, the inner surface is gently convex i. e. arched upward (dorsally) with the sides sharply depressed (see text fig. 7). The upper surface of this cavity is flat or nearly so, except for the median portion, which is prolonged dorsally into a broad notch or emargination, on either side of which lie the dorso-lateral alveoli. The outer wall of these is rounded, but the inner wall consists of two limbs, approximately at right angles to each other, one, the dorso-ventral limb, separating it from the median prolongation of the main cavity, the other being horizontal and dividing the lateral and main alveolar cavities (see text figs. 4 and 7). The position of this

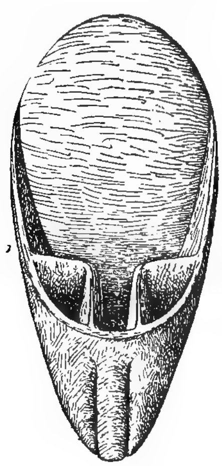


Fig. 4.

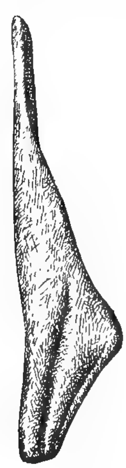


Fig. 5.

Fig. 4. *Chihlioceras nathani.* Dorsal view of a model of the final endosheath, which forms the compound endocone of the siphuncle of this species. Two thirds natural size.

Fig. 5. *Chihlioceras nathani.* Side view of the model of the endocone shown in fig. 4. Two thirds natural size.

final endosheath is nearer the dorsal than the ventral side of the siphuncle (text fig. 6) as is shown by the two parallel sections (text figs. 8 and 9), taken essentially parallel

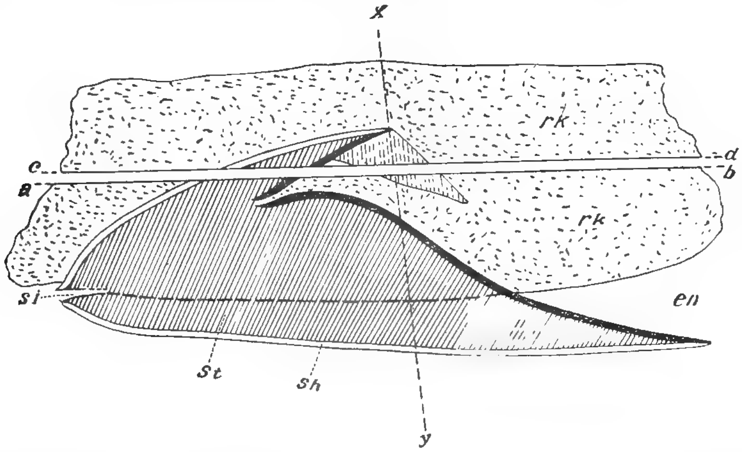


Fig. 6. *Chihlioceras nathani.* Restored longitudinal section, constructed from actual measurements along section *a - b* and *c - d*, and the exposed worn surface of the ventral side (lower dotted line), and with the aid of other specimens. x - y line of section shown in fig. 7. Two thirds natural size. *en*-final sheath, or endoconic lining; *sh*-shell-wall of siphuncle (ectosiphuncle). *st*-stereoplasmic filling of siphuncle; *si*-endosiphotube; *rk*-section of rock matrix.

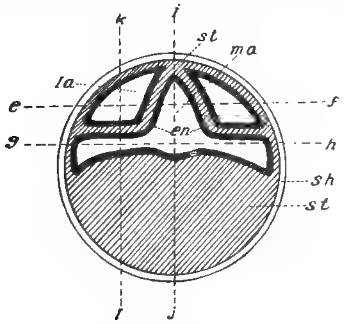


Fig. 7.

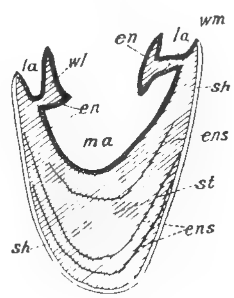


Fig. 8.

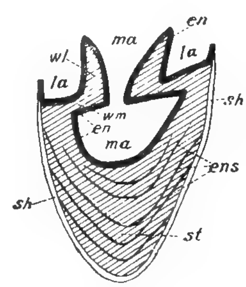


Fig. 9.

Fig. 7. *Chihlioceras nathani.* Transverse section along line x - y of fig. 6; 2/3 natural size. e - f. line of section of fig. 10; g - h. line of section of fig. 11; i - j. line of section of fig. 12; k - l. line of section of fig. 13; *en*-parts of endoconic lining or final sheath; *la*-lateral alveolus; *ma*-median alveolus; *sh*-shell of siphuncle (ectosiphuncle); *st*-stereoplasmic filling.

Fig. 8. *Chihlioceras nathani.* Somewhat restored section along line *a - b.* fig. 6. (For actual appearance of section see Plate II, fig. 11.) - 2/3 natural size. The section is cut obliquely to the axis of the lateral alveoli (see text fig. 2), and cuts the lateral walls (*wl*) as well as the lower walls (*wm*) of the lateral alveoli; *ens*-older endosheaths buried in the filling of stereoplasm *st*. (Other notations as in figs. 6 and 7.) 2/3 natural size.

Fig. 9. *Chihlioceras nathani.* Corresponding restored section along the line c - d in fig. 6. This section is here reversed, so that the parts have the same orientation as in fig. 8. Notation as in fig. 8. 2/3 natural size (See Plate II, fig. 12).

to the ventral surface of the siphuncle, as indicated by the lines a-b and c-d in text fig. 6, which is drawn to scale, and is two thirds natural size. The sections (text figs. 8 and 9) show that the walls of the alveolar cavities are infolded portions of the sheath, which, when considered separately i. e. as if freed from the enclosing organic lime - deposit, represents the aspect shown by the model, illustrated in text figs. 4 and 5. The walls, which separate the lateral from the main alveolar cavities, are thus double, with the addition of the crystalline, organically deposited lime (stereoplasm) between the two layers. This is diagrammatically represented in text figures 7 and 10, which represent respectively transverse and longitudinal sections through these walls, (for location see text fig. 7), and can be recognized from an inspection of figs. 8 and 9, which represent the actual oblique sections through both walls.

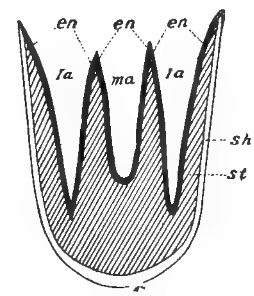


Fig. 10. *Chihlioceras nathani.* Diagrammatic longitudinal section along line *e-f.* in fig. 7, parallel to axis of lateral alveoli. (Notation as in fig. 7.).

That an endosiphuncle extends from the base of the main alveolus to the apex of the siphuncle is suggested by the occurrence of the apical endosiphuncular scar seen on all the specimens, and is further suggested by the appearance of what seems to be a part of this tube in the natural section shown in fig. 13, Pl. IV, i. e. the specimen from sections of which the reconstruction of the sheath is mainly developed.

A consideration of the structure of the final endosheath in the second species (*C. chingwangtaoense* (Plate II, figs. 13a, b.) shows very striking differences, but nevertheless a unity of plan. The main or median alveolar cavity has been much reduced, being subtriangular in outline, and only occupying the central third of the endosheath. The cavity too is short, though probably prolonged in the endosiphuncle. The dorso-lateral alveolar cavities are deep, and lenticular in section, the inner side being gently concave instead of rectangular. The partitions between the cavities are very thick, formed by the bent-over endosheath, with a thick filling of crystalline lime between. The crystalline filling (probably aragonite) has a radial structure where seen in section of the entire siphuncle. The outer wall of the dorso-lateral alveolar cavities was apparently formed by the wall of the siphuncle. The sections (text figs. 14, 15 and 16) show this structure. The length of the two lateral alveoli may be quite different on opposite sides as shown in the specimen figured (Plate II, fig. 13a).

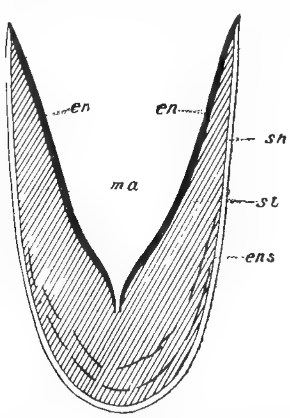


Fig. 11. *Chihlioceras nathani.* Diagrammatic longitudinal section through the broadest part of the median alveolus, along the line *g-h.* in fig. 7. (Notation as in fig. 7.)

In none of the specimens so far obtained has a camerate portion been preserved. All the specimens are annulated, the annulations being essentially of the type seen on the siphuncle of *Piloceras.* This suggests a camerate structure but does not prove it. The annuli appear to be slightly oblique, converging forward on the ventral side. This suggests, that if cameræ were present they were mainly developed on the dorsal and lateral surfaces of the siphuncle, as would naturally be the case in a structure which, as these evidently did, rested upon the ventral surface. No specimen is however known with a complete ventral surface, and the convergence is only shown by a slight obliquity upon the sides.

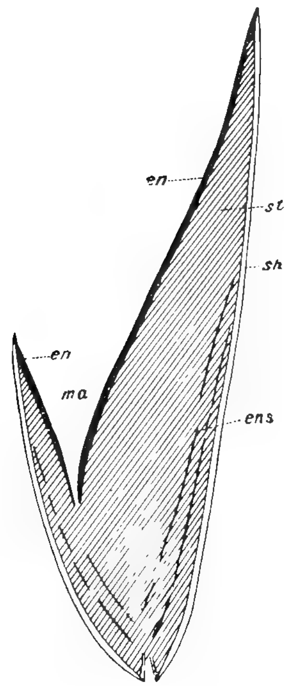


Fig. 12. *Chihlioceras nathani.* Diagrammatic longitudinal section in the median plane along the line *i - j.* in fig. 7. (Notation as in fig. 7.)

As indicative of the position of the specimens, it may be noted that in one slab of rock, both sides of which were weathered, and in which four specimens of *C. nathani* were found, three, on the same side of the slab, exposed the *dorsal* side (Plate V.) (this was apparently the upper surface of the slab though sufficient care was not taken at the time of collecting to determine this) while the fourth, on the opposite side of the stratum (apparently the under side), exposed the weathered *ventral* surface (Plate IV fig. 13). This slab was cut apart, essentially parallel to the bedding plane, and the two cut surfaces show the sections of the dorsal portion of the lower specimen, these being shown in Plate II, figs. 11 and 12. The position of the longitudinal axis of the lower specimen was however approximately at right angles to that of the upper specimens.

The remarkable character of the siphuncle warrants the placing of this genus into a distinct family, that of the CHIHLIOCERATIDÆ. The characters of this new family may be summarized as follows:

Relatively short and stout holochoanitic othoceracones (and cyrtoceracones?) with large siphuncle, generally divided by endosheaths, and filled with organically deposited calcium carbonate. Final endosheath prolonged into a ventral blade, and characterized by median and lateral endocones. Cameræ unknown, but if present, apparently as in *Piloceras*. Ordovician.

Chihlioceras nathani Grabau (sp. nov.)

Plate I. fig. 10; Plate II, figs. 11, 12; Plate IV, fig. 13; Plate V; Text figures 2-13.

Siphuncle beginning with a regular rounded end, characterized by a subcentral mammillon with a large central scar, which marks the beginning of the endosiphuncle. The expansion is rapid so that in the space of about 16 mm. from the apex (in the central specimen shown in Plate V) it has reached a diameter of 30 mm. From this point the expansion is regular, until at about the point near the apex of the median endocone, about 40 mm. farther (or 56 mm. from the apex of the siphuncle) the lateral diameter is 40 mm. This gives a rate of tapering of 1 mm. in 4. The earlier portion is regularly rounded, while the part occupied by the endocone is somewhat flattened on the ventral side. The endocone occupies something more than one half the length of the shell, inclusive of the anterior blade. The apical portion in the center is rounded dorsally and flat or gently concave on the ventral side, its section thus being semi-circular or compressed suboval, with the ventral side curved to a greater radius. Proceeding forward, the concave central portion narrows and flattens, while the sides of the blade become strongly and sharply depressed, until near the anterior portion of the blade they form less than a right angle with the side. The aperture of the endocone, i. e. the edge formed by its meeting with the shell of the siphuncle, is oblique to the axis of the siphuncle, the most projecting portion being the center of the blade (see the restoration, text figs. 2 and 3). Lateral alveoli of the endocone shorter than the main cavity. In the specimen shown in the center of Plate V the alveoli are not seen, but in the somewhat crushed right hand specimen of that group, they are recognizable (Plate I fig. 10), being displaced somewhat to one side. The inner walls of these lateral alveoli form approximately a right angle, and consist of the reduplication of the endosheath with crystalline calcium carbonate filling between. The outer wall of the lateral alveoli is convex and between it and the wall of the siphuncle, there is a thick layer of crystalline lime (organic deposit) which decreases wedge-like towards the rim of the endocone. (Text figure 10).

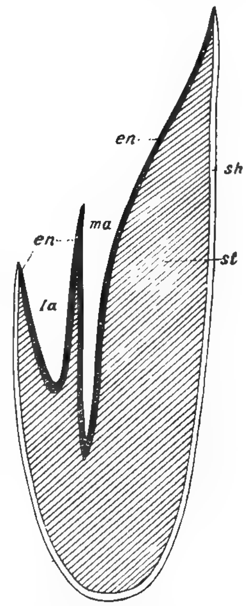


Fig. 13. *Chihlioceras nathani.* Diagrammatic longitudinal section half way between median plane and lateral margin, along line *k - l.* in fig. 7. passing through lateral part of median, and one lateral alveolus (Notation as in fig. 7.)

These lateral alveoli of the endocone hold a position above the base of the main endoconic cavity, so that there are distinct lateral chambers proceeding from this main median chamber, and in position ventral to the lateral alveoli. This is clearly shown by the sections (Plate II figs. 11 and 12) and is represented in the model of the endosheath illustrated in text fig. 4. The endosheath itself (i. e. the wall of the endocone) has a thickness of half a millimeter or less, but because of the filling of crystalline lime between the reduplicated portions, which form the lateral and median alveoli, the thickness of the compound wall separating these alveoli may be from 2.5 to 6 mm. (See the sections of these walls in figs. 11 and 12 Plate II).

The older portion of the siphuncle is filled solidly with crystalline calcium carbonate, this occupying the entire space between the wall of the endocone (final endosheath), and probably its endo-siphuncular prolongation, and the wall or shell of the siphuncle. There are however indications of one or more earlier endosheaths (See sections figs. 11 and 12 Plate II, and Plate V middle figure). The difference in the character of the outer zone of the solid portion of the siphuncle from that forming the inner portion, observable both in the worn specimen (Plate V, middle figure) and in the sections (Plate II figs. 11 and 12) suggest that at first the siphuncle was filled with closely set endosheaths (which in the large specimen of the group on Plate V formed a thickness of about 7 mm.), and then crystalline calcium carbonate (aragonite?) was deposited by the animal, without further formation of definite endosheaths, until the final one was formed by the adult animal. The appearance of these older endosheaths suggests their similarity to those of *Piloceras*, or to a primitive form from which both *Chihlioceras* and *Piloceras* were derived.*

The wall or shell of the siphuncle is thin but continuous. It is annulated, though indistinctly so, near the apical portion, while forward, the annulations become pronounced and regular. The annuli present a long gently convex forward slope and a shorter more abrupt, but still convex apical slope. There are 10 of these annuli in the space of 35 mm., giving them an average width of 3.5 mm. There is however a gradual increase in the width, the posterior ones being less than 3 mm. wide. The depressions between the annuli are very shallow. While this is the character in the earlier portion of the siphuncle, continuing for varying lengths in different specimens, it gradually changes in the later-formed portion, where the annuli become narrowly rounded, with broad gently concave interspaces. In the specimen shown in fig. 13 Pl. IV, this type of annulation begins about 30 mm. from the apex, and there are 10 annuli in the space of 38 mm., these also increasing slightly in width forward.

The annuli are oblique, bending forward on the ventral side. The angle which they form with the axis of the siphuncle on the side of the siphuncle, was found in one case to be about 30 degrees, but less than that in another specimen. Their ventral aspect is unknown.

Cameræ not known, none of the specimens showing any indications of them other than the annulations of the siphuncle. Though this annulation is suggestive of a camerate nature of the shell, it is not a positive indication, as camerate shells with

---

* In the locality from which these specimens were obtained, they are restricted to the lower division, while *Piloceras* occurs in the higher division, with one doubtful representation in the lower.

obliquely annulated outer wall are found in higher Ordovician beds of this region. The general similarity of the annulations to those of the siphuncle of *Piloceras* may indicate, however, a similar camerated shell.

Horizon and Locality: This species has been found in the Peilintze limestone associated with *Archæocyathus*, *Ophileta squamosa* etc., in the Shih-Mun-Chai region near Chingwangtao, Lingyühsien district, Chihli province. Several specimens were collected by Dr. F. F. Mathieu of the Kailan Mining Administration. The horizon is Lower Ordovician. The specific name is given in honor of Mr. W. S. Nathan, president of the Kailan Mining Administration, in appreciation of his keen interest in the development of Chinese geology, and his recognition of the important place which stratigraphic and palæontologic problems hold in the practical development of mining interests.

Chihlioceras chingwangtaöense Grabau (sp. nov.)

Plate II, Figs. 13a b. Text figures 14-16.

Siphuncle longer and more cylindrical than in the preceding species, tapering at the rate of 1 mm. in 6; section subcircular. Interior filled with crystalline calcium carbonate, which has an indistinct radial structure. This occupies the space between the shell or wall of the siphuncle on the one hand, and the wall of the compound endocone (final endosheath) on the other. There are no indications of older sheaths, though these may occur in the apical portion which is unknown. Endosiphuncle apparently central, but the indications are faint. Wall of the endocone prolonged forward in a flat blade which slopes forward, forming an angle of 12 degrees with the dorsal surface of the siphuncle (See text fig. 14). If the rate of tapering is uniform, the length of the anterior blade would approximate 110 mm.

The blade is flat, except for a slight median longitudinal depression, most marked in the alveolar portion. The lateral margins of the blade form a sharp angle with the sides of the siphuncle, and the wall or shell of the latter was evidently continued over at least the posterior part of the blade. Posteriorly the blade ends in the median alveolus, the base of which occupies one third of the width of the siphuncle. Its height is slightly less than the basal width, and its form is subtriangular but with curved sides. Its position is approximately in the center of the siphuncle or slightly above it. Its depth has not been ascertained, as some of the matrix which filled it, has not been removed. The partition between it and the lateral alveoli is thick, being from 7 to 8 mm. at the rounded forward end, and increasing in thickness apicad. (See section, text figures 15 and 16). It consists of the thin endoconic walls (reduplications of the endosheath) and the filling of crystalline calcium carbonate between these.

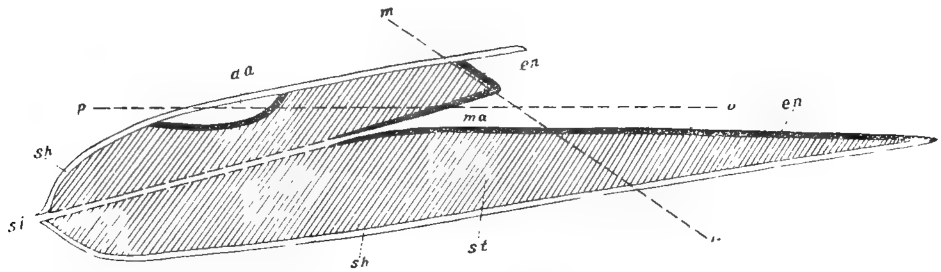


Fig. 14. *Chihlioceras chingwangtaoense.* Diagrammatic longitudinal section along the median dorso-ventral plane of a restored individual; *m-n.*-section line of fig. 15; *o-p.*-section line of fig. 16; *sh.*-shell (ectosiphuncular wall); *st.* stereoplasmic filling; *si.*-endosiphotube; *en.*-endoconic lining or terminal endosheath; *da.*-dorsal alveolus; *ma.*-median alveolus.

The lateral alveoli are lenticular in section, only the inner, gently concave wall being formed by a part of the endosheath, while the outer is formed by the wall of the siphuncle, and in the type specimen, as preserved, is broken away. In this specimen the size and form of the two lateral alveoli differ from each other, that on the right * being much larger. The line of junction between it and the siphuncular wall (shell) is a direct continuation of the plane of the anterior endoconic blade. The sides of this alveolus converge regularly. The left lateral alveolus is more irregular. At first there is a strong convergence of the sides, after which they continue more nearly parallel. Posteriorly the two alveoli join into a single broad median cavity, the floor of which is formed by the two lateral alveolar floors meeting in a low angle, to the left of the median line in the type specimen. (See fig. 13a Plate II). The length of this posterior confluent cavity can be estimated from the slopes of the lateral alveoli, this being indicated in the restored longitudinal section (text figure 14).

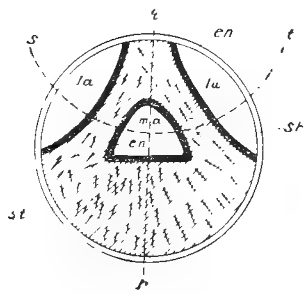


Fig. 15. *Chihlioceras chingwangtaoense.* Diagrammatic cross-section along line *m-n.* in fig. 14; *q-r.*-median dorso-ventral plane (line of section of fig. 14); *s-t.*-line of section of fig. 16; *la.*-lateral alveoli; other notations as in fig. 14.

The inner shell or siphuncular wall, is about 0.3 mm. in thickness and strongly and regularly annulated upon the sides, these annulations forming an angle of approximately 82^0 with the dorsal surface, or 70^0 with the plane of the anterior endoconic blade.

* The shell is oriented with the apex to the observer, the aperture or anterior end pointing away, and the ventral side, (i.e. flattened side of endocone), downwards. The right and left sides then correspond to the observer's right and left hand. In the figures on Plate II the position is reversed, so as to show the structure more clearly; therefore the references must also be reversed from those here given.

This indicates that on the ventral surface they formed a broad, low, forward arching curve or saddle, though the actual condition has not been observed. The annulations are broadly and regularly rounded and separated by concavities of equal form and width. There are six annulations in the space of 18 mm. giving an average width, between the centers of adjoining concavities, of 3 mm. Cameræ unknown, but their existence is apparently indicated by the annulations of the siphuncle.

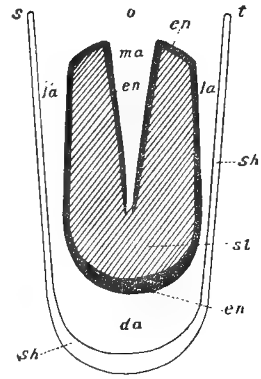


Fig. 16. *Chihlioceras chingwangtaoense*. Diagrammatic section along line *o - p*. in fig. 14 and line *s - t*. in fig. 15 (notations as in figs. 14 aud 15).

Measurements: Diameter at aperture of alveoli 35 mm.; at point of confluence of lateral alveoli 28 mm. Width of median alveolus at base 13.5 mm.; height of same 10 mm.

Horizon and Locality: A single specimen of this species (Pl. II figs. 13 a-b) was obtained by Dr. F. F. Mathieu from the weathered, iron-stained Peilintze limestone at Peilintze, associated with the preceding species and with *Archæocyathus* etc. The horizon is Lower Ordovician.

PHYLOGENETIC SIGNIFICANCE OF THE SIPHUNCLE OF THE HOLOCHOANITES.

It has long been known that in certain members of the suborder Holochoanites the early part of the siphuncle, so-called, is entirely devoid of surrounding cameræ. The genus *Proterocameroceras* shows perhaps the most extensive pre-camerate development of this part of the shell. This has been fully described by Whiteaves and especially by Ruedemann, who in discussing the siphuncle of *Proterocameroceras brainerdi* from the Fort Cassin or upper Beekmantown (Lower Ordovician) of Lake Champlain (U. S. A.) speaks of the apical portion as " projecting beyond the chambered shell for a distant of about 75 mm., gradually expanding from the blunt apical end, which here has a diameter of about 3 mm., to 11.5 mm. at the beginning of the phragmocone, where it contracts to 10 mm. and then gradually expands again".*

---

* R. Ruedemann - Cephalopoda of the Beekmantown and Chazy formations of the Champlain Region. New York State Museum, Bulletin 90 p. 407, 1906. *See also* R. Ruedemann, Structure of some primitive Cephalopoda. Annual Report State Palæontologist N. Y. 1903, N. Y. State Museum Bull. 80 p. 296. I regret that I have not had available, until after this paper was in type, this most searching study of the structure of the primitive Cephalopoda by this eminent palæontologist, and that my reference could, therefore, not be as extensive as was desirable.

In *Cameroceras* on the other hand the nepionic bulb or swollen end of the siphuncle, is largely or wholly surrounded by cameræ, and this is also the case in *Endoceras*, and generally in *Vaginoceras* except in such forms as *Vaginoceras belemnitiforme* Holm. These two genera differ from *Cameroceras* and *Proterocameroceras* in the absence of the siphuncular wall or shell, (the endosipholining of authors).

Another genus in which this preseptal cone or nepionic bulb exists before the camerate portion begins, is *Nanno* Clarke, also of Middle and early Upper Ordovician (Chazy and Black River) age. In this genus the siphuncle is strongly contracted at the beginning of the camerate portion, after which it remains in contact with the outer shell of the camerate portion, on the ventral side.

The presence of the siphonal wall or shell (endosipholining) in the more primitive genera is of marked significance. This wall is known to occur in *Proterocameroceras*, *Cameroceras*, *Nanno*, *Piloceras* and *Chihlioceras*, and perhaps in others. Where the shell begins with a non-camerate apical portion, i. e. with only the siphuncle, this siphuncular wall is the outer shell of the cephalopod hard structure. In other words the young cephalopod began shell-building with the "siphuncle" which consisted of the siphuncular shell-wall and the filling within it.

When we consider the length of this preseptal portion in *Proterocameroceras* (75 mm. in *P. brainerdi*) it is evident, that the filling of the interior by endosheaths and solid lime matter (stereoplasm), must have been carried on *pari passu* with the building of this shell, after the formation of a short initial hollow conical tube. For not only would such a long hollow tube be an element of extreme weakness, and therefore not likely to be preserved, but also, it is difficult to conceive that the cephalopod grew into such a long rod-like body, before it began the building of cameræ, and that this body soon thereafter began to shrink into the slender thread which occupied the endosiphuncle. But if the endosheaths and solid calcareous matter were formed progressively as the tube grew in length, then it appears that these endosiphonal structures are more primitive shell-features than the cameræ. In other words, for a considerable period of its early history the cephalopod built only a slender shell, which it progressively filled with calcareous matter, marked at certain periods by resting stages, when the conical endosheaths were built. If that is the case, the endosheaths have the same significance, in these primitive shells, as the septa have in a shell of *Orthoceras*, and must be considered the homologues of these septa, whereupon the endosiphuncle becomes the homologue of the siphuncle of *Orthoceras*, and the shell of the "siphuncle" of the young *Proterocameroceras* the homologue of the shell of *Orthoceras*. That the endosheaths, or septa of the primitive *Proterocameroceras* are deeply conical, while those of *Orthoceras* are saucer-shaped, is only a detail of structure, which cannot effect the general question of homology. Again the filling with solid lime in the primitive shell of *Proterocameroceras* (and of the socalled siphuncle of the majority of the Holochoanites), while the outer septal spaces of *Orthoceras* are generally empty, is another detail, not relevant to the general question of homology. Indeed there is sometimes the beginning of such an organic deposit about the siphuncle of *Orthoceras*, while in *Stereoplasmoceras* and in *Actinoceras* this is the rule. In these genera too, a secondary septum terminates the deposit of organic lime, this supplementary septum or pseudoseptum being comparable to the sheaths of the "siphuncle" of the Holochoanites (see Plates VI - IX, and discussion on a subsequent page of this memoir). Moreover such deposits are also found in certain Endoceratidæ such as *Vaginoceras oppletum* * where both crystalline lime and "pseudosepta" are formed. This, according to our interpretation, is a new feature, developed in the outer cameræ, and homœomorphic with, rather than homologous to the filling of the cameræ of *Stereoplasmoceras* and *Actinoceras*. It apparently represents a repetition of a structure which had its inception in the formation of the inner shell or "siphuncle" of the Holochoanites, and may perhaps indicate phylogerontism in the group.

We may here consider briefly the subject of lime deposition by the mollusks, and its bearing upon the problem before us. On the basis of some experiments, and the consideration of others by Murray and Irvine, Steinmann (1889) concluded that the precipitation of calcium carbonate by organisms was a purely chemical process, and was due to the formation of ammonia and carbon dioxide through the processes of decay which are constantly going on in the organism. These substances will precipitate calcium carbonate from the sea water where it is present in the form of calcium sulphate ($Ca\,SO_4$) and chloride ($Ca\,Cl_2$). Because of the relatively small amount of lime salts which the animal takes into its body, Steinmann assumed that a part of the lime was directly derived from the surrounding medium. Such precipitation could of course take place only on the edge of the shell if the mantle were free, and its shell-building surface in contact with the sea water. It has however been shown that this is not the case, at least not in those forms, chiefly fresh-water mollusks, which have so far been studied, for there the periostracum or outer horny covering, bends over the edge of the shell and joins the mantle-border by which it is indeed secreted. Thus lime deposition at the growing edge of the shell goes on entirely under cover of organic structures, and unless it can be shown that by some process of osmosis the sea water finds its way into the spaces between the mantle and the shell, direct precipitation of lime salts seems impossible. Physiologists

* Ruedemann, loc. cit. 1906 p. 415, fig. 4.

generally appear to stand on the ground that all the lime of the mollusk shell is furnished by the animal, being derived from the food-supply (see especially Stempell 1900, and Biedermann 1901), but it must be recognized that their generalizations are based on the investigation of only a limited number of types. That marine mollusks derive all their lime from the food, seems highly questionable when we consider the vast amount of lime deposited by some of these organisms, especially sedentary types such as oysters, hippurites etc. The conclusion seems unavoidable, that in some way the animal appropriates lime from the sea water direct, or that in some manner the sea water gains access to the region where lime is deposited. If this is the case, we must allow that the calcium is precipitated as carbonate by the CO_2 produced by the animal itself, together with some other product to satisfy the SO_4 ion. For the sea water does not contain a sufficient quantity of CO_3 ions ready to combine with the Ca ions and there is an excess of SO_4 ions which must be taken care of. Steinmann's hypothesis of the formation of ammonium carbonate, through normal decay of tissues, satisfies these requirements. The whole matter is a problem for the physiological chemist, and its solution must be left to him.

One thing, however, seems certain, namely that in different organisms there is a vast difference in the ability to deposit lime. Moreover in sedentary forms, lime deposition is far more active than in free moving types, being least in planktonic types. One need recall only the giant *Tridacna* shells of the Great Barrier reef, or the *Hippurites* of the Cretaceous. Furthermore, other classes of organisms, normally thin-shelled, have sedentary members in which the shell is enormously and grotesquely distorted by excessive lime deposition. Such is *Richthofenia* among the brachiopods, an organism originally classed as a coral because of its remarkable form. Again, types such as the oyster, which are thin-shelled when very young (prodissoconch stage), become heavy-shelled by abundant lime deposition after attachment, while the related *Pecten*, which leads a free-swimming existence, only builds a relatively thin shell. Any one who has seen the ponderous oyster shells of the Tertiary, sometimes several inches thick, must agree that lime deposition here has passed beyond the normal stage required for the protection of the individual.

Of course it may be argued that the nature and abundance of lime-secreting cells, and their relative activity serves to determine the habitat of the organism. That, in other words, types with a tendency towards excessive lime formation will assume a sedentary life, and so give rise to genera and species normally of sedentary habit. In this connection it is noteworthy that many mollusks will build excessively heavy shells in old age, and from this it might be argued that types which in normal adulthood deposit much lime, belong to phylogerontic series. Why senile individuals and senile races (if such they are) should have their lime-secreting mantle cells over-stimulated so that they deposit an excess of lime, is not quite clear. Nor is it easy to understand why they should absorb more lime salts from the sea or from the food (if that is the sole source of the lime salts, which is very doubtful) in old age than in their younger stages, especially as there is often no corresponding increase in size of the shell-building mantle. If on the other hand, deposition of lime is more or less a purely chemical process, as Steinmann holds, and that its rate and amount of formation depends upon the rate of production of reagents which precipitate the salts, either from the normal secretion of the animal, or from sea water, which in some way (by osmosis?) has gained access to the regions of deposition, then we can understand that with increasing old age, or increasing senescence of the race, increased decay of organic cells brings with it the increased production of ammonium carbonate, with the result that lime deposition also becomes augmented.

The fact that lime is not deposited upon the periostracum, which both Stempell and Biedermann cite as ample refutation of Steinmann's theory, can in reality not be regarded as such, for the completed priostracum, though of conchyolin, has essentially the character of an inorganic body, and does not produce the necessary reagents.

I am not advocating the direct precipitation theory of Steinmann, but it appears to me that the pure secretion theory, which refers lime deposition in molluscan shells solely to the epithelial cells of the mantle, or to special lime-secreting glands, meets with great difficulties when it is invoked for the explanation of excessive lime deposits, especially if all the lime salts are regarded as derived from the food of the animal and none from the sea water direct.

If in a cephalopod shell, the processes which make for lime deposition are most active at the growing edge of the mantle, the shell is rapidly elongated, while, by the rest of the mantle surface, only a thin nacreous shell-layer is formed. If the growth at the mantle edge is so rapid that the length of the shell eventually exceeds the stretching power of the animal, a periodic forward movement of the whole animal in the shell takes place, whereupon the continued separation of lime over the now free basal portion of the mantle-enclosed body, results in the formation of a septum. If the lime-separating processes are uniform all over the mantle surface of a cephalopod, (as they are in oysters among pelecypods), the basal part of a tubular or conical shell, such as an orthoceracone, will be filled solidly by successive layers of lime. These may have the form of consecutive endosheaths, or of crystalline lime with definite layers marking resting stages at intervals, *i. e.* of successive distant endosheaths with crystalline lime-filling or stereoplasm between. Thus viewed, the filling of the shell, whether with air-chamber-enclosing septa, with successive close-set endosheaths, or with solid lime, punctuated at intervals by endosheaths, is a matter of the relativity in the intensity of the lime-depositing ability, between the edge of the mantle and the entire surface.

Viewed in this light, the structure of the Holochoanites appears to be the natural result of a sedentary life-habit, or perhaps the tendency towards rapid lime deposition all over the mantle-surface, forced the animal to assume a benthonic mode of life, which eventually must have been sedentary to all intents and purposes. That the Holochoanites, or the majority of them, led such a life on the bottom of the sea, is abundantly attested by their structure (especially the ventral flattening), and by their general mode of occurrence in the rocks (*vide* position of *Chihlioceras* as discussed on p. 48).

The building of cameræ in the Holochoanites must on this view be regarded as a newly acquired character, these structures being analogous to, but not homologous with, the cameræ of the Orthochoanites (*Orthoceras etc*). They must represent an expansion and reflexion of the mantle-edge, resulting in the addition of a new shell *outside* of the shell proper (the so-called siphuncular shell or wall, or the endosipholining), and we thus have the original shell enclosed by a secondary one, analogous to, but of course not strictly homologous with, the so-called shell of the *Argonauta*, the guard of belemnites, and the "apical cap" of *Orthoceras truncatum.* These new shells would thus form sub-annular structures of triangular, and later, more or less rhombic sections, like an automobile tire or a life preserver compressed into a triangular or rhombic section; but in most cases not extending entirely around the original shell, because this rested upon the bottom. The first of these veritable life-preservers, which probably aided the animal in keeping its oral end from sinking into the mud of the sea-bottom, formed the new shell by its outer or exposed side, and its first "camera", by its upper and inner side, which latter lay next to the original (inner) shell, and formed the so-called siphonal funnel of the cameræ.

This interpretation meets with the difficulty of conceiving the *modus operandi* of the building of such an outer, closed air chamber around the shell. Especially would it seem hard to explain the manner of building of the inner wall of this chamber, i. e. the so-called siphonal funnel of the cameræ, that part next to the inner shell or endosipholining. This difficulty may perhaps be obviated by assuming that the animal built at first a sub-annular or semi-lunar trough around the margin of the shell, by a compound reflexed portion of the mantle-edge as shown in the following sketches (Figs. 17 and 18). Such a structure is entirely analogues to the lateral alveoli of the final endosheath of *Chihlioceras.* (Plate II, figs. 13 a, b., also text-figs. 4, 5, 7, 10, 13 pp. 45-49). The second outer trough, built in this manner, would then close the preceding one and convert it into an air-chamber, first by effecting the elongation of the outer part, that which forms the new shell built by the mantle edge, and then, by the subsequent withdrawal, for a space, of the base of the reflexed part of the mantle, effecting the building of the basal layer of lime, which is the so-called septum of the camerate portion of the Holochoanites.

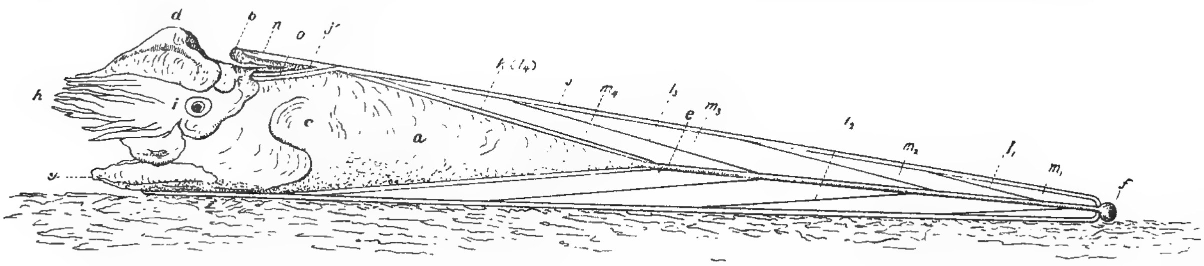


Fig. 17. Hypothetical restoration of a primitive holochoanitic cephalopod, represented as resting with its ventral or hyponomic side upon the sea-floor, and with the shell sectioned. The stage here represented is at the beginning or the building of the cameræ, previous to which it consisted only of the precamerate portion of the "siphuncle". This is here represented in section with several conical endosheaths, the spaces between which are filled with solid stereoplasm, except the median tube or "endosipho-tube", which ends in the embryonic bulb, this being however non-calcareous and not preserved. The animal rests upon the final endosheath of the stage which surrounds the *endocone* of this period. The hypothesis of camera-building by a reflexed fold of the mantle, analogous to the dorsal fold of the mantle in *Nautilus*, is here illustrated, the beginning of the first camera on the dorsal side being shown.
ANIMAL: *a*, mantle; *b*, marginal reflexed fold of the same, which is assumed to be functional in camera building; *c*, shell-muscle; *d*, hood; *e*, sipho, occupying the "endosipho-tube"; *f*, embryonic bulb, non calcareous (when calcifield it forms the protoconch); *g*, hyponome; *h*, tentacles or arms; *i*, eye (left side). SHELL: *j*, shell of early stage *i. e.* of preseptal part of "siphuncle", (ectosiphuncle of Ruedemann); *j'*, continuation of same into camerate state at the contraction of the "siphuncle", forming the "endosipholining" of authors; *k*, last-formed endosheath at this stage, enclosing the "endocone" which is continued in the "endosipho-tube"; *l*1 - *l*3, earlier sheaths (septa of primitive shell); *m*1 - *m*4, "siphonal" chambers (cameræ of primitive shell) filled solidly with stereoplasm; *n*, new shell or shell of camerate portion; *o*, shell-lining of first camera, deposited next to the continuation of the "old shell" (*i. e.* the continuation of shell of "siphuncle", the so-called endosipholining) and forming on the hypothesis here suggested the "siphonal funnel" or "neck" of the first "septum" which has not yet been built.

I am perfectly well aware that this interpretation meets with a grave objection because of the fact that in *Endoceras*, *Vaginoceras* etc., the septal portion of the cameræ is continued *downwards* in the siphonal neck, not upwards as such a mode of construction would require. But it must be remembered that in these forms, the septal necks take the place of the inner shell or the endosipholining, which is absent in these genera. Whitfield has recorded the observation, that the septal necks of *Vaginoceras* are continuous with the sheaths of the siphuncle though Ruedemann holds that this needs verification. If it is correct, then the septa merely mark the rapid outward expansion of the mantle above the edge of the endosheath (which is really the upper edge of the siphonal neck) there being no further need for a reflex of the mantle on the suppression of the inner shell.

That such a reflexing of the mantle has occurred in some of these ancient cephalopods, is shown by the structure of *Orthoceras truncatum* Barrande, from the Ordovician and Silurian rocks of Bohemia and England. In this form the earlier cameræ are frequently dropped off or destroyed, whether by accident or design, remains undetermined. The truncated end of the shell is then covered over by a new deposit of calcareous material of distinctive form and design. This "apical cap" or *calotte conique*, is evidently formed by the animal, and for its formation a reflexed shell-secreting portion of the body is necessary. Barrande supposed that the animal possessed long palmate brachial appendages more or less analogous to those of *Argonauta*. These were capable of

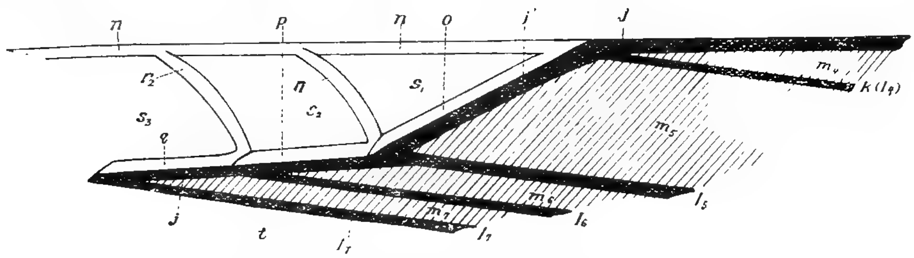


Fig. 18. Diagram to illustrate the dorsal portion of the early camerate part of the shell of a holochoanitic nautiloid cephalopod. (See fig. 17). *j*, "old" shell or shell of "siphuncle". *j'*, *j'*, continuation of same into camerate portion forming the *endosipholining*; *l4*, endosheath which at the stage represented by fig. 17 was the last one formed enclosing the endocone, (*k*. fig. 17); *l5*, *l6*, *l7*, endosheaths since formed, *l7* representing the last-formed one at this stage, and enclosing the endocone of this stage; *m4* to *m7*, intersheath spaces filled with stereoplasm; *n*, and *o*, as in fig 17; *p*, *q*, inner shell-lining of cameræ, forming the septal necks or funnels; *r1*, *r2*, septa of camerate portion; (*o*. forms septal neck of *r1*; *p*, of *r2*; *q*, of *r3* which has not yet been formed); *s1*, *s2*, *s3*, first second and third cameræ the last still open in front, and forming with the endocone *t*, a part of the *living chamber*.

reaching the basal portion of the shell, and having the power of secreting lime, they repaired the broken apex, reproducing the characters of the shell. Hyatt, on the other hand, considered that this outer shell-secreting organ was homologous with the fold of the mantle in *Nautilus* "This" he says, "is an active shell-secreting organ, which was certainly present, and also functionally active, in the Ammonites and Nautiloids, and probably more important in these ancient forms than it is now in the modern *Nautilus*. This is also more consistent with the structure of the Belemnoid, which, as is easily seen in the famous example of the preserved animal, had no such pair of enlarged arms and yet deposited exteriorly, a solid covering, the guard, which is in our opinion the homologue of the solid filling of the truncated end of *Orthoceras*." *

A similar organically deposited layer of lime covers the initial end of *Vaginoceras belemnitiforme* Holm, before the commencement of the outer cameræ.

It has been frequently noted, that when the outer cameræ begin building, the diameter of the inner shell or "siphuncle" is more or less abruptly contracted. This is found in *Cameroceras* in *Nanno* and in *Vaginoceras belemnitiforme*. This can be accounted for by the abrupt elongation of the animal's body necessary at this stage, if the animal

* Proceedings. Amer. Assoc. Adv. Sci. 1883 vol XXXII, p. 323.

forms a reflex fold of a part of its mantle, that which builds the initial outer "collar", which eventually becomes the first outer camera.

Whether this suggestion regarding the mode of building of this outer series of cameræ will be shown by future discoveries to be correct or not, I believe that the very existence of the initial precamerate stage of the "siphuncle" with its own shell-wall and with conical, septa-like sheaths, prolonged into an endo-siphuncle, indicates that it is a primitive shell-type which was complete in itself, and that the development of outer cameræ at a later stage adds a new feature to the shell as a whole. The continuance of the "siphuncular wall" or the shell of this primitive non-camerate organism, into the camerate portion in primitive forms, further emphasizes the independence of this inner structure. The homology of this inner shell with the shell of *Orthoceras*, and of the sheaths with the septa of *Orthoceras*, would therefore seem to admit of little doubt. Moreover, as we have learned to take ontogeny as an infallible guide to phylogeny, if rightly applied, we are forced to conclude that the most primitive Holochoanites were without the outer camerate portion, thus representing in their adult stages, the condition seen in the young of *Proterocameroceras*, *Nanno* and others of this type of structure. That the existence of such has not been absolutely determined, signifies little, for our knowledge of the earliest cephalopod faunas is still very meager. As noted in the description of *Chihlioceras*, it is possible that that genus was non-camerate, the annulations being merely surface "ornamentations" such as are found in the shells of many later cephalopods. Certainly there is no indication whatever in these shells, of the presence of cameræ, such as in found in other annulated "siphuncles" in our rocks, where portions of the "septal necks" still adhere to the shell of the "siphuncle", though there is no other trace of the cameræ. Furthermore the remarkable form of *Chihlioceras*, its oblique aperture, and the long anterior ventral blade, are hardly consistent with the idea of the former presence of cameræ. Possibly the same holds true of the rapidly expanding "siphuncles" of *Piloceras platyventrum* Grabau, of our rocks (Plate IV figs. 11 and 12), for although some specimens are annulated, these annulations show no trace of adhesion of "septal necks", while the apical portion shown in Plate IV fig. 11 is entirely without such annulations. It seems at least likely that this species too began with a non-camerate portion, and if cameræ were added, this took place only in the later stages, when the "siphuncle" had become cylindrical.

If we now enquire into the genetic relationships between the Holochoanites and the Orthochoanites, it would seem to be evident, that they can only represent divergent branches from a common ancestral stock. I have elsewhere suggested * that this

* Bull. Geol. Soc. America Vol. XXX, pp. 148, 149, 1919.

ancestral stock is represented by the sub-order, *Protochoanites* Grabau and Shimer, to which we have referred the only known Cambrian cephalopod *Volborthella*. This genus has been defined as a small orthoceracone with conical-shaped septa, pierced by a simple hole in the apex, though the presence of such a siphuncular hole has been questioned. Whether or not it occurs is of secondary importance as it appears that in some of the Holochoanites the "endo-siphuncle" is not present in the earliest part. But whether the known Cambrian protochoanite is the direct ancestor of both *Orthoceras* and the Holochoanites is of little moment. Certain it seems that shells so distinctive must represent divergent evolutional lines, one the orthochoanite branch becoming successful by the assumption of the chambered type of shell, the other, the holochoanite type disappearing with the close of the Ordovician, because its heavily weighted shell made active migration impossible in spite of the secondarily adopted device of outer cameræ. The extinction of the various genera of this group is in general coincident with great changes in physical geography, notably the extensive withdrawal of the seas at the end of the Paleo-Ordovician, and again at the end of Neo-Ordovician time, when practically the last members of the group perished. Nor is it an unwarranted assumption that the excessive development of the sedentary habit may have affected the reproductive powers of these animals in one way or another, so that extinction may be in part due to this cause.

We would then interpret the phylogeny of the early cephalopods in the following manner:

		(to Trias.)
Holochoanites (Ordovician)		*Orthochoanites* (Ordovician)
⋮		⋮
⋯⋯⋯⋯	*Protochoanites* (Cambrian).	⋯⋯⋯⋯

The *Cyrtochoanites*, represented in our rocks by *Stereoplasmoceras*, *Actinoceras*, *Cyrtactinoceras*, and *Gonioceras*, may have been derived from primitive *Orthochoanites*, or they may represent an independent line of evolution from the ancestral stock. The discovery of the genus *Stereoplasmoceras*, with characters intermediate between *Orthoceras* and *Actinoceras*, makes the former view the more likely one.

We may here briefly refer to the remarkable early Ordovician cephalopod *Diphragmoceras* Hyatt. This has the "siphuncle" divided by tabulæ alternating with the septa of the camerate outer shell. Both the cameræ and the chambers of the siphuncle are empty. This genus has sometimes been referred to as representing a transition from the Holochoanites (Endoceran type) to the Orthochoanites (Orthoceran type), but it is difficult to see how it can be so regarded. It represents really an Endoceran type in which the sheaths have assumed the form of tabulæ separated by interspaces, and as such rather supports the explanation of the relationship between the endosheaths of Holochoanites and the septa of Orthochoanites given above. Thus it is a case of parallel development to *Orthoceras*, or the assumption, by the inner or true shell in a holochoanitic type, of the orthoceran character. Unless we assume that the outer shell is suppressed in the development of the Orthoceran type, we cannot regard this form as in any way showing ancestral characters. Moreover, if such were the origin of *Orthoceras*, the close genetic relation of the endosheaths of the one to the septa of the other type, would be demonstrated.

Suborder **Orthochoanites** Hyatt

Family **CYCLOCERATIDÆ** Hyatt

Genus **CYCLOCERAS** McCoy

Cycloceras (?) peitoutzense Grabau (sp. nov.)

Plate VI, figs. 1-4

A number of fragments of an annulated orthoceracone have been obtained from the upper beds of the Actinoceras limestone a short distance west of Chaokouchuang. Although they belong to different individuals and show considerable variation in size, they are nevertheless regarded as representing a single species. As this is the only annulated orthoceracone known from north China, it will be described despite the imperfect character of the material.

The smallest shell fragment (Pl. VI, fig. 1) is about 30 mm. long, the diameter ranging from 5.3 mm. at the lower (partly concealed) end, to 7.2 mm. at the upper end. Eight annulations are shown in a distance which is 23 mm. from the center of the first to the center of the eighth annulation. The annulations appear to be straight, encircling the shell without deflection, rounded, but separated by broad, strongly concave interspaces which gradually increase in length with the growth of the shell. Very faint longitudinal lines are visible upon the early portion of this fragment, but the greater part seems destitute of them. Siphuncle somewhat excentric, its diameter at the upper end of the fragment being 1.25 mm. Sutures and septa not visible.

A second fragment (Plate VI, fig. 2) shows 7 annulations the distance between the centers of the first and seventh being 26 mm. The diameter of the shell at the upper end is 12.2 mm.

This fragment too shows no longitudinal lines, but in some of the interspaces occur very faint indications of concentric lines. The specimen appears to represent the filling of the living chamber, as a longitudinal section shows a total absence of septa.

A still larger specimen, which is a partly crushed and incompletely exposed shell, has a diameter of about 13.5 mm. and is characterized by abrupt annulations, the centers of which range from 4.5 to 4.8 mm. apart. The annulations themselves have a thickness of about 1 mm.; the summit is rounded, and the interspaces are very nearly flat in some parts, though they show a concavity in others. No longitudinal sculpture is shown, but there is again a faint indication of fine concentric lines in the interspaces.

Only a few septa are indicated, their position corresponding apparently to the annulations. Their concavity is about equal to half the distance between the annulations. Siphuncle slightly excentric, large, its diameter being about 2.5 mm. where the diameter of the shell is about 13.5 mm.

Another specimen of this type (Plate VI, fig. 3) has the annulations slightly oblique, but sharply elevated, compressed and separated by deep flat interspaces. The distance between five annulations (including 4 interspaces) is 24 mm. the width of the annulations being a little over 1 mm. at the base but only about half that at the top. The diameter of this fragment is approximately 14 mm. and it appears to be slightly curved.

A still larger fragment apparently a part of the same individual as the preceding (Plate VI, fig. 3) shows annulations 8.5 mm. apart, their thickness being nearly 2 mm. at the base, and their height about the same. This specimen shows fine sharp concentric striæ somewhat narrower than the interspaces between them, covering the entire shell, including the annulations (Plate VI, fig. 4). There are about five of these striæ in 1 mm. The diameter of this fragment was probably between 18 and 20 mm. Siphuncle unknown.

The last three specimens described differ rather strongly from the fragments illustrated in figs. 1 and 2 of Plate VI especially in their narrow compressed and high annulations, and the very broad and nearly flat interspaces. It is quite possible that two species are represented, but the material is too incomplete to warrant such a separation, especially as the internal characters are not ascertainable.

The generic position of this shell is in doubt. The entire absence of longitudinal sculpture except in the very young stages, would suggest that it belongs to the genus *Protocycloceras* of Hyatt. The faintness of the longitudinal sculpture on the young, however, together with the pronounced character of the annulations, and further the general weathered character of the surface, suggests the possibility that if more perfect material were obtained, the longitudinal sculpture would be found to persist into the later stages as discontinuous ridges in the interspaces. In that case the shell would be referable to the genus *Cycloceras*. One might also argue, from the fact, that these fossils are associated with *Actinoceras*, and other late Middle and early Upper Ordovician fossils, that they belong more likely to *Cycloceras*, rather than to *Protocycloceras*, which is most distinctive of the Lower Ordovician. Nor does the siphuncle help in the proper determination of the generic position of the form, as it is at present known only in section or on the septal surface. The presence, in the largest fragment, of fine sharp concentric striæ, without indications of longitudinal striæ, however, makes reference to *Cycloceras* doubtful. Indeed this feature rather suggests *Dawsonoceras*, but the concentric striæ are regular, instead of being the frilled edges of the growth-lines as in that genus. Such a surface character has not been recognized in other Ordovician cephalopods, and it is possible that we are dealing here with a new genus. However, as the material is too incomplete, and as too little can be ascertained of the septa and the character of the siphuncle, it seems best for the present to place the specimens in the genus *Cycloceras*, especially as in species of that genus the longitudinal sculpture is not always preserved.

Horizon and Localities: In the upper beds of the Actinoceras or Machiakou limestone, in Limekiln Ravine, near Pei-tou-tze N.W. of Chaokouchuang, Kaiping basin, Chihli. (Coll. Geo. B. Barbour) also in the same formation in other outcrops near Chaokouchuang and Pei-tou-tze. (Collected by the Survey expedition).

Suborder **Cyrtochoanites** Hyatt

Family **LOXOCERATIDÆ** Hyatt

Genus **STEREOPLASMOCERAS** Grabau (gen. nov.)

Non-annulated, regularly expanding orthoceracones with nummuloidal siphuncle, the nummuli more or less irregular and extending from septum to septum, widest near the centers of the cameræ, but without secondary annular deposits, or if these are present, they are irregular. Septa generally compound, or complicated by pseudosepta which extend only partway across the phragmocone, and join the preceding or succeeding septum. The space thus enclosed by the pseudosepta is commonly filled with crystalline stereoplasm deposited by the animal, this being present in varying amount, sometimes filling the whole or nearly the whole camera, especially in the older (earlier) parts of the phragmocone.

This genus is closely related to *Loxoceras*, McCoy, with which it agrees in the character of the siphuncle. Its distinctive character however is seen in the development of the compound septa, or septa and pseudosepta, with stereoplasmic deposit between. In these respects the genus is related to *Actinoceras*. Indeed this genus may be considered as intermediate between *Loxoceras*, and *Actinoceras*, partaking of some characters peculiar to the one and of others characteristic of the other.

The exterior of the shell is unknown except that it is not annulated. So far as can be ascertained, the surface is smooth. Expansion is regular, and although the living chamber is still unknown, there is no reason for assuming that it is other than in *Orthoceras*.

Genotype. *Stereoplasmoceras pseudoseptatum* Grabau, Ordovician.

It is highly probably that the specimen figured by Crick as *Orthoceras* or *Actinoceras* (Geol. Mag. New Ser. Dec. IV. Vol. X, Pl. XXII fig. A) belongs to this genus, for as far as can be ascertained from the reproduction of the photograph it shows the pseudosepta and stereoplasmic filling of *S. pseudoseptatum*.

Stereoplasmoceras pseudoseptatum Grabau (sp. nov.)

Plate VI, figs. 5-7. Plate IX, fig. 11.

Shell regularly tapering, apparently at a variable rate, though this may be due to the variation in direction in which the sections are cut. In a specimen from Lincheng, Shantung (cat. no. 80) the rate of tapering appears to be 1 in 6.5 while in a sectioned specimen from Ningyang Shantung (Plate VI, fig. 6 cat. no. 57) it is only 1 in 12.5. Still another section of an typical specimen from Tangshan (Plate VI, fig. 5, cat no. 58) shows a rate of tapering of 1: 9.75. These variations are probably due to the fact that the sections are cut somewhat obliquely and so do not give the true rate of tapering. The true rate lies probably between the two extremes - *i.e.* about 1: 9.

Section subcircular, apparently a little flattened on one side. Septal distance about 4.6 mm. (varying in the different specimens from 4.5 (rarely 4) to 4.7, the shell diameter varying from 25-30 mm. but not in the same proportion). Towards the apertural end in the longer specimens, the interval increases to 5 mm. or to a little more, the maximum shell diameter observed being somewhat less than 40 mm. The depth of the septa is from 1 $\frac{1}{2}$ to 1 $\frac{3}{4}$ camera. The septa are conspicuously compound, owing to the numerous pseudosepta. On the upper side of the septum, the pseudosepta extend about one third the diameter of the shell towards the center. At first they are more or less parallel to the septum, then slope more or less abruptly to the septal surface near the center where they either join the septum, becoming confluent with it, or continue as an independent layer in contact with the septum at the center. At the shell margin these pseudosepta again join the main septum. The pseudosepta on the under side of the true septa are more irregular. As seen in section, some are annular, joining the main septum in the center as do the pseudosepta above. In other cases the pseudosepta diverge from the main septum some distance in from the shell-margin, and continue across the center to within a similar distance of the opposite shell-margin. These pseudosepta thus have a greater curvature than that of the true septa. When the pseudoseptum is confined to the marginal portion of the section, it is in close contact, for a space, with the pseudoseptum which joins the next preceding septum on the upper side. Again, the pseudoseptum on the under side may become irregular, as it approaches the center, being abruptly bent down, before it bends up again to join the under side of the septum above it. The space between the pseudosepta and the septum to which they belong both above and below this true septum, is filled solidly with stereoplasm in the form of crystalline calcium carbonate (probably aragonite, at least originally). Thus in general the septa appear thickened on both upper and lower marginal portions by nearly equal amounts of stereoplasm, while the center is free from such thickening, the cameræ being filled only by the lime-mud in which the shell was buried. In the older parts, where the lower pseudosepta seem to extend across the center (possibly due to the position of the section) nearly the whole of the cameræ appears filled with the stereoplasm.

The siphuncle is excentric, situated about half-way between the center and the margin of the slightly flattened side, or a little nearer to the latter. Around it the cameræ are often free from stereoplasm for some considerable space. The siphuncle is nummuloidal, expanding to 7 mm. in the center, where the septal distance is 4 mm. but it does not appear to be regular. At the septa it contracts to about 2.5 mm. There are either no stereoplasmic deposits, or, when present, they are irregular, and have the nature of a norrower tube within the more expanded outer nummulus. Characters of exterior of shell and of living chamber unknown.

A section of a specimen of *Stereoplasmoceras* from the Machiakou limestone of Wên-nan, Shantung (Plate IX fig. 11), appears to belong to this species, representing the earlier portion of the conch. The shell tapers at the rate of 1 in 6. The siphuncle, though appearing centran in the section, is only about 4 mm. from the ventral margin at the lower end of the specimen, and 5.5 mm. at the upper end. The diameter of the nummuli is 7 mm. where the shell section is 28 mm. wide, in the upper end of the section, and 5 mm., where the section is 18 mm. wide. The septal interval ranges from about 3.8 mm. in the lower, to 4 mm. in the upper part. The concavity of the septa is equal to nearly 2 camera lengths. In the median portion of the specimen, the nummuli show a distinct narrow central tube, which extends from septum to septum. Around these septal necks, there is an irregular deposit of stereoplasm which partly fills the nummuli, the remainder being filled by crystalline calcite of secondary origin. The central tubes or septal necks, stop abruptly at a septum about one-third the length of the fragment from the bottom, this abrupt cessation suggesting that they are not present in the earlier nummuli, which contain only an irregular deposit of stereoplasm. The pseudosepta are of the type described for the larger specimens of this species.

HORIZON AND LOCALITIES: So far as known, this species is confined to the Machiakou limestone where it is associated with *Actinoceras.* Characteristic specimens have been obtained from Lincheng in Shantung (F. F. Mathieu), from Ningyang, Shantung, and Tangshan and Lushan, Chihli, (Survey collection), from Wên-nan, Mon-Yin-Hsien Shantung (V. K. Ting coll.) and from Chaokouchuang, Chihli (Survey expedition of 1921). It is thus seen to be a widespread species.

Stereoplasmoceras machiakounense Grabau (sp. nov.)

Plate VI, Figs. 8

Shell subcylindrical, tapering very gently, section apparently circular, siphuncle subcentran.

Septa moderately concave, the depth equal to about one camera. Septal distance varying from 4 mm. in the lower part of the fragment, to 6 mm. in the upper, the diameter of the shell being about 20 and 21 mm. respectively. Pseudosepta irregularly developed, occurring in one part of a chamber but absent in another. Some cameræ are without pseudosepta, and are solidly filled with stereoplasm. In other cases, the camera on one side of the section is without stereoplasm, while on the other side, where a pseudoseptum is present, it may be partly filled by this deposit. So far as can be ascertained the stereoplasm is confined to the upper surface of the septum.

Siphuncle gently nummuloidal the nummuli swelling to a diameter of 5.3 mm. in the center, and contracting to 3 mm. at the septal ends. There is no stereoplasm in the siphuncle which is filled only with the matrix.

Another specimen from Lincheng Shantung, referred to this species, has a septal distance of 7 mm. where the shell is 21 mm. in diameter. The rate of tapering of this specimen, as indicated in the section, is 1 in 8.5. There is comparatively little stereoplasm in the cameræ, and it appears to be confined to the upper surface of the septum and bounded above by a pseudoseptum. The siphuncle is not shown in this specimen.

This species differs from *S. pseudoseptatum* in its proportionately more distant and somewhat shallower septa, in the narrowly nummuloidal siphuncle, the comparatively few pseudosepta and the frequent complete filling of the cameræ with stereoplasm.

HORIZON AND LOCALITIES: In the Machiakou limestone at Machiakou Chihli province, (H. C. T'an, cat. no. 15,) and in the same horizon at Lincheng, Shantung province (F. F. Mathieu, cat. no. 79). In both places the species is associated with *Actinoceras richthofeni*, *A tani* etc. and is of early Upper Ordovician age. A specimen referred with some hesitation to this species, because of its narrower septal interval (4 where the diameter is 14 mm., 4.5 where it is 18 mm.) came from Tse-yan, Ning-yang Hsien, Shantung. It has the same rate of tapering, and slight amount of stereoplasm found in the Lincheng specimen. (Survey collection cat. no. 82).

Stereoplasmoceras actinoceriforme Grabau (sp. nov.)

Plate IX, figs. 9a-b, 10a, b.

Shell rather strongly tapering, the rate varying from about 1 in 6, to 1 in 7, with the cross-section either subcircular to suboval, and the siphuncle nearly centran, or circular with the siphuncle slightly excentric. The dimensions of the lower end of a well-preserved section (Plate IX, fig. 9b) are: transvese diameter, 17 mm., distance from center of siphuncle to ventral (?) side, 7 mm..

Siphuncle strongly nummuloidal, giving the shell an *Actinoceras*-like appearance, but without the regular siphonal fillings characteristic of that genus. In one specimen (Plate IX, fig. 10a) the siphuncle appears to have been wholly empty, becoming filled with the fine matrix of calcilutyte, in which the shell was embedded. This, in the lower two nummuli preserved, has separated out, showing the inside of the wall of the nummulus which is quite regular and fairly smooth. In a second, larger, specimen (Plate IX, fig. 9a, b) the nummuli are filled with coarsely crystallized calcite, the outlines of which are distinct from the walls of the nummuli.

Diameter of nummuli varying from 5 to 5.5 mm. and their length, which is also the septal interval, from 2.7 mm., where the diameter of the shell is from 16 to 18 mm. (Plate IX, fig. 10a), to 3 mm. or a little over, where the diameter is 20 mm. (Plate IX, fig. 9a). Depth of septa a little more than one camera length. Pseudosepta and stereoplasmic deposits in the cameræ very irregular.

This species differs from the others of this genus in its suboval section, nearly centran siphuncle, and short septal interval, as well as in its irregular pseudosepta and stereoplasmic deposits. From *S. machiakounense* it differs, moreover, in the strongly nummuloidal siphuncle, the nummuli of which are much broader than long, whereas it is the reverse in *S. machiakounense*. From *S. pseudoseptatum* it differs in its smaller size, in the subcentran position of the siphuncle, and in the irregularity of the pseudosepta and stereoplasm; also in the regularity of the siphonal nummuli, and their complete freedom from deposits of stereoplasm. The species might easily be mistaken for an *Actinoceras*, but the absence of annular deposits shows that it belongs to the *Loxoceratidæ*.

HORIZON AND LOCALITIES: In the Machiakou limestone of early Upper Ordovician (Black River) age at Kushan, Chihli, and at Wên-nan Mon-Yin-Hsien Shantung (V. K. Ting coll.).

Family **ACTINOCERATIDÆ** Sæmann.

Genus **ACTINOCERAS** Bronn

The type of this genus is *Actinoceras bigsbyi* Bronn, a widely distributed American species, which occurs in the late Middle and early Upper Ordovician (Stones River, Black River and Trenton). It ranges from Tennessee northward to arctic America (Iglook Island, Fox Channel), westward to Iowa and Lake Winnipeg, and eastward to New York. The shell expands rapidly at first forming an irregularly conical apical end which is characterized by a large foramen, surrounded by a distinctly swollen ring. This feature has been figured by Foord for *A. bigsbyi* from arctic America and Canada, and it is equally well shown in a specimen of *A. tani* in the survey collection (Plate VII, figs. 7a, b). The apical cone of *Actinoceras*, in the specimens figured by Foord, and in our form, is somewhat asymmetrical. In the American form the apical foramen or scar is moreover situated obliquely, while in the Chinese form it is normal to the axis. This foramen apparently marks the point of decortication of the embryonic chamber or protoconch.

After the initial rapid expansion, the rate of increase of the tube is diminished, being in some cases more nearly that of an ordinary *Orthoceras*, but more rapid in others so as to produce a very stout structure. In some cases as in *A. richthofeni* the rate of expansion diminishes again after a while so as to produce a more cylindrical final portion. In rare cases the form is slightly curved. The cross-section varies from circular to oval.

The Siphuncle. This is generally large and inflated in the cameræ so as to produce a pronounced nummuloidal character or a succession of *nummuli.* * In size the siphuncle varies from less than one fourth to more than half the diameter of the conch. In the rapidly expanding apical end of the shell the siphuncle quickly reaches a large size and thereafter expands very little if at all, although the diameter of the shell may increase. Thus in the older part of *A. richthofeni* the siphuncle may occupy more than half the diameter of the shell, while in the expanded portion it does not occupy much more than one third that diameter. In position the siphuncle is centran or excentric even submarginal, though it is not always possible in sections to determine with certainty that the centran appearing position is not due to the manner in which the section is made.

The walls of the siphuncle are thickened by secondary deposits of carbonate of lime. Frech (Richthofen Vol. V. Plate 2 fig. 1) has illustrated a section of *A. crassiventrum* Wahl. which shows the manner of thickening of the siphuncular wall. According to this, the portions opposite the ends of the septa and those in the inflated portions in the cameræ are thickened independently, the former in advance of the latter. As a result of this addition of new material, the central cavity is reduced to a narrow central tube or endosiphuncle, from which lateral annular diverticula extend into the inflated portion of the siphuncle. Frequently the thickening has progressed so far that the whole or nearly the whole of the inflated portions (i. e. the diverticula) become filled solidly, leaving only a central more or less cylindrical tube, the endosiphuncle. This is the case in the majority of specimens of *A. tani* and *A. richthofeni* though the specimen figured by Frech (Richthofen V. Plate 2 fig. 8a,) still shows the presence of these lateral diverticula.

In some forms, as in *A. richthofeni*, the deposition of stereoplasm in the siphuncle is more pronounced in the anterior portion, this resulting in the formation of oblique diverticula from the central tube. This is fully described and illustrated under *A. richthofeni* (See text fig. 19, p. 79, and Plate IX, fig. 4.)

A specimen of *A. richthofeni* in the collection of the Survey, shows the interior of the siphuncle in a fair state of preservation and unfilled by foreign material, the former

---

* See the foot - note on page 76

filling having been removed by weathering. From this specimen it appears, that the thickening is not uniform all around the periphery of the siphuncle but rather in the form of bead-like enlargements. (Plate VII, fig. 3). This seems to be analogous to the structure of the siphuncle of *A. bigsbyi* figured by Foord (Cat. Foss. Cephalopoda Brit. Mus. Plate I. pp. 164-165 figs. 20-22) where a series of tubuli run from the endosiphuncle to the outer rim of the intra-cameral expansions, *i. e.* the nummuli. These tubuli have also been observed in specimens of *A. tani* from the Chinese rocks, and probably represent a feature usual in this genus.

According to Foord, the central tube or endosiphuncle is provided with a distinct wall of which the tubuli are diverticulations. Their number has been estimated by Bronn as 16 in *A. bigsbyi*, but the number of foramina figured in this species by Foord is very much greater. Those so far observed in Chinese specimens are few, probably not more than 16.

The significance of these tubes and foramina is not clear. Owen (Palæontology, 1860 p. 85) suggested that they may have served for the passage of blood-vessels to the living membrane of the septal chamber, which would imply that these chambers were not merely empty spaces, cut off as in Nautiloids generally. The thickenings of the wall of the siphuncle were regarded by Hyatt "as strictly homologous with the successive sheaths of the endoseptum of *Piloceras* and *Endoceras*". I would however interpret the endocones of the *Holochoanites* as the crowded septa of an inner shell, comparable to an orthoceracone, which would make them entirely distinct from the thickening of the siphuncle of *Actinoceras*.

Suggestions have repeatedly been made regarding the significance of these siphuncular thickenings. Frech suggests that the thickening represents an attempt to render mechanically weak cylindrical structures more resistant against wave and current attack, the siphuncle thus being transformed into a supporting structure, or into a species of back-bone. That the solidified siphuncle became such a supporting structure, and that because of it the genus *Actinoceras* was a long-lived one, extending from the Ordovician to the Carboniferous, may be conceded, though it is by no means certain that *Actinoceras* as now understood is monophyletic. In other words it is not improbable that the *Actinoceras* type of siphuncle was independently developed in more than one phyletic series, representing thus parallelism in development, rather than genetic relationship. The origin of the structure however must be sought in the purely mechanical processes of lime separation as the result of the decay of the cells of the older part of the siphuncle, the gradual contraction of which was a concomitant phenomenon of the functional detereoration of that part of the animal's anatomy. I would regard this excessive lime separation rather as evidence of senescence, and consider the Actinoceran type a phylogerontic phase of orthoceraconic development.

The apertural end of the siphuncle. A specimen of *A. richthofeni* from Huo-Luh, Chihli province, presented to the Survey collection by Miss Clarke, shows a section of the apertural end of the siphuncle (Plate VII, fig. 2). This has a maximum diameter of 12 mm. and shows a conical depression about 25 mm. in depth and 8 mm. across at the upper end. The sides of the apertural cone are formed by the obstruction rings or rosettes of stereoplasm deposited about the septal necks, this deposit being slight in the upper part and increasing in thickness downward. This gives the inner surface of the cone an undulating appearance, contracting at the septal necks, and expanding between the septa, in conformity with the expansion of the siphuncle. The continuation of the cone in the endosiphuncle is not shown in the section, but undoubtedly existed. The funnel-shaped apertural end of the endosiphuncle resembles that of the Silurian genus *Discosorus* Hall, but there is no lining membrane or sheath as in that genus. It merely represents the still unfilled portion of the siphuncle and shows that the filling by "obstruction rings" progressed regularly from behind forward. There are indications in the specimen that the cameræ of the shell continued beyond the upper end of this cone thus suggesting that the upper end of the siphuncle consisted of a series of hollow nummuli. If this was the case, the upper portion corresponds in character to the genus *Stereoplasmoceras* and as it represents a more primitive stage in development through which the shell passed as a whole (the filling being subsequent to the formation of the nummuli) the suggestion lies near that *Actinoceras* is a derivative from *Stereoplasmoceras,* which in turn is derived from *Loxoceras*, and that from *Orthoceras.*

The septal thickening. In practically all of the specimens of *Actinoceras* from the Machiakou limestone, a striking thickening of the septa by stereoplasm or organic deposits of carbonate of lime has taken place, so that the cameræ are more or less completely filled by this calcareous deposit. Complete filling is rare, but has been observed in some cases, while in others the thickening has proceeded only far enough to fill about one half of the camer&. The thickening is most generally produced by addition of lime to the upper surface of the septum, but in other cases it appears to be added to the under side as well. It is however possible that this appearance is deceptive, and due to the irregularity of the septum, which bends forward before reaching the inter-nummuloid contractions of the siphuncle (see *A. coulingi*, Plate VIII, fig. 1 cat. no. 4). The deposit is very often thickest near the siphuncle, close to which it frequently thins away abruptly, leaving a subtriangular area next to the outer margin of the nummulus, which area was vacant space and has been filled in by the lime mud after burial of the shell. (Plate VII, fig. 6).

The material which forms the thickening of the septa is crystalline carbonate of lime, similar in all respects to that which fills the nummuli of the siphuncle. It is readily distinguished from the mud-filling of the open spaces, which is a uniform dark calcilutyte.

The thickening of the septa is not uniform. In a specimen of *A. coulingi* (Plate VIII, fig. 1) it is comparatively slight in the young or apical part of the shell, becomes most marked in the middle portion, and is comparatively slight in the apertural or last-built portion of the shell. This feature is also shown in a specimen of *A. tani* (Plate VII, fig. 6). In this specimen the upper surface of the organic deposit is smooth though somewhat undulating, having the appearance of a definite secondary septum. In this species, the thickening increases slightly near the siphuncle, and then thins away very rapidly, generally with a concavity of surface.

That this lime-deposit is of organic origin, *i. e.* deposited by the animal which occupied the shell, is beyond question, for only by such an origin can the uniformity of the deposit be explained. That it was formed on successive floors of the living-chamber, *i. e.* that each deposit was formed before the next covering septum was built, seems to me also evident, for there is absolutely no indication that the cameræ were in subsequent communication with the animal, the small tubuli of the siphuncle notwithstanding. I would interpret the filling of the cameræ as a process strictly analogous to the filling of the "siphuncle" by similar crystalline lime in the *Holochoanites*, the "supplementary septum" or "pseudo-septum" which commonly terminates it, being comparable to the endosheaths (as are also the true septa). Thus after the formation of each septum, deposition of lime continued upon it for a time, after which, during a resting stage, a pseudoseptum in close contact with the crystalline lime was formed. This was followed by a forward movement of the animal in the shell, and the formation of a new septum, which thus was distant for a certain space (generally less than half the height of the camera) from the pseudoseptum and crystalline deposit. After that the deposition of crystalline lime recommenced upon the surface of the new septum.

Distribution. *Actinoceras* appears abruptly in the Ordovician rocks of North America and north China. A doubtful species (*A? mendax* Salter) has been described from the Durness limestone of Sutherlandshire (north Scotland), where it occurs in the higher beds (Balnakiel and Croisaphuil groups), a horizon representing essentially the Beekmantown or perhaps early Chazy of eastern North America. * The species has also been reported from Skye, and doubtfully from Newfoundland and the Mingan Islands.

* See Grabau, A.W., Bull. Geol. Soc. Amer. Vol. 27, pp. 568-570, 1916.

Most of the American Ordovician species occur in the Black River or early Trenton formations, though some range down into the Stones River (late Chazyan), and others up into the Galena limestone (late Trenton) or even into the Cincinnatian. Their geographical distribution ranges from the south central United States to the Arctic regions. No species is known from the Ordovician of Europe with the exception of the Scottish form noted, but the formation in which this occurs, is an extension of the North American, not of the typical European Ordovician. * In the Silurian on the other hand, this species is not uncommon in western Europe as well as in North America, and it again occurs, though less abundantly, in the Lower Carboniferous (Mississippian or Dinantian) of these countries, though this may possibly be a distinct development of Actinoceran characters in another genetic series.

In China the genus appears to be practically confined to the northern provinces, though Yabe describes and figures two fragments of undetermined species from Hsingshou Hsien, northwest of Ichang, Hupeh province. As the Ordovician of south China is much better known than that of north China, and as these are the only fragment so far obtained from the neighbourhood, though still to the north, of the Yangtze, it would appear that the genus is unrepresented in the south of China.

Actinoceras richthofeni Frech

Plate VII, figs. 1-3, Plate IX, figs. 4-8.

1911 *Actinoceras richthofeni* Frech, in Richthofen, China, Vol. V., p. 8, Plate II, fig. 4a (4b?).

This species was figured but scarcely described by Frech, who merely states that the siphuncle is subcentral in position and occupies about one-third of the diameter of the shell. His illustration shows rather strongly concave septa about 3.4 mm. apart, while the siphuncle has a fairly regular diameter of 14 mm. in the large end, which is 36 mm. in diameter, and 12 mm. in the smaller end, which is 20 mm. in diameter. The distance between the two measured points is 46 mm., giving a rate of tapering of nearly 1 mm. in 3, though this is only approximate, as it is not certain that the section is parallel to the axis of the shell.

Shell oval in section, the two diameters being as 1 to 1.4 in the younger, and as 1 to 1.5 in the more mature portion; tapering at the rate of 1 in 3, or 1 in 3.5 laterally, but

---

* Grabau loc. cit. The genus occurs on Bear Island and King William Land, in the arctic region.

only at the rate of 1 in 6 or 7 dorso-ventrally. Shell-surface apparently with longitudinal flexuous striæ; sutures somewhat flexuous, slightly arching forward on one of the sides. Average distance between cameræ 3.75 mm., less in the younger stages. Depth of cameræ, in center, equal to about 3 camera-lengths or slightly more. Siphuncle nummuloidal, large, centran, and oval in section, corresponding to the section of the shell. It increases less rapidly in diameter than does the shell, its lateral diameter being 14 mm. where that of the shell is 41 mm., (Plate IX, fig. 7); and 10 mm. where that of the shell is 30 mm. while its dorso-ventral diameter is 11.5 mm. where that of the shell is 28 mm., and 9 mm. in the younger stage, where that of the shell is only 24 mm. (Plate IX, fig. 8). It is thus more nearly circular in section in the younger stages. Siphuncle as a rule only partially filled by rosettes of stereoplasm, leaving a large central tube, from which lateral, more or less forward-bending diverticula extend into the nummuli.* Cameræ only partially (seldom entirely) filled with secondary stereoplasm.

The most complete specimen obtained is a fragment of the lower part of a large conch preserving 12 cameræ complete and portions of 3 others. This specimen is shown on Plate IX, figs. 7a-7e, and clearly shows the oval section which in the upper part is 41 mm. in lateral, and 27 mm. in dorso-ventral diameter. Three views of the specimen were drawn (7a-7c), after which it was sectioned, the two sections being shown in figs. 7d-7e. The form of the siphuncle corresponds to that of the shell, and its two diameters at the upper end of the fragment are each about one third that of the corresponding diameter of the shell. The nummuli are only partially filled with rosettes of stereoplasm, leaving a large median tube from 2 to 2.5 mm. in diameter. At the lower end of the specimen the diameter of the lower nummulus is 11.5 mm., the form being practically circular. At the upper end, the nummulus, next to the highest complete nummulus, has a diameter of 15.3 mm. while the highest completely preserved one, has a diameter of only 14 mm. Here the dorso-ventral diameter is also 11.5 mm. This shows that while there is in general an increase in diameter laterally, there is also some variation. From the median tube, a lateral tube traverses the center of each nummulus, in some cases extending outward approximately at a right angle, in others bending slightly forward. Again it may bend forward and then outward as seen in the second nummulus from the top (fig. 7e). In a few cases the opening of this tube in a pore on the periphery of the nummulus is well shown in the sections.

The septa are thickened by secondary stereoplasm, which appears to occur both on the upper and under side of the septum, though this feature is somewhat obscured by

---

* The term *nummulus* (pl. *nummuli*) is here used for the individual beads of the nummuloidal siphuncle, whether these are filled with secondary deposits or empty. These nummuli may be compared to the individual checker-like elements *chu* (珠) of the Chinese calculating frame or *Suanp'an* (算盤).

the development of crystalline calcium carbonate of inorganic origin in portions of the cameræ, especially on one side of the siphuncle. Pseudosepta generally define the stereoplasm. Some cameræ were however empty, having been filled by the matrix only (a fine brownish calcilutyte) which also fills the median tube.

Only traces of the shell are preserved which appears to have been rather thin, and marked by more or less flexuous longitudinal striæ.

In a fragment of a smaller (younger) individual from the same locality (Plate IX, fig. 8) the sides are more sharply acute (slightly accentuated by pressure in the specimen), while the siphuncular nummuli are proportionately larger and have a nearly circular transverse section. The dorso-ventral diameter of the interior of the shell (the septate stone-mold) at the largest end preserved, is 24 mm., and its transverse diameter about 34 mm. while the corresponding diameters of the siphuncle are 9 and 10 mm. respectively. The depth of a single camera in this specimen is 12 mm. where its short diameter is 22 mm. The septal interval at this stage is slightly smaller than usual, being on the average 3.33 mm.

Because of the oval transverse section of the shell, the specimens practically always lie upon one of their broader sides, and hence the weathered sections always expose the transverse diameter of the shell, and the tapering seen is that of the lateral margins, and hence the greater of the two. A dorso-ventral section, if obtained, would show a very different rate of tapering, and a much narrower shell. The great depth of the cameræ would however appear in such a section as well.

A larger specimen of this species from Tangshan (Plate VII, fig. 1), is 111 mm. long but incomplete at both ends. At the widest part preserved, it is 46 mm. in width, while at the lower end it is 24 mm. wide, the distance between these points being 66 mm. This gives a rate of tapering of 1 mm. in 3, essentially the same as that of Frech's figured specimen. The diameter of the siphuncular nummuli in this wider part is about 16 mm., or about one third the width of the shell. In the lower part it is about 13.5 mm., and therefore more than half the width of the shell.

The septa are about 3.8 mm. apart in the upper, and 3.6 mm. in the lower part. In a specimen on the same slab with the one just described, the interior of the siphuncle is well preserved (Plate VII, fig. 3). This shows that the secondary deposits at the inner ends of the septa are not continuous all around the siphuncle, but form a series of rounded thickenings, there being about six of these to the circumference, judging from the number shown in the specimen, which is one longitudinal half of the shell. This accounts for variation in thickness of these inner deposits, as observed in different sections; sections through the centers of two opposite beads would show the greatest amount of thickening, while sections through the depression between the beads would show the least, others falling between these.

In the majority of specimens the septa show secondary thickening, either on one or on both sides. This is however seldom if ever as extensive as in *A. tani.* In some cases, indeed, it is scarcely developed, or is strongly developed on one side only, as in the type figured by Frech (*loc. cit.* Plate 2 fig. 4a). The bowl-shaped depression which is formed around the siphuncle by the abrupt oblique truncation of the deposit near the siphuncle; in such species as *A. tani* and some others, is seldom developed. I have not seen it in perfection in any specimen of this species, though it occurs in individual septa. Not infrequently the deposit widens towards the siphuncle, and comes in close contact with it. One or two pseudosepta are commonly present in each camera characterized by such deposit. One may divide the deposit into two parts, and the other terminate it, after which there is an interval represented by an empty space (filled, except in weathered specimens, by the rock matrix *) and then a new septum follows.

In some cases the stereoplasm is included between the septum and a pseudoseptum next in front (see fig. 6 Plate IX). Again there may be a slight deposit of stereoplasm both on the upper and under sides of the septum, but this is generally irregular, especially on the under side, as if the septum had been broken. Thickening by stereoplasm on both sides of the septa is indicated in Frech's figure of the type, but I have not seen any specimen in which the thickening is as regular as is shown on the right side of his figure. A fragment which I refer to this species (Plate IX, fig. 5) has the cameræ nearly filled with stereoplasm, the septa appearing out of position, ending apparently against the nummuli. This would give the appearance of Frech's figure, if we assume that the septa are pseudosepta, and that true septa occur in the midst of the stereoplasm deposit. Of this there is however no indication. In fact, the septa are strongly bent backwards, so as to rest for a space against the upper or frontal surface of the next preceding nummulus. If a deposit of stereoplasm exists on the under side of the septum it could hardly be explained otherwise, than by assuming its formation to have taken place after the formation of the septum, in which case there must have remained some organic connection between the camera and the animal.

* It is a noteworthy fact, that the originally empty portions of the cameræ are almost always filled with the rock matrix (generally in our specimens a calcilutyte) in which the shell as a whole is embedded. It does not seem likely that the lime-mud, fine though it was, could filter through the "endosiphuncle" and the radiating tubules into these cameræ (no mud-filled tubules have been observed), and we therefore must conclude that it entered through fractures in the outer shell, formed no doubt by crushing after burial. In some cases the shell is seen to have been worn away before final burial, and in such specimens of course all empty spaces were filled by the lime-mud, and in some cases even other foreign substances, such as fragments of other fossils, are enclosed.

The inner tube of the siphuncle (endosiphuncle of authors) varies in diameter with the progress of siphuncular filling. In a specimen (Plate IX, fig. 4) in which the siphuncle has a width of 15 mm., it is only 1 mm. wide. In another (Plate VII, fig. 3), where the diameter of the siphuncle is about 11 mm., the open central tube has a diameter of about 5 mm. In the latter specimen, broad open diverticula diverge laterally, terminating in the centers of the nummuli, apparently in fine tubuli. In the former example, where the central tube has been narrowed to a diameter of 1 mm., the diverticula are reduced to tubes which curve obliquely downwards and outwards. Thus the tube which terminates in a pore in the center of a nummulus, reaches the endosiphuncle at a point almost in the median horizontal plane of the nummulus next forward. This peculiar structure is seen in a weathered section from Lincheng, province of Shantung, and appears also, but in a less marked degree, in the type specimen from Manchuria figured by Frech. It indicates that the deposition of material, was most pronounced on, and finally practically confined to, the anterior part of the floor of each nummulus as illustrated in text fig. 19. The deposits on the bottom of a single nummulus may be likened to a series of closely approximated superposed septa, the first slightly but normally concave, with a well-marked siphonal funnel, and thickened at the funnel-edge; each succeeding septum becoming more thickened at the funnel-edge, and having its funnel end invaginated into that of the preceding one. In consequence of the thickening of the septum at the funnel-edge, the central portion would rise more and more, the septum curving upwards from the rim to the funnel-edge, until the center of the septum, still pierced by the funnel-holes, is higher than the rim. This would mean a progressive collapse of the siphonal expansions, until they represented only a thin double membrane. Some slight additions of lime have meanwhile been made to the inside of the upper (forward) surface of the inside of the nummulus, by the upper surface of the siphonal expansion. Thus, what appears as a lateral tube in section, may in reality be the section of the space occupied by this collapsed siphonal

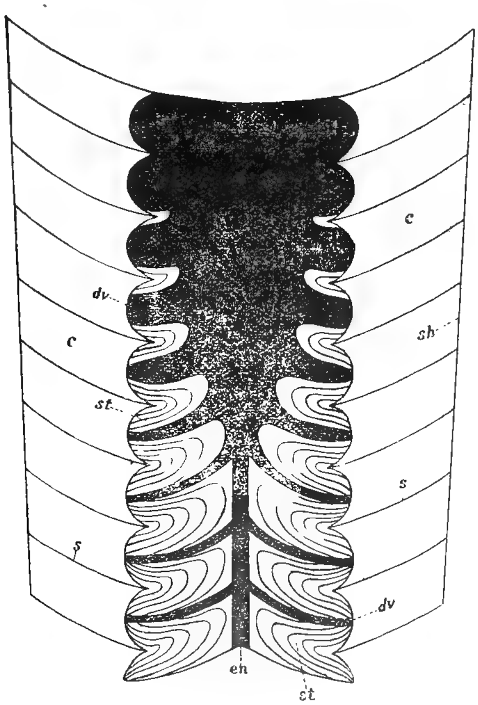


Fig. 19. Diagrammatic section of the part of a shell of *Actinoceras richthofeni* represented on plate IX, fig. 4. drawn to scale. The siphuncle is here shown in the process of filling by stereoplasm. In the upper part it is shown empty, successive layers of stereoplasm are added, in such a way that the diverticula from the central tube curve from the periphery of the nummuli forward or orad, as shown in the lower part of the figure, and in the drawing of the specimen (plate IX, fig. 4). Twice natural size. (*c*, cameræ; *dv*, diverticula of endosiphotube; *en*, endosiphotube; *s*, septa; *sh*, shell; *st*, stereoplasmic filling of nummuli).

expansion, which is more or less continuous across the siphuncle, and into which the several pores of the siphonal wall open. This is well shown in the specimen illustrated in fig. 4 Plate IX, where the end of the siphuncle has been severed off along one of these planes of weakness.

Aperturally the endosiphuncle terminates in a conical expansion, as described on page 73. It may continue beyond this in a series of hollow nummuli.

The mural pores of the siphuncle, if they are present in this species, are not well preserved. In a specimen in which they might be expected to appear prominently there appears to be no positive indication of them. This may be merely due to the manner of preservation, or the pores may in reality be absent, or may have been completely filled during the progress of shell growth.

So far as can be determined from the fragmentary material, the exterior of the shell is without ornamentation except fine flexuous longitudinal lines.

Comparisons. Frech compares this species with a fragment figured by Barrande * under the name *Orthoceras* (*Actinoceras*) *richardsoni* from Little Manitoulin or Cockburn Island Lake Huron, Canada, and calls attention to the fact, that Barrande's specimen can not be regarded as belonging to *A. richardsoni* Stokes. This would suggest that the Chinese species, or a closely allied but unnamed species, also occurs in the early Upper Ordovician (Trenton) of North America. I know of no other described species with which our Chinese form can be compared.

HORIZON AND LOCALITIES: In the Machiakou (Upper Tsinan) or *Actinoceras* limestone, widely distributed in north China. The type comes from Hsiau-sörr, Fengtien, (Manchuria), and was collected by von Richthofen in 1869. Yabe cites the species as common at Kwa-sen-do, Ko-to-gun, Hei-an-nan-dö, in Korea.** In Chihli province it has been obtained from Tangshan, Machiakou, and Chaokouchuang, all in the Kaiping basin, and from Huo-Luh Hsien in the southwestern part of the province (by Miss Clarke). In Shantung province it has been found near Lin-cheng by Dr. F. F. Mathieu and at Seng Chuang, Ningyang district and Wên Nan, Monyin-Hsien, by Dr. Ting.

Actinoceras tani Grabau (sp. nov.)

Plate VII, figs. 4-7.

Shell slender, tapering at a rate varying from 1 in 5 to 1 in 7 according to the direction of the section measured. Cross-section faintly oval. Siphuncle excentric, on

---

* Syst. Sil. de la Bohême, Vol. II Text III. 1874, p. 737, pl. 234, figs. 2, 3.
** Pal. Southern China 1920, p. 54, footnote.

the shorter axis of the section, and distant from the nearest shell-margin a variable amount, this ranging from about half, to a little more than its full diameter. From the opposite shell-margin it is separated between two to three times this amount. In a specimen from Tangshan (Plate VII, fig. 5, cat. no. 26) the diameter of the siphuncle is 5 mm. where the shell is 22.3 mm. in diameter, while in another specimen from Shantung, the siphuncle has a diameter of 4.5, the shell diameter being 17.5 mm. (cat. no. 66). In the specimen illustrated in figure 6 Plate VII, (cat. no. 1), where the siphuncle is apparently centran, because of the position of the section, it retains a very uniform diameter of 6 mm. while that of the shell ranges, at the point of the section, from 16 to 20 mm. As this is a shell with excentric siphuncle,* the section does of course not represent the maximum diameter nor the true rate of tapering.

In a specimen from Chihli (Plate VII, figs. 4a, b, cat. no. 69) which shows the greatest rate of expansion observed (1 in 5), the siphuncle appears centran in longitudinal section, but the transverse section shows it to be about one half its diameter from the margin. The siphuncle is 8 mm. in diameter where the shell in the same section is 24 mm. The endosiphuncle (endosiphotube) is about 1.5 mm. in diameter or a little more, and appears as a regular cylindrical tube. The septa average 2.6 mm. apart. They are sometimes double, and the cameræ are largely filled with stereoplasm.

The nummuli, or expansions of the siphuncle in the cameræ, are generally regular and symmetrical, though now and then one is shorter, or of smaller diameter. When well exposed, the peripheral mural pores may be seen, ranged around the ambitus of the nummulus. In a specimen from Tangshan (Plate VII, fig. 7c), they are small, and each is situated at the summit of a low pustule, the pustules being separated by a space equal to about twice their diameter. I estimate their number on a single nummulus to be about 24.

The septa are strongly thickened by the addition, on the upper side, of stereoplasm, which has a crystalline structure and is terminated by a smooth-surfaced supplementary septum or pseudoseptum in each camera. The thickening proceeds to within a short distance of the siphuncle, when it dies away abruptly, the pseudoseptum sloping steeply and generally concavely to the septum, which latter joins the siphuncle in the constriction between the nummuli. Thus a sort of saucer-like depression is formed around each nummulus, which appears to lie in it like the pudding in a dish.

The thickening, by stereoplasm, is not uniform in successive cameræ, nor within the same camera. As will be seen from the natural section of the specimen illustrated in

* This can not be positively seen in the specimen in question, but as it has all the other characters of this species, which from other specimens is known to have an excentric siphuncle, the above inference may be safely made.

figure 6 on Plate VII, the same camera may show a thickening on one side to the extent of half the height of the camera, while on the opposite side the thickening may fill nearly the whole of the camera. In a general way, there is a decrease in the amount of the deposit from the older septa forward to the younger.

The apical end of this species is shown in a specimen from Tangshan (Plate VII, figs. 7a,b). This begins with a somewhat asymmetrical subconical initial chamber, about 9 mm. in depth. At its apex is the large siphuncular foramen, surrounded by a swollen annulus, the whole producing an apical mammelon, about 7 mm. in basal diameter. The central scar or siphuncular opening is about 3.5 mm. in diameter. At its upper end the initial chamber has a lateral diameter of 16.6 mm. and a dorso-ventran of 16 mm. The mammelon lies to one side of the lateral, but, on the dorso-ventral axis. Above the initial chamber the ventral (?) side (side nearest to which the siphuncle lies) becomes faintly concave longitudinally as if the shell were taking on a cyrtoceraconic form. This continues for about five chambers after which it disappears and the surface slope is normally orthoceraconic. Almost from the first the septa average 3 mm. apart at the suture, their concavity being equal to about the depth of one camera. This early portion of the shell has a somewhat greater angle of divergence than is characteristic of later stages, being about 1 in 4.

Surface features of shell unknown.

This form is readly distinguished by its slender character, gentle rate of tapering, septal distance, character of stereoplasm and excentric siphuncle. The latter is not however always seen in its true relation in longitudinal section, for if this is normal to the dorso-ventral axis the siphuncle appears centran as in fig. 6 Plate VII.

Horizon and Locality: *A. tani* is probably as common as, if not more so than *A. richthofeni*, and occurs in practically the same localities, in the Machiakou limestone. Specimens have been obtained from Tangshan (F. K. Morris, G. B. Barbour), Machiakou (H. C. T'an), and Chaokouchuang (Survey expedition) Chihli; from Lincheng, from Chan-chin-Hsien, and elsewhere in Shantung (F. F. Mathieu, J. G. Andersson and V. K. Ting) and from Chilio, south of Shih-T'ou Chiang, Chihli (G. B. Barbour). The specific name is given in honor of Mr. H. C. T'an of the Chinese Geological Survey.

Actinoceras coulingi Grabau (sp. nov.)

Plate VIII, figs. 1, 2.

1903 *Actinoceras* (*Ormoceras*) aff. *tenuifilum* Hall. Crick, Geological Magazine N. Ser. Dec. IV, Vol. X, p. 481, pl. XXII fig. C.

1920 *Actinoceras* (*Ormoceras*) sp. indet. Yabe, Palæontology of Southern China, pl. XIX fig. 9. (not pl. XVIII fig. 12).

Shell large, tapering at the rate of about 1 in 5 to 1 in 5.5. Siphuncle centran or nearly so, increasing very slowly in diameter, the nummuli strongly flattened above and below so as to be in contact with the septum for nearly one fourth their width on all sides. At a point where the shell is 24.2 mm. in diameter, the siphuncle is 8.5 mm. (Plate VIII, fig. 2, cat. no. 27). In another specimen (Plate VIII, fig. 1, cat. no. 4) the diameter of the siphuncle is 9.5 mm. where that of the shell is 25 mm; and 11 mm. where that of the shell is 31 mm. the rate of tapering being about 1 in 20 to 1 in 22. Septa regularly concave, their depth at the center being equal to 1 $\frac{1}{2}$ or 1 $\frac{3}{4}$ cameræ, and their distance apart about 3 mm. or somewhat more, where the shell is about 30 mm. in diameter. Cameræ mostly filled with stereoplasm which often has the appearance as if it were deposited on both sides of the septum (See Plate VIII, figs. 2, cat. no. 27). I have, however not been able to satisfy myself that this is actually the case. Instead it would appear that the septa are more or less undulating, partly so away from the siphuncle, but more usually near it, where there is sometimes a marked annular depression of the septum, so that it comes to lie almost opposite the ambital portion of the nummulus. In other cameras again this depression is not seen, and sometimes in section one side appears regular while the other shifts backwards. Commonly the stereoplasm fills the camera almost or quite to the siphuncle and completely to the next succeeding septum. In other cases however, where the septa maintain their normal position, the stereoplasm stops before reaching the siphuncle, leaving a saucer-shaped depression around the nummulus as in *A. tani*.

The specimens on which this description is based, agree in all essentials with the photograph of a specimen collected by Samuel Couling M. A. near Ching Chow Fu, Kiao-chow, province of Shantung, and figured by G. C. Crick (*loc. cit.*) on his Plate XXII, fig. C. His specimen may have been larger than ours, for the scale is not indicated, but the proportions are essentially the same, the siphuncle being 15.8 mm. where the shell is 47 mm. and the septa 3.3 mm. apart. Crick compares his specimen with *A. tenuifilum* Hall of the Black River beds of North America. In that species, however, the siphuncle is proportionately broader (the proportions being about as 1 to 1.9, whereas in the Chinese species, they are as 1 to 2.8). The septal interval is also greater, being in the American species 7 to 7.5 mm. where the shell is 27 mm. wide, the proportions of depth of camera to diameter being approximately as 1 to 6.5 instead of ranging between 1 to 8 and 1 to 10, as in the Chinese species. In *A. tenuifilum* the septa are also frequently displaced apicad and made to appear double by the development of pseudosepta.*

Crick describes a specimen from the Couling collection, apparently of this species, which has a length of 95 mm., and a maximum width of 50 mm. tapering very slowly, and with a siphuncle at that point about 24 mm. in diameter. He describes the cameræ as 11 mm. high, but that seems out of all proportion to the shell, (being as 1 to 4.5 as compared with 1 to 8 or 1 to 10 in the typical forms) and would argue a rapid elongation of the chambers with the growth in length of the shell.

Horizon and Locality: This species has been obtained from the Machiakou (Actinoceras) limestone of Hsi-Hsien, province of Honan, (L. C. Taun), from Machiakou, Luan Hsien, Chihli province (H. C. T'an), and from Lincheng, Shantung province (F. F. Mathieu). The specimen collected by Samuel Couling, came from Ching Chow Fu, Kiaochow, Shantung. Yabe (*loc. cit.* Plate XIX, fig. 9) figures a specimen of *Actinoceras* from No-lu-ping Hu-ch'i, Hsing-shan-Hsien, province of Hupeh, which may belong to this species, though the specimen is in a very imperfect condition. The other specimen figured by Yabe (Plate XVIII, fig. 12) from Pan-tse-ya, same district and province does not belong here, the septal interval being proportionately much greater than is normal for this species, while the siphuncle is submarginal.

The specific name is given in honor of Samuel Couling, A. M. Editor of the China Review, Shanghai, who first brought to the notice of scientific men the occurrence of the genus *Actinoceras* in the Ordovician rocks of China, and to whom the Survey is indebted for courtesies in connection with these studies.

Actinoceras suanpanoides Grabau (sp. nov.)

Plate VIII, figs. 3*a*, *b*. 4*a*, *b*; Plate IX. figs. 1*a*, *b*.

Shell slender, tapering at the rate of about 1 in 5.5; section apparently oval, with a slight flattening on the ventral side. Siphuncle excentric nearest the flattened side, from which it is separated by a distance equal to about half its diameter. In the early stages the siphuncle occupies more than half the diameter of the shell ($\frac{2}{3}$ in some cases?) but later the proportional diameter is not much over one-third that of the shell. The nummuli are somewhat flatter on the forward as compared with the posterior end and the

* See the figure of the American species reproduced in Grabau and Shimer; North American Index Fossils Vol. II p. 116; fig. 1351.

endosiphuncle seems to be obliterated by filling. Cameræ fairly uniform, their length averaging perhaps 3.5 mm. where the shell has a diameter of 15 mm.; nor do they materially increase with the increase in the shell diameter to 20 mm. Their concavity is nearly equal to the depth of two chambers. Stereoplasmic filling of the cameræ is pronounced in the earlier part of the shell, but becomes less so in the later cameræ. For the most part it is added to the anterior portions of the septa, but in some cases it appears also to be added to their posterior surfaces, but this is very irregular and may be a secondary deposit. The septa are sometimes undulating, in some cases bending back nearly to the center of the nummulus of the preceeding camera. In some cases the stereoplasm ends near the siphuncle in a saucer-like surface as in *A. tani*, while in other cases it extends nearly or quite to the nummulus. In still other cases it is more weakly developed in one part than in another of the same camera (see the section Plate VIII, fig. 3).

Outer surface of shell unknown.

This species has the general form and character of *A. tani*, but the cameræ are about half again as long as in specimens of that species of the same diameter, and the concavity of the septa is much greater. The stereoplasmic filling is also more irregular in the present species than in *A. tani*.

A fragment of a shell 8 cm. in length, and apparently of this species was obtained from Wên-Nan, Mon-Yin-Hsien, Shantung. This is figured on Plate IX (figs. 1 a-b). The rate of tapering is not ascertainable with accuracy because the shell is slightly crushed on one side, but appears to have been about 1 in 7. At the lower end of the fragment, where the diameter is about 19 mm, the siphuncle has a diameter of about 8.5 mm. whereas that of the sections figured is about 7 mm.

The distance from the ventral margin is 3.5 mm. that from the dorsal 7 mm. Where the diameter of the shell is 24 mm., the distance of the siphuncle from the ventral margin is still 3.5 mm. The average distance between the septa is 3.5 mm. The sutures visible on the exterior of the inner mold, are somewhat undulating, extending forward on the ventral side (the side to which the siphuncle is closest) in a gentle saddle, to the extend of about 1 camera-length beyond the lateral and dorsal sides. In the earlier portion, this saddle is less pronounced, its increase in length thus corresponding to the proportional approach of the siphuncle to the ventral side. The concavity of the septa in the larger portion of the fragment is equal to about the depth of two cæamer.

Horizon and Localities: In the Machiakou limestone of Tai-an, Shantung province. Survey collection. A small specimen apparently representing the apical portion of this species was obtained from Sen Chuang, Ning Yang, Shantung, and another from Lincheng, Shantung (F. F. Mathieu), and a fairly well-preserved internal septate mold from Wên Nan, Mon-yin-Hsien, Shantung (V. K. Ting).

The specific name is given in allusion to the Chinese calculating frame or *Suanp'an* (算盤), to the elements of which, *i. e.* the single row of *Chü* (珠) the siphuncle of this species shows a marked resemblance.

Actinoceras submarginale Grabau (sp. nov.)

Plate VIII, figs. 5*a*, *b*; Plate IX, fig. 3.

Shell of medium size tapering at the rate of about 1 in 4, the siphuncle submarginal and occupying about one-half the diameter of the shell or somewhat less, regularly swelling between the septa, and constricted at the septal openings to about two-thirds its width. Endosiphuncle large, its diameter about 3 mm. where that of the siphuncle is 15 mm. with deverticula extending into the nummuli. Mural pores not observed. The section of the shell is apparently suboval while that of the siphuncle is circular. It is so close to the shell on one side, that it appears almost to touch it, but the septa are continuous around it, showing that the contact is not absolute. In form the siphuncle tapers gently, the rate being approximately 1 in 19 in a characteristic specimen.

The septa range from 4 to 4.7 mm. apart and are, as a rule moderately concave, though in one specimen (Plate IX, fig. 3, cat. no. 56.) some of them exhibit rather marked curvature, involving in some cases as much as the depth of two chambers. The space between the septa ranges from 4 to 4.4 mm. in specimens of about thirty mm. diameter. In a specimen sectioned so as to give the siphuncle a subcentran appearance, although it is in reality close to the margin (Plate VIII, fig. 5*a*, *b*) the septa are at first rather flat-lying, and somewhat undulating, after which, near the margin, they bend strongly forward (upward). In this respect the two specimens figured show a marked contrast, but it must be remembered that they show the shell in sections practically at right angles to each other.

The stereoplasm is variable. In one specimen (fig. 5) it fills the greater part of the cameræ leaving only a narrow space beneath the next septum. The filling extends to the siphuncle and makes the entire shell a very solid and compact mass. In another specimen (fig. 3) the filling is comparatively slight, and the septa hence have weathered out in relief from the section and were readily broken away.

Sections of this species made so as to give the appearance of a centran siphuncle (Plate VIII, fig. 5a) might be taken for *A. richthofeni.* They can however be readily distinguished by the slight depth of the cameræ. In a transverse section of course, the subcircular outline and submarginal position of the siphuncle readily distinguish this species.

Horizon and Localities: This species has been obtained from the Machiakou limestone of the Kaiping basin in eastern Chihli province. It has been found at Tangshan and more doubtfully at Machiakou (Survey expedition). A natural section, apparently of this species, has also been obtained from the same horizon at Wên-Nan, Mon-Yin-Hsien, Shantung (V. K. Ting coll.).

Actinoceras nanum Grabau (sp. nov.)

Plate VII, fig. 8; Plate IX, fig. 2.

Shell slender, the longest specimen observed being about 70 mm. in length and 10 mm. in diameter at the basal end. It tapers at the rate of about 1 in 4. A second specimen (Plate IX, fig. 2) about 45 mm. long, has a basal diameter of 6.5 mm. and tapers at the rate of 1 in 5.75. A third specimen (Plate VII, fig. 8), the most perfectly preserved, has a length of about 18 mm., its basal diameter is 6 mm. and its rate of tapering 1 in 4.

Siphuncle centran, small, the greatest diameter of the nummuli being 2.1 mm. where that of the shell is 9.4 mm.; strongly nummuloidal, contracting at the septa to a diameter of 0.7 mm. Endosiphuncle subcylindrical, about 0.6 mm. in diameter.

Septa gently concave. In the best preserved specimen they are 1.3 mm. apart where the diameter of the shell is 10 mm. and practically the same where the shell diameter is 8.5 mm. In another specimen, (Plate IX, fig. 2) the septal interval is 1.6 mm. where the shell diameter is 10 mm. and that of the nummuli about 2 mm.

Stereoplasm slightly developed or almost absent. When present, as in fig. 8 Plate VII, it is thickest near the siphuncle, but thins away rapidly before reaching this.

This species is readily recognized by its tapering to a very narrow end which is 6 mm. or less, a diameter found in no other species in these rocks; by the very approximate septa (from 1.3 to 1.6 mm. where the shell is 10 mm. in diameter); and by the minute centran siphuncle, which is smaller than that of any other species known from these rocks.

Horizon and Locality: This species has so far been found only in the Machiakou limestone of Tangshan in the Kaiping basin, eastern Chihli. It is less common than some of the other species.

Actinoceras curvatum Grabau (sp. nov.)

Plate VIII, fig. 6.

Shell gently curved, with large siphuncle close to the convex side, though not in contact with the shell. The diameter of the siphuncular elements or nummuli, in the only known specimen, is 12 mm. and their length 2.4 mm. giving a proportion of 1 to 5. They are moderately contracted at the septal crossing so that their narrowed portion is about 8 mm. in diameter. Diverticula from the endosiphuncle (the latter not exposed in the sepcimen) extend nearly to the outermost margin of the nummulus where there appear to be rather widely-spaced mural pores, which are, however, not well shown except now and then in one or another of the nummuli.

There is some variation in the length of the individual nummuli, but no appreciable change throughout the part of the shell shown, which is about 80 mm. long. The average length of the nummuli remains the same so far as exposed, but the diameter apparently decreases somewhat apicad, but this can not be determined with certainty. The width of the shell cannot be ascertained but judging from the septa preserved, it could not be less than 20 mm. in the lower part, and probably was 25 mm. The septa are strongly oblique towards the siphuncular side. If the curvature was regular, with a shell width of 25 mm., the depth of the septa was equal to that of two cameræ.

While the septal distance in the upper part of the shell was presumably that of the nummuli-length, or 2.4 mm. on the average, it was somewhat greater in the earlier part of the shell, where the septa are preserved. There the average is 2.7 mm., some of the septa being separated by as much as 3 mm.

Stereoplasmic thickening of the septa is moderate, being confined to the upper surface of the septum and occupying one-half of the septal interspace or less. It is irregular, swelling in some parts, and thinning away in others. It seems to be least developed on the inner or concave side. It was apparently bounded above by a pseudoseptum.

Horizon and Locality: A single imperfect specimen has been obtained by Dr. F. F. Mathieu from the Machiakou limestone of Lincheng, province of Shantung. Though imperfect, it is thought worthy of description, as it is the only curved *Actinoceras* known from these rocks. The species is placed in the genus *Actinoceras* rather than *Cyrtactinoceras*, because of its slight curvature, moderate tapering, and large actinoceran siphuncle. Another smaller specimen with narrower siyhuncle (9 mm. where shell is 15 mm. wide), but otherwise similar, and also showing slight curvature, has been obtained from the same horizon, south of Wên-Nan, Mon-Yin-Hsien, Shantung. (V. K. Ting coll.)

Genus **CYRTACTINOCERAS** Hyatt.

This genus, founded by Hyatt, with *Cyrtoceras rebelle* Barrande as the genotype, was more fully defined by Ruedemann (N. Y. State Museum Bull. 90, 1906, p. 488), who referred to it two species from the Chazy limestone (Middle Ordovician) of the Lake Champlain region in eastern North America. They are rather short and stout cyrtoceracones with highly nummuloidal siphuncle, characterized as in *Actinoceras*, by stereoplasm which is arranged as obstruction rings or "rosettes" around the septal necks. The cameræ too are filled with stereoplasm, this being very extensive in one of the Chazy species. In the type of the genus, the section is depressed, the septa rather closely arranged, the siphuncle moderately nummuloidal shrinking somewhat in old age, and filled in the middle stages with rosettes. It is near the convex side of the conch, but somewhat variable in position, approaching the center again in old age (Ruedemann).

From curved forms of *Actinoceras* the species of this genus may be distinguished by their rapid enlargement, this producing relatively short stout shells. The siphuncle of the curved *Actinoceras* species is also much larger in proportion than is that of *Cyrtactinoceras*.

Cyrtactinoceras frechi Grabau (sp. nov.)

Plate VIII, figs. 7 - 10.

Shell a comparatively small breviconic cyrtoceracone of subcircular or somewhat oval section and gentle curvature, the shorter of the two transverse axes in the plane of curvature. The shell tapers at the rate of 1. in 2.5 in the early stage, having a transverse diameter of 10 mm. at the second septum, below which it is rounded off acutely. Seventeen millimeters above the second septum it has a transverse diameter of 18 mm. while the shorter axis measures 15 mm. At this point the siphuncle is situated about 4 mm. from the convex side and has a diameter of 4.5 mm. being approximately circular in section. The increase of the shorter axis in another specimen (Plate VIII, fig. 7 cat. no. 2) is from 9 mm. to 13 mm. in the space of 17 mm. giving a rate of tapering of 1 in 4.25. In this specimen the siphuncle has a diameter of about 4 mm. at the lower end, not changing appreciably throughout. Its distance from the outer margin of the upper end of the specimen is about 4 mm. but it is only about 2 or 2.5 mm. from this margin at the lower end. In a specimen from Chaokouchuang (Plate VIII, fig. 8) with a shorter diameter of about 10 mm. at the base, the siphuncle is 2 mm. from the outside and has a diameter of 3 mm. or a little more. The transverse diameter here is about 11.5 mm. Fourteen millimeters higher, these diameters are 12 and 15 mm. respectively, giving rates of tapering of 1 in 7 and 1 in 4 respectively. In a sectioned specimen from Shantung (Plate VIII, fig. 10) the diameter of the siphuncle is 4 mm. where that of the shell is 15 mm., and it is 2.5 mm. from the convex side. In form it is strongly nummuloidal and filled with stereoplasm deposited in rosette form as in *Actinoceras*. There is a narrow subcentral endosiphuncle.

Septa from 2.6 to 2.75 mm. apart, of moderate curvature, and with comparatively little stereoplasm in the cameræ, this being most extensively developed on the convex side.

This species differs from the American Middle Ordovician (Chazy) species mainly in its excentric siphuncle, and longer cameræ in the young. It has much less stereoplasmic deposit in the chambers than has *C. champlainense* Ruedemann, and it curves less than does *C. boycii* Whitfield. A short section of the shell might easily be mistaken for a small species of *Actinoceras*.

Horizon and Localities: In the Machiakou limestone of early upper Ordovician (Black River) age at Tangshan, Machiakou, and Chaokouchuang, all in the Kaiping basin of eastern Chihli province, (Collections: T. C. Wang, H. C. T'an and Y. C. Sun respectively). Also from Chingchuang, Ning-yang district, Shantung province (coll. V. K. Ting).

The specific name is given in memory of the late Dr. Fritz Frech of Breslau Germany, to whom we owe the fifth volume of Richthofen's great work on China, and whose labors have done so much towards increasing our knowledge of the invertebrate fossils of China.

Genus **GONIOCERAS** Hall

The presence of the genus Gonioceras in the Ordovician rocks of north China was first suggested by G. C. Crick * in his discussion of the fossils collected by Mr. Samuel Couling, M.A., Editor of the China Review, south of Tsing-tshou-fu (Ching-Chow-Fu) in Shantung. In his plate (fig. B) Crick gives a photographic reproduction of one of the specimens which, if natural size, (the scale is not given) shows an actinoceran shell with apparently empty cameræ 2.2 mm. long, and a strongly nummuloidal siphuncle, the nummuli of which are 15.5 mm. in diameter. He further refers to a rubbing of another specimen, "about 25 centimeters long, displayed in section on the surface of a slab". Commenting on these specimens, he says "although the relative proportions of the parts of the shell, the relatively wide siphuncle and the very shallow chambers, agree fairly well with those of *Actinoceras imbricatum* Hisinger, sp. from the Silurian (Upper Ludlow) of the Island of Gotland, Sweden, it seems scarcely likely that an example of this species could be so worn down as to expose the siphuncle for a length of 25 centimerers".** Crick therefore refers his specimen to the genus *Gonioceras* Hall.

I must confess that the evidence has seemed to me inconclusive, as the specimen might have been an *Actinoceras* with the siphuncle near one side. Nor is the photographic reproduction given by Crick entirely satisfying, as it leaves many of the characters of the specimen in an indeterminable state, especially the nature of the cameræ. A specimen in the Survey collection showing a similarly wide siphuncle and short cameræ, appeared to be related to the form described by Crick, but this too I was at first disposed to refer to *Actinoceras*, as aside from the proportions, it seemed to show no very decisive characters differentiating it from other species of that genus which occur in these rocks, except the empty cameræ, a feature not found in any other species of *Actinoceras* in the Ordovician rocks of China. This led to a more careful study of the specimen, with the result that several of the septa were found to show the true *Gonioceras* curvatures. This settles the question as to the presence of the genus *Gonioceras* in the Ordovician of north China, and it lends a strong measure of probability to the correctness of the interpretation suggested by Crick, and to him must be given the credit for the discovery of this unique organism in China, a discovery of very great importance, as already pointed out by Ruedemann. For, as this genus is otherwise only known in the Chazy, Black River and early Trenton of eastern and central North America, extending to the base of the Stones River group in Tennessee, it places beyond the question of a doubt the former intimate

* Geol. Mag. Dec. IV. Vol. X. pp. 483-484 pl. XXII, 1903.
** *loc. cit.* p. 483.

marine connection of these two districts, a connection which nearly all of the other fossils so far obtained from the highest Ordovician rocks of north China have persistently pointed to.*

The specimen of *Gonioceras* described below, came from Seng Chuang in Ning-Yang, province of Shantung, about 190 km. (315 li) southwest of the locality where Mr. Couling's specimens (described by Crick) were found. So far then this genus is only known from Shantung but its discovery in Chihli province may now be looked forward to with confidence.

Gonioceras shantungense Grabau (sp. nov.)

Plate VIII, figs. 11a, b.

cf. *Gonioceras* sp. Crick. Geological Magazine, New Series Dec. IV. Vol. X. pl. XXII, fig. B, 1903.

Form of shell unknown, but apparently of the usual expanded and thin character of the genus. Siphuncle probably excentric, but the exact position in the shell not known, the only specimen in our possession having apparently been worn before embedding. The siphuncular elements (the nummuli) are apparently uniform or enlarge only very slightly forward. They are 11.5 mm. in greatest diameter in the section shown, which is probably cut a short distance beyond the central plane, no evidence of an endosiphuncle appearing. From the fact that the transverse section shows only about 4 mm. of thickness for the siphuncle, it would appear that, provided it was circular, its diameter was originally about 13 mm. The stereoplasmic filling is distinctly actinoceran consisting of rosettes of obstruction rings at the septal necks. At this point the siphuncle contracts to 7.5 mm.

The septa average 2.4 mm. apart, and the cameræ are without stereoplasmic filling except for a very slight thickening at the points where they become free from the

---

* I may add that my reticence in accepting as conclusive the argument for the occurrence of this genus in the Chinese rocks, was to a large extent influenced by my hope of finding just such satisfactory evidence of the former intimate connection of northern China and eastern North America, as this occurrence affords, for as the study of the Chinese material progressed, this connection became more and more evident. Still I was loth to accept any but the most conclusive evidence, and the discovery of an undoubted specimen of *Gonioceras*, coming as it did towards the close of these studies, affords therefore unparalleled satisfaction. I may further note, that a specimen of *Columnaria*, which I am unable to distinguish from the common *C. halli* of the American Black River beds has come into my hands. This specimen, found in the collection of Yenching college (Peking) is said to have come from the hills of eastern Szechuan, north of the Yangtse, and west of the southernmost locality (in Hupeh) in which *Actinoceras* has been found. As long however as the shadow of a possibility remains, that in the vicissitudes which a student collection suffers, an American specimen might have been substituted for the original specimen from central China, I am unwilling to include it in this memoir. A further note regarding it will, however, be published in the Bulletin of the Survey.

siphuncle. Most of the septa are broken off a short distance beyond the siphuncle, but near the base of the section a few of them are found to continue outward, and although they are somewhat broken they show the undoubted rather sharp return curve, so characteristic of this genus. This is shown in the illustration.

In its general form and character this species comes nearer to *Gonioceras chaziense* Ruedemann * from the middle Chazy limestone of Chazy N.Y. on Lake Champlain (U. S. A.) then to either of the other two known species from the higher rocks. The siphuncle of the Chazy species is however only 7 mm. in diameter while the distance between the septa averages 2 mm. The greatest width of that shell is a little over 70 mm. that of our species can not be ascertained. In the Chazy species each septum rises within the body of the conch to the height of five cameras, before it forms the characteristic return curve. In our species this character is much less pronounced, the septum scarcely rising to the height of one and a half camera, and the angle of recurvature is rather charp, while beyond it the septum continues with a gentle forward concavity. It is at or near the angle of recurvature, that most of the septa are broken away.

Horizon and Locality: The single known specimen came from Seng Chuang, (Shen Tsun) Ning-Yang, province of Shantung, where it was collected by Dr. V. K. Ting. The specimens described by Crick, which may belong to this species (though the fact that one of his specimens was 25 cm. in length, makes this doubtful) were collected by Mr. Samuel Couling near Chingchow Fu, Kiaochow, also in the province of Shantung.

Class **CRUSTACEA** Lamarck

Sub-Class **TRILOBITA** Walch

Order **Opisthoparia** Beecher

Family **ASAPHIDÆ** Burmeister

Genus **ASAPHUS** Brongniart

Asaphus boehmi Lorenz

Plate I, figs. 8, 9.

1906 *Asaphus boehmi* Lorenz. Beiträge zur Geologie und Palæontologie von Ostasien, II. p. 84, pl. XVII, figs. 4, 5a, 5b.

---

* N. Y. State Museum Bulletin No. 90 p. 494 plate 36 figs. 3 and 4.

Original Description:

"Wir haben hier zweifellos einen echten *Asaphus* und zwar die engere Gattung *Asaphus* vor uns, deren Grenzen Fr. Schmidt * umschrieben hat. Die Unterabteilungen Salters ** konnten keine passende Anwendung finden."

"Kopfschild ist nur in einem Exemplar vertreten. Glabella nach vorn birnenförmig verbreitert. An Furchen ist nur eine sehr tiefe und breite Basalfurche an der hinteren Glabella vorhanden. Hinter der tiefen Basalfurche ist eine schmale, flache Occipitalfurche entwickelt. Der zwischen den beiden Furchen gelegene Rand trägt einen kleinen Höcker. Die Augen liegen weit hinten. Durch den charakteristischen Verlauf der Gesichtsnaht bekommen die Wangen das Aussehen von zwei flügelartigen Lappen, die hinten zu beiden Seiten der Glabella liegen. Die Gesichtsnähte laufen scheinbar vor der Glabella zusammen. Das Pygidium ist in seiner Gesamtform parabolisch. Ein breiter Randsaum bildet die Umrandung. Die Segmentierung ist zahlreich, aber schwer sichtbar. Auf den Seitenteilen sind die Pleuren mit unbewaffnetem Auge kaum zu erkennen. Die Rachis hat eine charakteristische Form. In ihrem hinteren Verlauf gleichmässig schmal, verbreitert sie sich unvermittelt nach vorn. Die Schale ist geädert. Diese Skulptur entspricht wohl den Terrassenlinien von Fr. Schmidt.

"Ich nenne diese Art nach meinem früheren Lehrer, Herrn Prof. Dr. Georg Böhm an der Universität zu Freiburg i./Br.

"Ich sammelte diese Fossilien in einem gelblichen mergligen Kalkschiefer hart am Wege etwas unter dem Gipfel des Hoschan. Das Alter der Schichten ergibt sich durch das Auftreten obiger Trilobitengattung als zweifellos untersilurisch. ***

Two small fragmentary pygidia from Chaokouchuang are referable to this species. The axis is strongly elevated and broadens rather rapidly in the anterior portion; the sides are concave. The anterior ring is narrow and continued as a distinct but narrow ridge along the anterior border of the limb on either side of the axis. The other axial rings, of which 5 are partly preserved on one specimen, are about twice as wide as the first, separated by narrow and shallow transverse furrows, their shallowness making the annulation of the axis scarcely visible except in certain positions. Lateral furrows of axis rather pronounced. Limb smooth except for the anterior bounding ridge; doublure of margin rather broad, marked by irregular longitudinal lines. Entire surface of pygidium finely punctate.

---

* 1898. Mém. de l'acad. imp. des sciences St. Pétersbourg. Classe phys.-math. (8) vol. VI.
** A Monograph of the British Trilobites, 1864-1883 p. 146-149.
*** Lorenz: *loc. cit.*

Measurements: The following are the measurements of the pygidia described and of that figured by Lorenz.

	Chihli Specimens described		Shantung Lorenz type
	a	b	c
Anterior width of pygidium	12.5 mm.	12. mm.	16. mm.
Width of axis at anterior end	3.3 ,,	3.5 ,,	5. ,,
Greatest length of pygidium	?8. ,,	8. ,,	11.5 ,,
Length of axis	?6. ,,	7. ,,	8. ,,

HORIZON AND LOCALITY: In the Machiakou limestone of Chaokouchuang in the Kaiping basin, Chihli province (Survey expedition coll.). Lorenz's type came from essentially the same horizon near the summit of the Hoshan in Shantung.

Asaphus sp.

There is at least one other species of *Asaphus* (or *Isotelus?*) in the collections from the Kaiping basin, but the material is too fragmentary for description. It indicates, however, a much larger species than *A. boehmi*. *Asaphus?* of an indeterminate species has also been recorded by Weller in these rocks near Tsai-Kia-Chuang in Shantung. Other species are found in south China, but these are excluded from the present discussion.

BIBLIOGRAPHY.

BARRANDE, J. Système Silurien du centre de la Bohême. Praha.

BIEDERMANN, W. 1901. Untersuchungen über Bau und Entstehung der Molluskenschalen. Jenaische Zeitschrift für Naturwissenschaft. Bd. 36, pp. 1-164, Taf. I-VI.

BILLINGS, E. 1865. Palæozoic Fossils, Vol. I, Geological Survey of Canada.

BROWN, J. COGGIN. 1913. Contributions to the Geology of the province of Yunnan in western China, III. Notes on the Stratigraphy of the Ordovician and Silurian beds of western Yunnan. Records Geological Survey of India Vol. XLIII pt. 4, pp. 327-334.

CLARKE, JOHN M. 1897. The Lower Silurian Cephalopoda of Minnesota. Minnesota Geological Survey. Palæontology. Pt. II, pp. 761-812 plates 48-54.

CRICK, G. R. 1903. Notes on some specimens of straight-shelled Nautiloidea collected by the Rev. Samuel Couling, M.A. Ching-Chow-Fu, Kiaochow, North China. Geological Magazine, New Series, Decade IV. Vol. X. pp. 481-485, pl. XXII.

DAVIDSON, THOMAS. 1865-1870. British Silurian Brachiopoda. Palæontographical Society. Monographs vols. XIX, XX, XXII, XXIV.

FORD, ARTHUR H. 1888. Catalogue of the Fossil Cephalopoda in the British Museum. Part I Nautiloidea. London.

FRECH, F. 1895. Ueber Palæozoische Faunen aus Asien und North Afrika. Neues Jahrbuch für Mineralogie Geologie und Paläontologie, 1895, Bd. II.*

FRECH, F. 1911. Das Silur von China. In Richthofen, China. Vol. V, pp. 1-17, plates I-IV.

GRABAU, A. W. & SHIMER, H. W. 1909. North American Index Fossils, Invertebrates. Vol. I. (Protozoa to Gastropoda), New-York.

GRABAU, A. W. & SHIMER, H. W. 1910. Ibid. Vol. II (Conularida to Echinoidea). New York.

GRABAU, A. W. 1916. Comparison of American and European Lower Ordovicic Formations. Bulletin Geological Society of America. Vol. 27, pp. 555-622.

HALL, J. 1847. Palæontology of New York. Vol. I. New York State Geological Survey.

HINDE, J. G. 1889. On Archæocyathus, (etc.) from Cambrian Strata of North America, Spain, Sardinia, and Scotland. Quarterly Journal of the Geological Society of London, Vol. XLV, pp. 125-148, pl. V.

* Not seen.

KAYSER, E. 1883. Mittel- und Obersilurische Versteinerungen aus dem Gebirgsland von Tshau-Tien (China). In Richthofen China Vol. IV. article 3. pp. 37-49, plates III & IV:

LORENZ, TH. 1906. Beiträge zur Geologie und Palæontologie von Ostasien, unter besonderer Berücksichtigung der Provinz Schantung in China. II Palæontologischer Teil, mit 3 Tafeln u. 55 Figuren im Text. (pp. 53-108 pls. IV-VI). Aus Zeitschrift der Deutschen Geologischen Gesellschaft. 1906.

MANSUY, H. 1912. Paléontologie, in Étude Géologique du Yun-nan Oriental par J. Deprat et H. Mansuy, 2e Partie. Memoirs du Service Géologique de l'Indochine. Volume I. Fascicule II, Hanoi-Haiphong, 1912.

MARTELLI, 1901. Fossili del Siluriano inferiore dello Schensi. Bolletin della Soc. Geol. Ital. 1901.*

PELLIZZARI, 1913. Fossili Palæozoici antichi dello Scensi (Cina). Rivista Italiana di Paleontologia. Vol. XIX. 1913.*

RICHTHOFEN, F. VON. 1883. 1911. China. Vols. IV & V. Berlin.

ROEMER, FERDINAND. 1876. Lethæa geognostica, oder Beschreibung und Abbildung der für die Gebirgs-Formationen bezeichnendsten Versteinerungen, I Theil, Lethæa palæozoica, plates.

ROEMER, F. & FRECH, F. 1880-1897 *ibid.* Text.

RUEDEMANN, R. 1904. Structure of some primitive cephalopods. Annual Report New York State Palæontologist 1903. N.Y. State Museum Bulletin 80, pp. 296-384. Pls. 6-13.

RUEDEMANN, R. 1906. Cephalopoda of the Beekmantown and Chazy Formations of the Champlain Basin. New York State Museum. Bulletin 90, pp. 393-605, 38 plates.

STEINMANN, G., 1889. Ueber Schalen- und Kalksteinbildung. Bericht der Naturforschenden Gesellschaft zu Freiburg. Vol. 4.

STEMPELL, WALTER, 1900. Ueder die Bildungsweise und das Wachstum der Muschel- und Schneckenschalen. Biologisches Centralblatt, Band XX, pp. 595-606; 637-644; 665-680; 698-703; and 731-741. (With extensive literature references.)

TAYLOR, T. GRIFFITH. 1910. The Archæocyathinæ from the Cambrian of South Australia, with an account of the morphology and affinities of the whole class. Memoirs of the Royal Society of South Australia. Vol. II, pt. 2, pp. 1-188, 16 plates & text figures. Adelaide.

* Not seen.

ULRICH, E. O. & SCOFIELD. 1908. The Lower Silurian Gastropoda of Minnesota. Minnesota Geological Survey, Palæontology Part. II.

VERNEUIL, E. DE. 1845. Palæontologie (of Russia) in Murchison, de Verneuil and Kayserling, Geology of Russia. Vol. II.

WELLER, STUART. 1913. A report on Ordovician Fossils collected in Eastern Asia in 1903-04. In Willis, Research in China, Vol. III, pp. 279-294. plates 25, 26.

WINCHELL, N. H. & SCHUCHERT CHARLES. 1893. The Lower Silurian Brachiopoda of Minnesota. Minnesota Geological Survey. Palæontology, Part III. No. 1.

YABE, H. & HAYASAKA, I. 1920. Palæontology of Southern China. Geographical Research in China 1911-1916, Reports, pp. 1-221. Atlas of 28 plates. Tokyo Geographical Society.

List of Chinese Localities referred to, arranged Alphabetically under Provinces.

(See Map Fig. 20.)

Chihli 直隸

Chao Kou Chuang	趙各莊
Ching Hsing	井陘
Huo Lu	獲鹿
Ku Shan	鼓山
Liang Chia Shan	亮家山
Ma Chia Kou	馬家溝
Pei Lin Tze	北林子
Shih T'ou Chiang	石頭江
Tang Shan	唐山
Yeh Li	冶里

Manchuria 東三省

Hsiau Sörr	小市

Shantung 山東

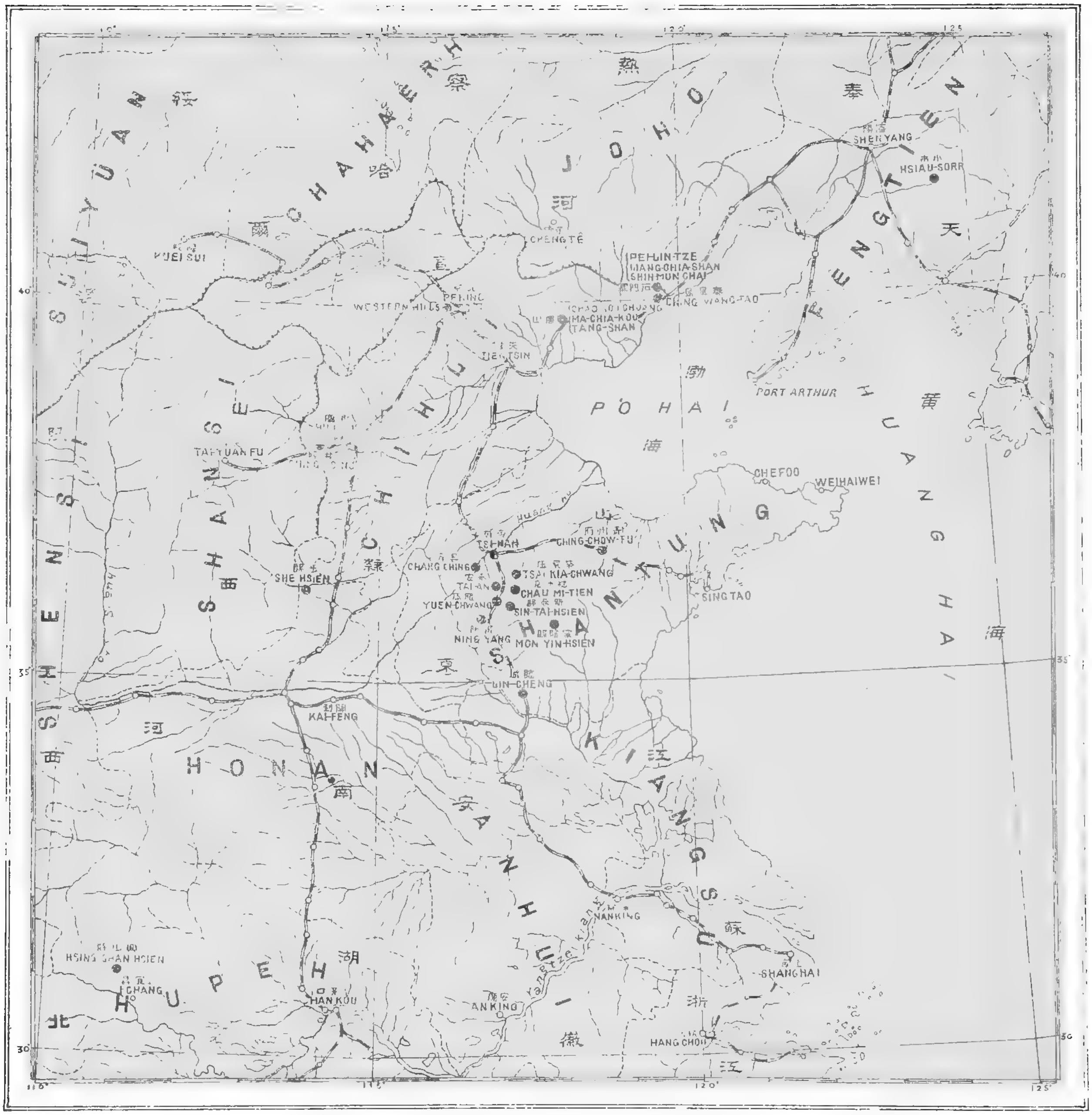
Chang Ching	長青
Ching Chow Fu	青州府
Ching Chuang	青庄
Ho Shan	胡山
Lin Ch'êng	臨城
Mon Yin	蒙陰
Ning Yang	甯陽
Shen Tsun (Seng Chuang)	沈村
Tai An	泰安
Tsai Kia Chuang	蔡家莊
Wên Nan	汶南

Honan 河南

Shê Hsien	涉縣

Hupeh 湖北

Hsing Shan Hsien	興山縣
Hu Chi	戶溪
No Lu Ping	
Pan Tze Ya	播子埡



Boundaries of Provinces — Railroads and Stations — Great Wall
● Ordovician Localities ○ Other important Cities

50 0 50 100 150
Scale of Miles

Fig. 20. Map of North-eastern China, showing the localities where Ordovician fossils have been found. (See the list on the preceding page.)

EXPLANATION OF

PLATE I

PLATE I.

Lower Ordovician Anthozoa (1-3) and Cephalopoda (10); Peilintze Limestone. Upper Ordovician Brachiopoda Pelecypoda and Trilobita; Machiakou Limestone.

Drawings by K. C. Liu (劉光城) *Photographs by T. I. Loo* (盧祖蔭)

Fig. 1. *Archæocyathus chihliense* Grabau..p. 12
1a. Mold of part of interior of caliculum with weathered section near the upper edge of the caliculum. Natural size.
1b. Photograph of partial section of caliculum 50 mm. below preceding; nearly natural size. The right and left sides are reversed with reference to fig. 1a. Lower Ordovician Peilintze limestone, Shih-Mun-Chai, Chihli. (Coll. F F. Mathieu, Cotype G. S. Ch. Cat. No. 75).

Fig. 2. *Archæocyathus chihliense* Grabau..p. 12
Photograph of polished section of a compressed caliculum same horizon and locality. Natural size. (Cotype Coll. F F Mathieu, G. S Ch. Cat. No. 76).

Fig. 3. *Archæocyathus chihliense* Grabau..p. 12
3a. Photograph of thin section of a nearly circular caliculum. Natural size.
3b. A small portion photographically enlarged × 10; same horizon and locality. (Cotype Coll. F. F. Mathieu, G. S. Ch. Cat. No. 98).

Fig. 4. *Orthis calligramma* var. *orthambonites* von Buch (de Verneuil)..............................p. 15
4a brachial-,4b pedicle-,4c side-view of a small fragmentary specimen × 3; Machiakou limestone, Chao-Kou-Chuang, Chihli province. (G. S. Ch. Cat. No. 94).

Fig. 5. *Orthis calligramma* var. *orthambonites* von Buch (de Verneuil)..............................p. 15
5a pedicle-,5b brachial-,5c lateral-,5d frontal-views of a larger, somewhat distorted and more nearly complete specimen. × 2. (In 4d the upper valve is the brachial, which appears as the deeper of the two because of the position in which the specimen is drawn). Same horizon and locality. (G. S. Ch. Cat. No. 93).

Fig. 6. *Strophomena* cf. *incurvata* (Shepard)..p. 17
Part of pedicle valve, with outline restored × 3.
Upper Ordovician, Machiakou limestone, Chao-Kou-Chuang. (G. S. Ch. Cat. No. 109).

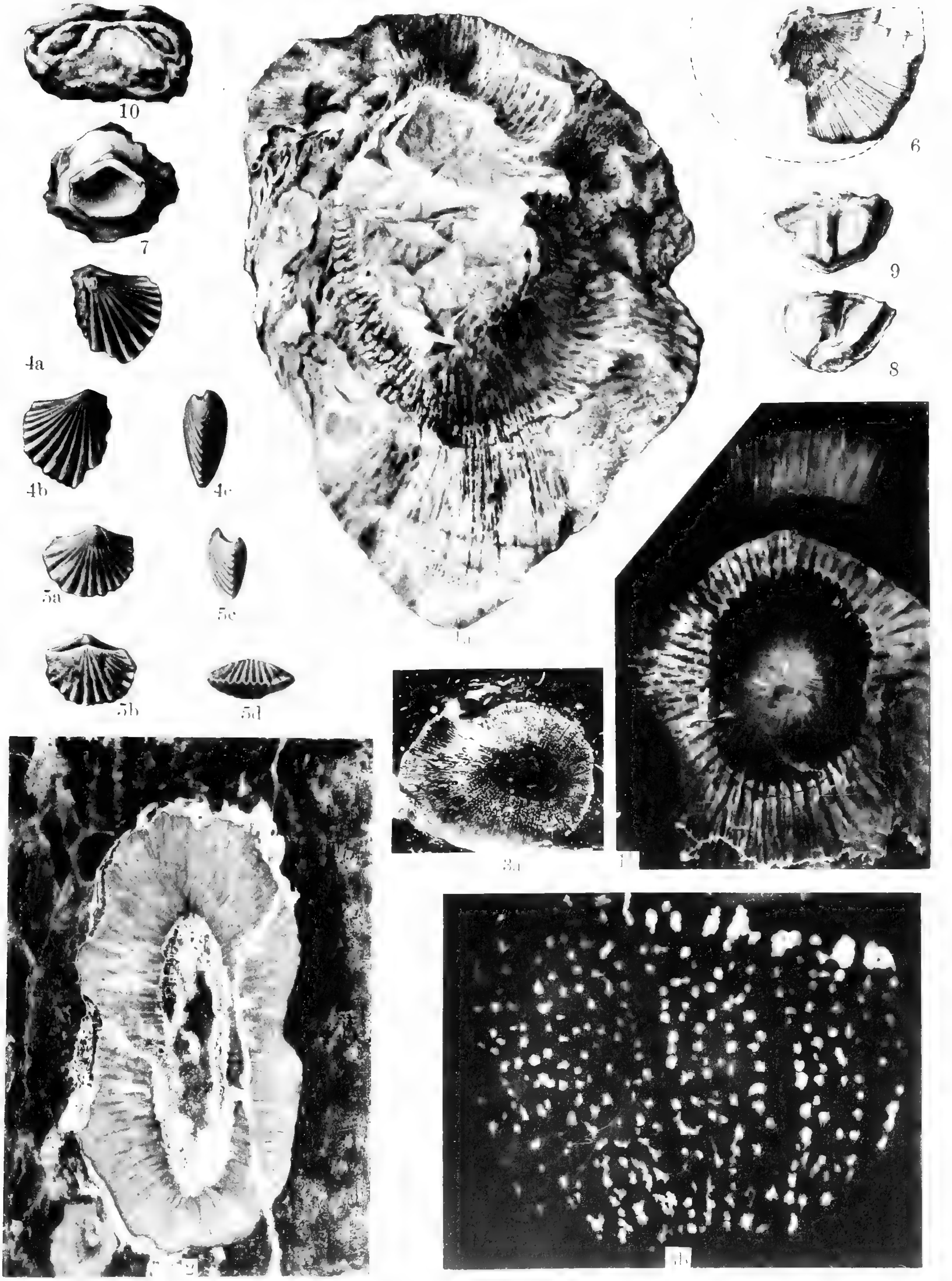
Fig. 7. *Ctenodonta symmetrica* Grabau..p. 19
Interior view of a right valve, showing the hinge line, (with the teeth somewhat too clearly represented), the muscular scars and anterior muscular ridge The ventral margin is imperfect. Enlarged twice Machiakou limestone, Tangshan, Chihli. (Holotype G. B. Barbour Coll. G. S. Ch. Cat. No. 51).

Fig. 8. *Asaphus bohmi* Lorenz..p. 93
An imperfect pygidium, enlarged × 2. showing broad ringed axis, and concave marginal rim. Machiakou limestone, Chao-Kou-Chuang, Chihli. (G. S. Ch. Cat. No. 92).

Fig. 9. *Asphus bohmi* Lorenz..p. 93
Another pygidium from the same horizon and locality as the preceding but exfoliated, showing narrow axis, × 2. (G. S. Ch. Cat. No. 110).

Fig. 10. *Chihlioceras nathani* Grabau..p. 48
Apertural view of the siphuncle shown in the right hand figure of Plate V. to show the main and lateral alveoli. The specimen is slightly crushed, and is weathered. Lower Ordovician Peilintze limestone, Shih-Mun-Chai region, Chihli. (G. S. Ch. Cat. No. 111).

Pl.I.



EXPLANATION OF

PLATE II

PLATE II.

Ordovician Gastropoda and Cephalopoda (11-13); Lower Ordovician: Peilintze and Liangchiashan Limestones; Upper Ordovician: Machiakou Limestone.

Drawings by K. C. Liu (劉光城)

Fig. 1. *Ophileta plana* Grabau......p. 20
Adult specimen, natural size, embedded in rock (which is not fully represented). The surface is weathered. Liangchiashan limestone (Lower Ordovician) Liang-Chia-Shan, Chihli, Coll. F. F Mathieu. (Cotype G. S. Ch. Cat. No. 84).

Fig. 2. *Ophileta plana* Grabau......p. 20
Young shell, top (2a) and side (2b) views. Natural size. The surface sculpture is only apparent, and due to weathering. Liangchiashan limestone (Lower Ordovician) Liang-Chia-Shan, Chihli. Coll. F. F Mathieu. (Cotype G. S. Ch. Cat. No. 83).

Fig. 3. *Ophileta squamosa* Grabau......p. 22
3a Top view of a small specimen with lax final whorl, enlarged twice. 3b side view of the same, × 2. Peilintze limestone, Pei-Lin-Tze, Shih-Mun-Chai, Chihli. Coll. F. F. Mathieu. (Cotype G. S. Ch. Cat. No. 86).

Fig. 4. *Ophileta squamosa* Grabau......p. 22
Umbilical view of a fragment of the whorls of a young specimen × 2. Peilintze limestone, Pei-Lin-Tze, Chihli. Coll. F. F. Mathieu. (Cotype G. S. Ch. Cat. No. 85).

Fig. 5. *Ophileta squamosa* Grabau......p. 22
Natural section of an adult specimen, natural size. Peilintze limestone. Pei-Lin-Tze, Chihli. Coll. F. F. Mathieu. (Cotype G. S. Ch. Cat. No. 95).

Fig. 6. *Ophileta squamosa* Grabau......p. 22
A much weathered section of an adult specimen. Natural size. Peilintze limestone, Pei-Lin-Tze, Chihli, Coll. F. F. Mathieu. (Cotype G. S. Ch. Cat. No. 89).

Fig. 7. *Eccyliopterus kushanensis* Grabau......p. 23
7a Summit view of the holotype natural size. 7b Umbilical view of the same, natural size. 7c Cross-section of the shell to show form of whorls and degree of embracing. Machiakou limestone, Ku-Shan, Hwo-Luh-Hsien, Chihli. (Holotype G. S. Ch. Cat. No. 96).

Fig. 8. *Eccyliopterus sinensis* (Frech)......p. 23
8a-c. Summit, lateral and umbilical views of a characteristic specimen from Nei-Ya-Shan, near Ichang, Hupeh, South China. (For comparison with *E. kushanensis*.) 8d section of the same to show form of whorls and excessive embracing. Middle? Ordovician. G. Langford Smith Coll. (G. S. Ch. Cat. No. 97).

Fig. 9. *Eccyliomphalus tangshanensis* Grabau......p. 24
Worn under surface of the partly exposed holotype. Natural size. Machiakou limestone, Tang-Shan, Chihli. (Holotype G. S. Ch. Cat. No. 6).

Fig. 10. *Salpingostoma terrilli* Grabau......p. 35
a top, b side, and c anterior views of the type and only known specimen which is crushed and partly broken. Natural size. (Holotype. G. S. Ch. Cat. No. 32).

Fig. 11. *Chihlioceras nathani* Grabau......p. 48
An oblique section through the upper part of the endocone of the specimen fig. 13 on pl. IV. (For location see text fig. 6a-b, p. 46). Peilintze limestone, Shih-Mun-Chai region, Chihli. F. F. Mathieu Coll. (Cotype G. S. Ch. Cat. No. 110).


7a
4
1
3a
7b
7c
8a
8c
10b
10a
3b
8b
8d
9
13b
2a
2b
10c
13a
6
11
5
12

Fig. 12. *Chihlioceras nathani* Grabau..p. 48
Another section through the same specimen parallel to the preceding and about 2mm. farther dorsad. The section is shown on the opposing cut surface of the rock and its position is therefore reversed as here viewed. (For location see text fig. 6, line c-d, also text Figs. 8,9 which show the two sections in the same orientation). Peilintze limestone, Shih-Mun-Chai region, Chihli. F F. Mathieu Coll. (Cotype G. S. Ch. Cat. No. 111). (See, also, Pls. IV & V).

Fig. 13. *Chihlioceras chingwangtaoense* Grabau..p. 51

13a. View of the type from the upper or dorsal side. Natural size. The specimen is reversed in position as compared with the other figures, to show the median alveolus, and the inner surfaces of the lateral alveoli. (For restored sections see text figures 14-16).

13b. Side view of the same.
Peilintze limestone, Pei-Lin-Tze, Shih-Mun-Chai region, eastern Chihli. (Holotype, Coll. by F. F. Mathieu, G. S. Ch. Cat. No. 113).

EXPLANATION OF

PLATE III

PLATE III.

Ordovician Gastropoda; Lower Ordovician:—Pelintze and Liangchiashan Limestones; Upper Ordovician:—Machiakou Limestone.

Drawings by K. C. Liu (劉光城)

Fig. 1. *Lophospira morrisi* Grabau...p. 25
A nearly complete characteristic specimen, enlarged twice. Machiakou limestone, Tangshan, Chihli. (Cotype, G. S. Ch. Cat. No. 32, collected by Messrs. Morris, Barbour and Terrill).

Fig. 2. *Lophospira morrisi* Grabau...p. 25
2a. View of the spire from an oblique angle, to show the position of the peripheral band, and the growth-lines upon the shoulder × 2.
2b. A portion of the shoulder of the ultimate whorl enlarged six times to show the nature of the peripheral band and the growth lines. Machiakou limestone, Tangshan, Chihli. (Cotype, G. S. Ch. Cat. No. 51; Coll. G. B. Barbour).

Fig. 3. *Lophospira pulchelliformis* Grabau...p. 26
Spire of a characteristic specimen × 2, viewed slightly from above, (with resulting foreshortening), to show the peripheral band. Machiakou limestone, Tangshan. Cotype, G. S. Ch. Cat. No. 51; Coll. G. B. Barbour).

Fig. 4. *Lophospira pulchelliformis* Grabau...p. 26
Portion of a spire, lateral view × 2. showing amount of embracing, form, and strong lower carina. Machiakou limestone, Tangshan. (Cotype, G. S. Ch. Cat. No. 41; Survey Coll).

Fig. 5. *Lophospira trochiformis* Grabau...p. 27
5a., 5b. opposite sides of the holotype, showing the trochiform spire and strong peripheral carina. × 2. Machiakou limestone, Tangshan. (Holotype, G. S. Ch. Cat. No. 40).

Fig. 6. *Lophospira acuta* Grabau...p. 27
An average specimen, with a small mass of matrix adhering and the basal portion imperfect × 2. Machiakou limestone, Chao-Kou-Chuang. (Cotype, G. S. Ch. Cat. No. 47).

Fig. 7. *Lophospira gerardi* Grabau...p. 28
A typical specimen from the Machiakou limestone at Chao-Kou-Chuang, Chihli. Enlarged twice. (Cotype, G. S. Ch. Cat. No. 44).

Fig. 8. *Lophospira gerardi* var. *laxa* Grabau...p. 28
The Holotype, showing the lax whorls entirely free at the aperture, the strong subsutural ridge and marked concavity of shoulder × 2. Machiakou limestone, Chao-Kou-Chuang, Chihli. (Holotype, G. S. Ch. Cat. No. 49).

Fig. 9. *Lophospira terrassa* Grabau...p. 29
View of the type, attached to rock, twice natural size. Machiakou limestone, Tangshan, Chihli. (Holotype, G. S. Ch. Cat. No. 33).

Fig. 10. *Lophospira obscura* Grabau...p. 30
The type specimen, embedded in rock and partly worn so as to show the internal mold × 2. Machiakou limestone. Tangshan, Chihli. (G. S. Ch. Cat. No. 37).

Fig. 11. *Pagodispira derwiduii* Grabau...p. 31
The type specimen, twice enlarged. The aperture is restored. Machiakou limestone, Chao-Kou-Chuang, Chihli. (Holotype, G. S. Ch. Cat. No. 15).

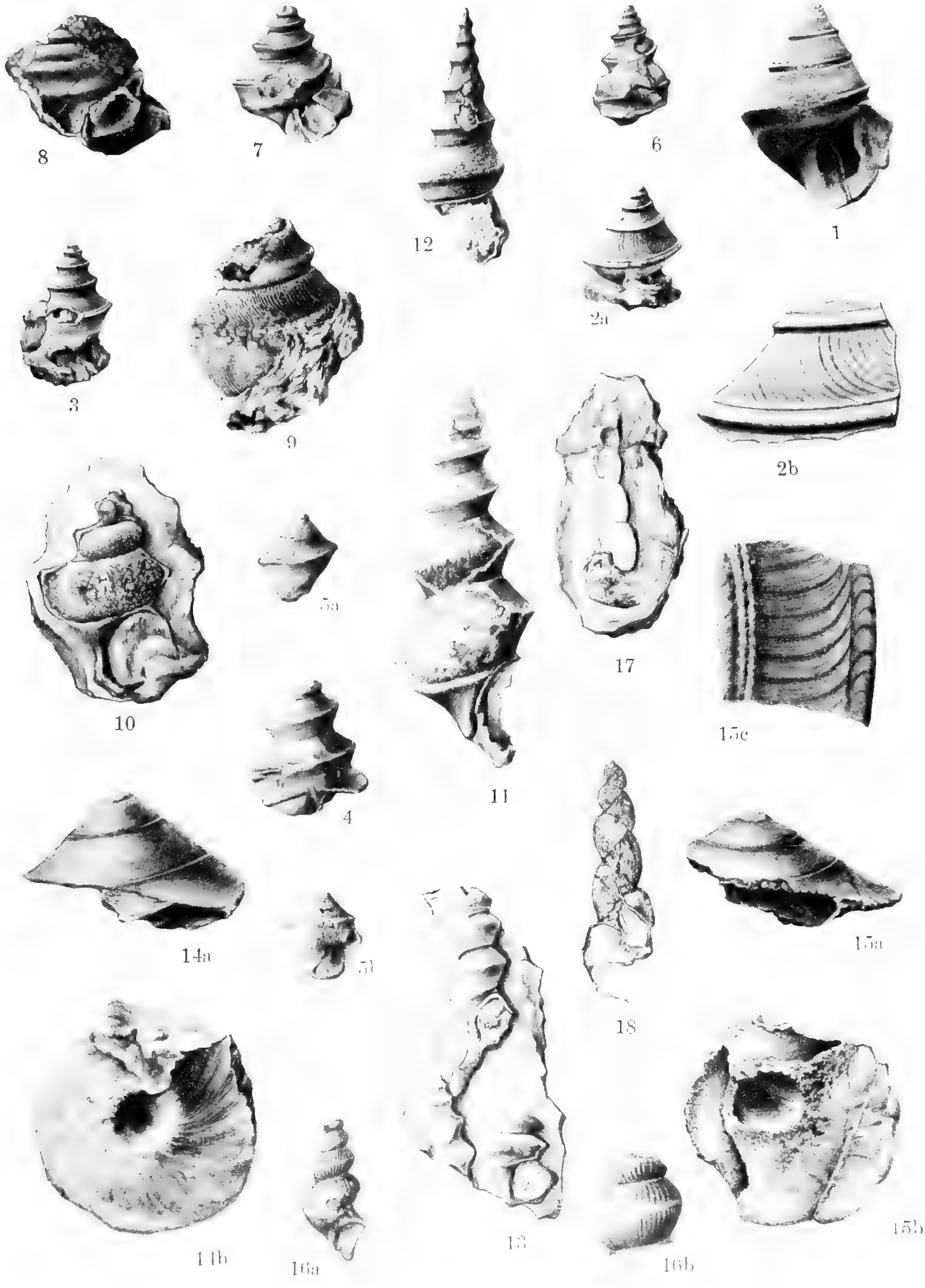

8
7
12
6
1
3
9
2a
2b
10
5a
11
17
15c
4
14a
5b
18
15a
14b
16a
13
16b
15b

Fig. 12. *Pagodispira dorothea* Grabau...p. 32
The type specimen, twice enlarged. Machiakou limestone, Tangshan, Chihli. (Holotype, Coll. by Geo. B. Barbour, G. S. Ch. Cat. No. 50).

Fig. 13. *Pagodispira dorothea* var. *laxa* Grabau..................... ....p. 32
The type specimen twice enlarged. Machiakou limestone, Chao-Kou-Chuang. (Holotype, G. S. Ch. Cat. No. 13).

Fig. 14. *Liospira barbouri* Grabau... .....p. 33
14a. Side view of a nearly perfect high-spired form × 2.
14b. Umbilical view of same. × 2. Machiakou limestone, Tangshan, Chihli. (Cotype, Coll. by G. B. Barbour. G. S. Ch. Cat. No. 42).

Fig. 15. *Liospira barbouri* Grabau...p. 33
15a. Side view of an imperfect low-spired shell. × 2.
15b. Umbilical view of same × 2.
15c. Enlargement of part of the final whorl to show lines of growth, peripheral band, and marginal notch. × 4. Machiakou limestone, Tangshan, Chihli. (Cotype, Survey Collection G. S. Ch. Cat. No. 43).

Fig. 16. *Hormotoma doquieri* Grabau......................... ....p. 34
16a. The type specimen, enlarged four times.
16b. Two of the whorls still farther enlarged. (× 8).
Liangchiashan limestone Shih-Mun-Chai region, eastern Chihli. (Holotype, Coll. F. F. Mathieu G. S. Ch. Cat. No. 99).

Fig. 17. *Fusispira* sp.. ....3. 36
A natural section in the rock; natural size. Peilintze limestone, Shih-Mun-Chai, eastern Chihli. Coll. F. F. Mathieu. (G. S. Ch. Cat. No. 90). (This section is weathered to such an extent, that the back of the whorls is shown beyond the umbilicus, giving the shell a sinistral appearance).

Fig. 18. *Fusispira* sp... ....p. 36
A natural section in rock; natural size. Peilintze limestone, Shih-Mun-Chai, eastern Chihli, Coll. F. F. Mathieu. (G. S. Ch. Cat. No. 89).

EXPLANATION OF

PLATE IV

PLATE IV.

Ordovician Cephalopoda; Lower Ordovician:—Peilintze, Liangchiashan, and Yehli Limestones; Upper Ordovician:—Machiakou Limestone.

Drawings by K. C. Liu (劉光城)

Fig. 1. *Proterocameroceras mathieui* Grabau ....p. 36
1a. Lateral view of a weathered specimen showing part of the siphuncle, and several cameræ. Natural size.
1b. End view of the same specimen showing aperture of endosiphocone. Natural size.
1c. Section of the same showing form and position of siphuncle. Natural size. Peilintze limestone, Shih-Mun-Chai, near Chingwangtao, eastern Chihli. (Cotype, Coll. by F. F. Mathieu, G. S. Ch. Cat. No. 100).

Fig. 2. *Proterocameroceras mathieui* Grabau ....p. 36
2a. View of a small portion of the shell embedded in rock, showing flattened siphuncle and cameræ, natural size.
2b. End view of the same, natural size;
2c. A portion of the shell and adjoining part of the siphuncle enlarged to show the relation of the siphuncular funnels to the outer shell on the ventral side. Peilintze limestone, Shih-Mun-Chai, near Chingwangtao, eastern Chihli. (Cotype, Coll. F. F. Mathieu, G. S. Ch. Cat. No. 101).

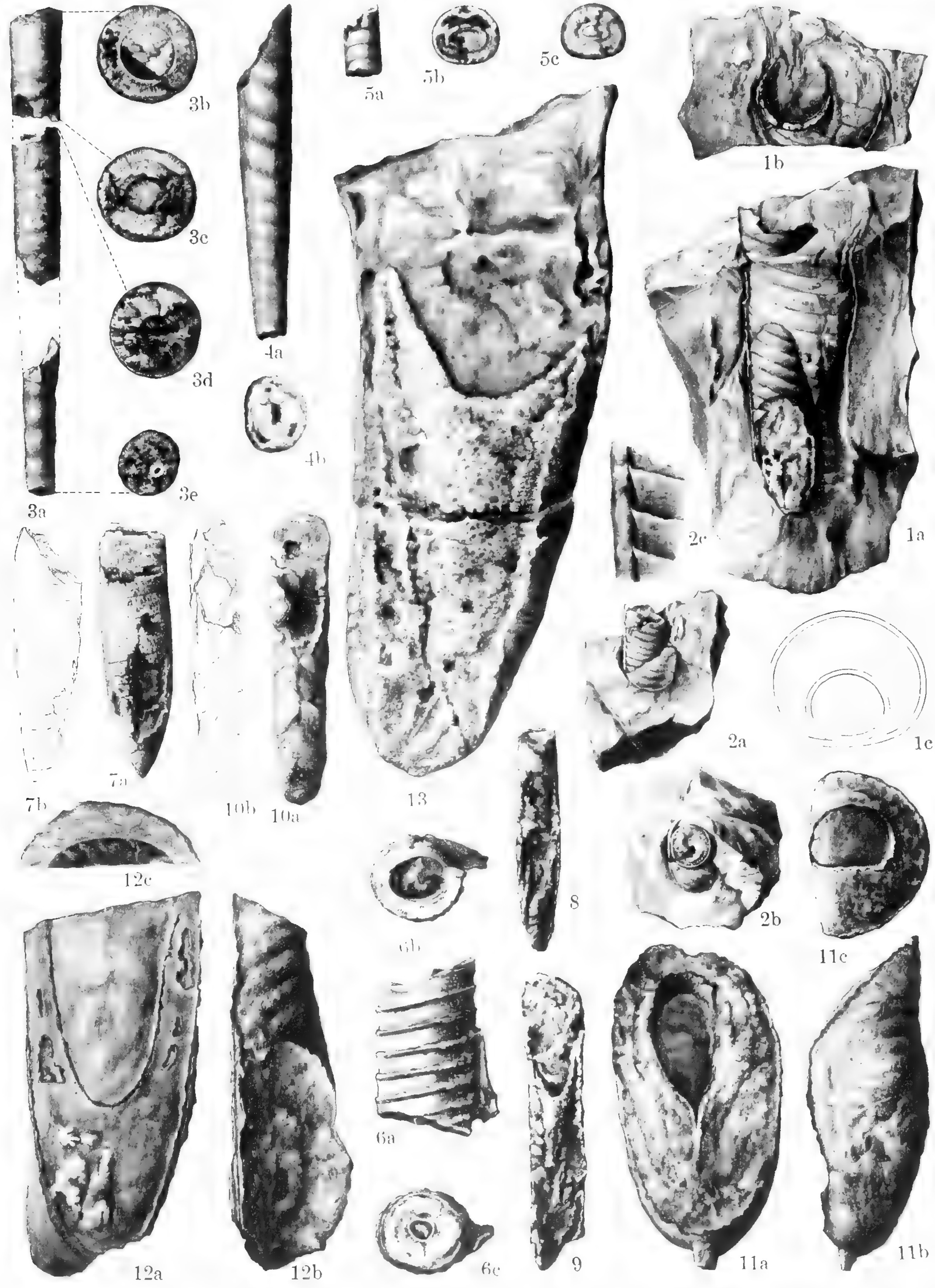
Fig. 3. *Proterocameroceras mathieui* Grabau. ....p. 36
3a. A free siphuncle in three sections. Natural size.
3b.-3e. End views of the same at points indicated, × 2. Peilintze limestone, Shih-Mun-Chai, near Chingwangtao, eastern Chihli. (Cotype, F. F. Mathieu Coll., G. S. Ch. Cat. No. 102).

Fig. 4. *Cameroceras styliforme* Grabau..p. 39
4a. The siphuncle of a young or apical portion of a shell, showing the rate of tapering and oblique annulations. Enlarged twice.
4b. Enlargement of the broken smaller end of the same specimen showing the flat ventral side, the endosiphocoleon, and an older endosheath with open lumens remaining; × 4. Liangchiashan limestone (Lower Ordovician), Liang-Chia-Shan, Shih-Mun-Chai, eastern Chihli. (Cotype, F. F. Mathieu, G. S. Ch. Cat. No. 103)

Fig. 5. *Cameroceras styliforme* Grabau..p. 39
5a. Ventral view of an older portion of the siphuncle, showing the ventral saddle formed by the septa. Natural size.
5b. Upper, and 5c. lower ends of the fragment enlarged × 2. to show the endosiphocoleon. Liangchiashan limestone, Shih-Mun-Chai, near Chingwangtao eastern Chihli. Lower Ordovician. (Cotype, Coll. F. F. Mathieu, G. S. Ch. Cat. No. 104).

Fig. 6. *Cameroceras styliforme* Grabau..p. 39
6a. Lateral view of a silicified fragment of the siphuncle, of a more mature portion than that represented by figs. 4 & 5 showing portions of the septa adhering × 2.
6b. Upper and 6c. lower ends of the fragment, showing the last endosheath, its continuation in the endosiphocoleon and indications of older sheaths × 2. Liangchiashan limestone, Liang-Chia-Shan Shih-Mun-Chai, near Chingwangtao, eastern Chihli. (Cotype, Coll. F. F. Mathieu, G. S. Ch. Cat. No. 105).

Fig. 7 *Suecoceras yehliense* Grabau..p. 40
7a. View of the type specimen as exposed on the rock surface. Natural size.


3b
3c
3d
3e
3a
4a
4b
5a
5b
5c
1b
1a
2c
13
7a
7b
10b
10a
2a
1c
12c
6b
8
2b
11c
6a
12a
12b
6c
9
11a
11b

7b. Lateral view of the same, the left hand side is attached to the rock. Natural size. Yehli limestone (Lower Ordovician), Yeh-Li, near Ma-Chia-kou, Chihli. (Holotype, Y. C. Sun Coll. G. S. Ch. Cat. No. 24).

Fig. 8. *Suecoceras attenuatum* Grabau..p. 41
Apical portion of the siphuncle, showing rate of tapering. Natural size. Yehli limestone, Yeh-Li, Chihli. (Cotype, Y. C. Sun Coll. G. S. Ch. Cat. No. 20).

Fig. 9. *Suecoceras attenuatum* Grabau..p. 41
Silicified and partly broken specimen referred to this species, showing the last endosiphosheath, and its excentric position. Natural size. Yehli limestone, Yeh-Li, Chihli. (Cotype, Y. C. Sun Coll. G. S. Ch. Cat. No. 22).

Fig. 10. *Vaginoceras tsinanense* Grabau..p. 41
10a. Ventral view of siphuncle, showing the strong saddle made by the septal necks. Natural size.
10b. Lateral view of the same, showing obliquity of septal necks. The left hand side is attached to the rock. Machiakou limestone, Tangshan, Chihli. (Holotype G. S. Ch. Cat. No. 25).

Fig. 11. *Piloceras platyventrum* Grabau..p. 42
11a. Natural section of the siphuncle, showing the excentric endocone with flattened venter; the endosiphuncle with its terminal projection (this is not as large as here shown, some rock adhering which can not readily be separated), and the crystalline filling. The specimen is either a young form or the endocone extends further apicad in this specimen than in others (see fig. 12). It is filled with rock matrix enclosing foreign material.
11b. Side view of the same showing faint constriction at commencement of annulations. Natural size. (The constriction is slightly over-emphasized owing to the position of the specimen).
11c. End view of the same, showing position and form of endocone. Natural size. Liangchiashan limestone, Shih-Mun-Chai region near Chingwangtao, eastern Chihli. (Cotype, F. F. Mathieu, Coll., G. S. Ch. Cat. No. 108).

Fig. 12. *Piloceras platyventrum* Grabau..p. 42
12a. Natural section of a siphuncle of a large and older specimen of subcircular cross-section. The section is transverse to the dorso-ventral diameter but somewhat oblique. The endocone with filling of rock-matrix, and the crystalline filling of the earlier part with indications of older sheaths are shown. Natural, size.
12b. Side-view of the same, showing subcylindrical outline, with the oblique annulations, which converge in a low broad saddle on the venter (right side). The lower part is fractured, showing complete filling with stereoplasm or organically deposited lime. Older sheaths are indicated in this fracture by dark lines. Natural size.
12c. End view (upper) of the fragment, showing the very slight flattening at this stage of the endocone on the ventral side, which is the center of the convex surface (top side of fig. 12c, right side of fig 12b), as shown by the converging annulations. The thickness of the lime-filled portion of the siphuncle is slightly greater on the venter than on the sides. Liangchiashan limestone, of Liang-Chia-Shan Shih-Mun-Chai region, near Chingwangtao, eastern Chihli. (Cotype, F. F. Mathieu, Coll. G. S. Ch. Cat. No. 109).

Fig. 13. *Chihlioceras nathani* Grabau..p. 48
Ventral aspect of a typical specimen partly worn, but showing the endosiphuncle in the lower part. (Sections of this specimen are shown in figs. 11 & 12 of pl. II, and a reconstruction in text-figures 2 to 6 pp. 45-46) Peilintze limestone near Chingwangtao, Chihli. (Cotype, F. F. Mathieu, Coll., G. S. Ch. Cat. No. 110). (See also Plate V. which shows the upper side of the same slab on the under side of which this specimen occurred).

EXPLANATION OF

PLATE V

PLATE V.

Lower Ordovician Cephalopods:—Pelintze Limestone.

Drawings by K. C. Liu (劉光城)

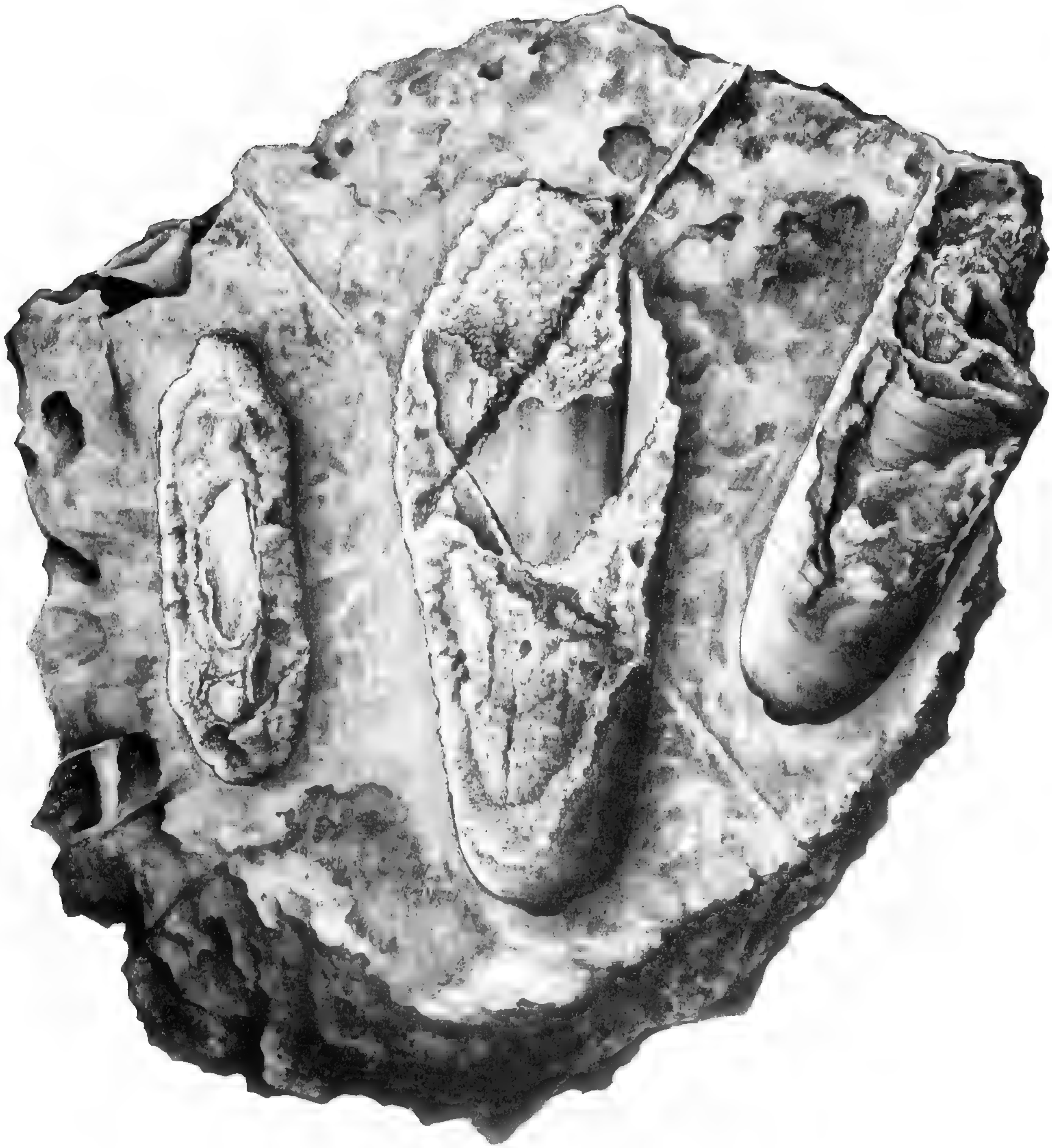
Chihlioceras nathani Grabau........................ ....p. 48

A group of three individuals, natural size, all with their upper or dorsal surfaces exposed, and all more or less worn. The rock has also been subject to slight deformations; two fracture lines with slight faulting are shown, the fractures having been filled by calcite veins. The left hand specimen shows only a portion of the blade, but the central one shows a large part of it. The lateral alveoli in this specimen are not preserved, not extending back so far. They are however shown, though in a somewhat crushed condition, in the right hand specimen (see the front view of this on plate I. fig. 10). There is a difference in the rate of tapering of the two most perfect specimens, also in the annulations, and perhaps, though this can not be said with certainty, in the conformation of the endocone. More perfect material may demonstrate, that two distinct species are represented.

On the underside of this rock-mass occurred the specimen of this species figured on plate IV fig. 13, and the sections of which are shown on plate II figs 11 & 12. This specimen lay in the same position as those here shown so far as the dorso-ventral surfaces were concerned, and therefore, being on the under side of the slab, exposed the ventral side. Its longitudinal axis was however transverse to those of the specimens here shown. In its detailed character it corresponds closely to the right-hand specimen of the group on this plate. As it is also the specimen which has furnished, in its sections, the details of internal structure, from which the models (Text figs 2 to 5) are constructed, it must be considered the genotype, in case the specimens here shown prove to represent distinct species. The middle one in that case will be a new species.

The outer zone of the middle specimen is formed apparently by a succession of endosheaths which were closely crowded in the apical part of the siphuncle. The inner part, become porous from weathering, represents a solid mass of stereoplasm (organically deposited lime) apparently without further endosheaths until the final one is reached.

Peilintze limestone, Pei-Lin-Tze, Shih-Mun-Chai region near Chingwangtao, eastern Chihli. (Cotype, Collected by F. F. Mathieu and presented to the collection of the Geological Survey of China, Cat. No. 111). See further plates I, II, & IV.



EXPLANATION OF

PLATE VI

PLATE VI.

Upper Ordovician Cephalopoda:—Machiakou Limestone.

Drawings by K. C. Liu (劉光城)

Fig. 1. *Cycloceras? peitoutzense* Grabau...p. 63
Fragment of the small end of a shell with rounded annulations. Natural size. Machiakou limestone, Pei-Tou-Tze (near Chao-Kou-Chuang), Chihli. (Cotype, G. S. Ch. Cat. No. 28).

Fig. 2. *Cycloceras? peitoutzense* Grabau...p. 63
Living chamber (without septa) of an immature iudividual, with sharp annulations. Natural size. Machiakou limestone, Pei-Tou-Tze (Kaiping basin), Chihli. (Cotype, G. S. Ch. Cat. No. 29).

Fig. 3. *Cycloceras? peitoutzense* Grabau...p. 63
The largest specimen obtained, partly embedded in rock. In the upper part is shown a portion of what was probably the living chamber. The surface here shows very fine concentive striæ (see fig. 4). The lower part, which appears to be part of the same specimen does not preserve the striæ The position of the two fragments, and the form of the smaller one suggest that the shell was curved. Natural size. Mackiakou limestone, Chao-Kou-Chuang, Chihli. (Cotype, G. S. Ch. Cat. No. 107).

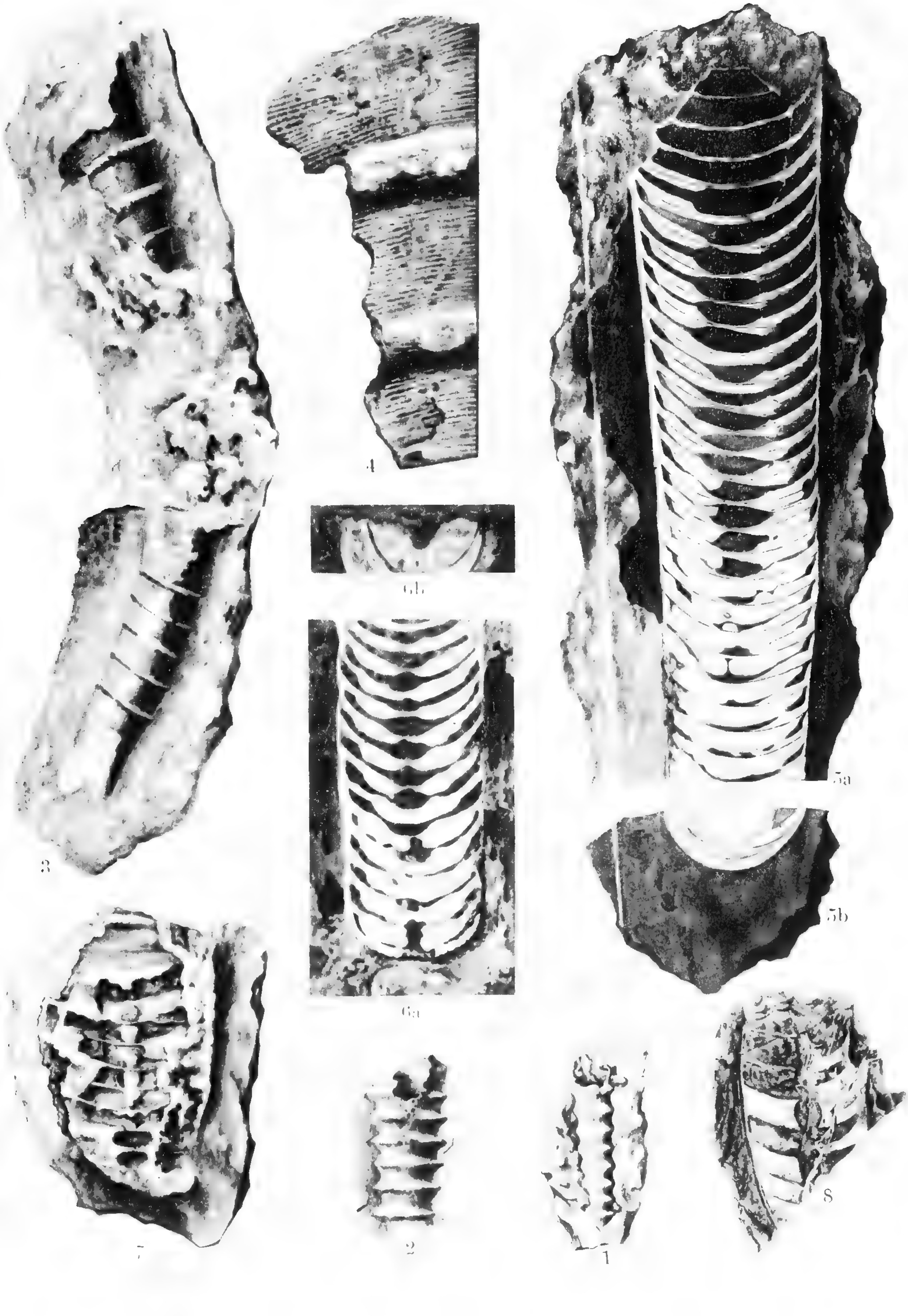
Fig. 4. *Cycloceras? peitoutzense* Grabau...p. 63
Enlargement of part of surface of figure. 3, (× 3.) to show the fine concentric striæ.

Fig. 5. *Stereoplasmoceras pseudoseptatum* Grabau...p. 66
5a. Longitudinal section of a large specimen, not showing siphuncle, but showing pseudosepta and stereoplasmic filling. Natural size.
5b. Cross section of the same. Natural size. Machiakou limestone, Tangshan, Chihli. (Cotype, G. S. Ch. Cat. No. 58).

Fig. 6. *Stereoplasmoceras pseudoseptatum* Grabau...p. 66
6a. Longitudinal section, showing depth of septa, pseudosepta, and filling of stereoplasm. Natural size.
6b. Cross-section of same. Natural size. Machiakou limestone, Ning-Yang, Shantung. (Cotype, G. S. Ch. Cat. No. 57).

Fig. 7 *Stereoplasmoceras pseudoseptatum* Grabau...p. 66
A natural section, weathered, showing the septa, pseudosepta and excentric siphuncle. The strongly nummuloidal character is shown in the lower part and the non-Actinoceran type of filling in the upper. Natural size. Machiakou limestone, Chao-Kou-Chuang, Chihli. (Cotype, Survey Expedition Coll., G. S. Ch. Cat. No. 78).

Fig. 8. *Stereoplasmoceras machiakounense* Grabau...p. 68
A natural section in the rock, showing narrowly nummuloidal siphuncle, pseudosepta and filling of stereoplasm. Natural size. Machiakou limestone, Ma-Chia-Kou, Chihli. (Holotype, H. C. T'an Coll., G. S. Ch. Cat. No. 15).


4
3
6b
6a
5a
5b
7
2
1
8

EXPLANATION OF

PLATE VII

PLATE VII.

Upper Ordovician Cephalopods:—Machiakou Limestone.

Drawings by K. C. Liu (劉光城)

Fig. 1. *Actinoceras richthofeni* Frech...p. 75
An average adult individual weathered so as to show siphuncle. The specimen probably represents a little more than half the original length. Natural size. Machiakou limestone, Tangshan, Chihli. (T. C. Wang Coll. G. S. Ch. Cat. No. 5).

Fig. 2. *Actinoceras richthofeni* Frech...p. 75
Portion of a polished rock surface showing the apertural end of the siphuncle in section. The gradual thickening of the septal rosettes is shown. Also a portion of the camerate part of the shell is shown. Natural size. Machiakou limestone, Huo-Luh, Chihli. (Coll. Miss Clarke; G. S. Ch. Cat. No. 13).

Fig. 3. *Actinoceras richthofeni* Frech...p. 75
A portion of a weathered section of the siphuncle, showing the rosettes around the septal necks and the nature of the endosiphuncle and its diverticula. Enlarged three times. Machiakou limestone, Tangshan, Chihli. (T. C. Wang coll., C. S. Ch. Cat. No. 5). (See also plate IX).

Fig. 4. *Actinoceras tani* Grabau...p. 80
4a. Longitudinal section showing open endosiphuncle. Natural size.
4b. Transverse section. Natural size. Machiakou limestone, Kushan, Huo-Luh-Hsien, Chihli. (Cotype, G. S. Ch. Cat. No. 69).

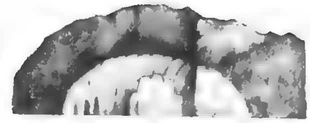
Fig. 5. *Actinoceras tani* Grabau...p. 80
The lower end of a typical specimen showing blunt apical portion, rate of tapering and, in upper part, septa and siphuncle. Natural size. Machiakou limestone, Tangshan, Chihli. (Cotype, Coll. Messrs. Morris, Terrill & Barbour, G. S. Ch. Cat. No. 26).

Fig. 6. *Actinoceras tani* Grabau...p. 80
Natural weathered section, showing siphuncle with part of endosiphuncle exposed, and the nature and amount of the stereoplasm in the cameræ. Machiakou limestone, Ma-Chia-Kou, Chihli. (Cotype, H. C. T'an coll. G. S. Ch. Cat. No. 1).

Fig. 7 *Actinoceras tani* Grabau...p. 80
7a. Apical portion of a characteristic shell, showing form, slight constriction and sutures. Also the large subconical initial chamber. Natural size.
7b. Apical view of the same showing the scar of the siphuncle with its swollen rim, situated subcentrally at this end; at the upper end of the fragment the siphuncle is strongly excentric. Natural size.
7c. A single nummulus of the siphuncle, with surrounding septal portion enlarged × 4, to show the mural pores on the periphery. Machiakou limestone, Tangshan. (Cotype, Coll. Messrs. Morris, Terrill and Barbour, G. S. Ch. Cat. No. 16). (See further, plate IX).

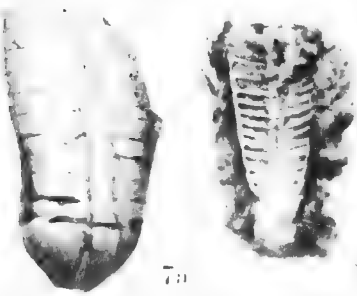
Fig. 8. *Actinoceras nanum* Grabau...p. 87
Natural section of the apical portion of a typical specimen, showing the small siphuncle with its endosiphuncle, the septa, and rate of tapering. Natural size. Machiakou limestone, Tangshan, Chihli. (Holotype, T. C. Wang Coll. G. S. Ch. Cat. No. 8). (See also plate IX).

2



4b

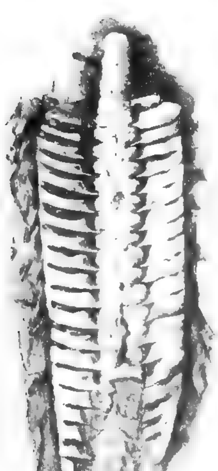
4a

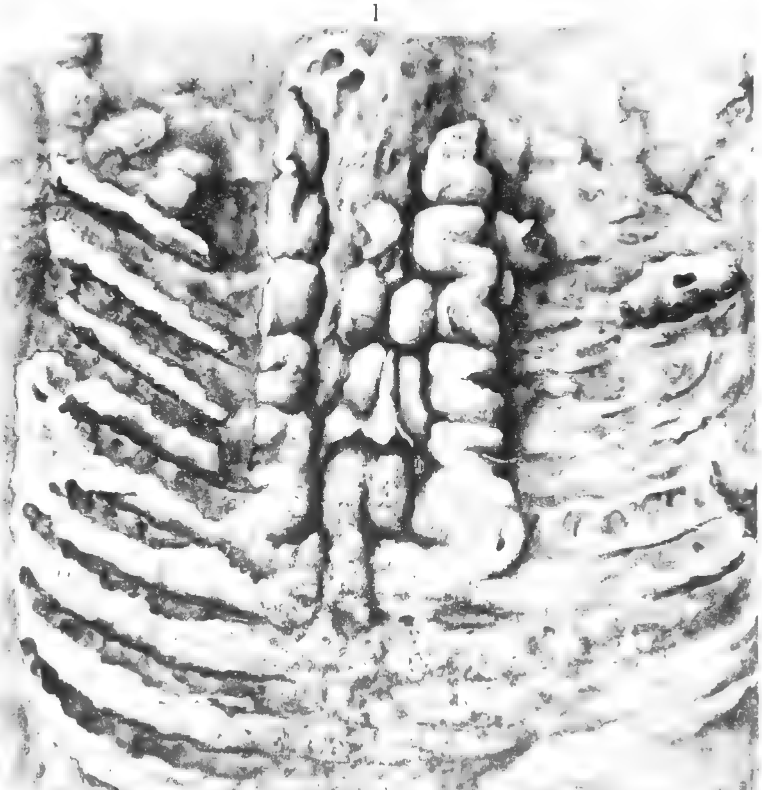


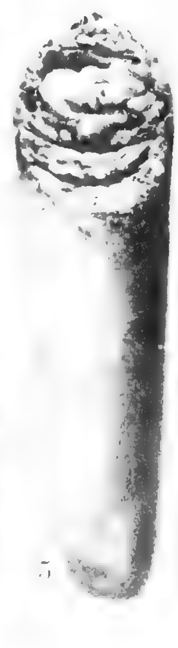
7a

7b

7c







5

EXPLANATION OF

PLATE VIII

PLATE VIII.

Upper Ordovician Cephalopoda:—Machiakou Limestone.

Drawings by K. C. Liu (劉光城)

Fig. 1. *Actinoceras coulingi* Grabau.........p. 82
A natural section upon the rock surface, somewhat weathered, and showing the siphuncle, irregular septa, and filling of cameræ by stereoplasm. Natural size. Machiakou limestone, Hsi-Hsien, Honan. (Cotype, A. C. Taun coll., G. S. Ch. Cat. No. 4).

Fig. 2. *Actinoceras coulingi* Grabau.........p. 82
Polished section of a characteristic specimen, showing the siphuncle and nature and extent of filling of cameræ. Natural size. Machiakou limestone, Ma-Chia-Kou, Chihli. (Cotype, H. C. T'an coll. G. S. Ch. Cat. No. 27).

Fig. 3. *Actinoceras suanpanoides* Grabau.........p. 84
3a. Somewhat oblique polished section showing depth of cameræ and their filling, and, in the lower part, the siphuncle. The rate of tapering appears abnormally great owing to the oblique direction of the section. Natural size.
3b. Transverse section of upper end. Machiakou limestone, Tai-An, Shantung. (Cotype, G. S. Ch. Cat. No. 53).

Fig. 4. *Actinoceras suanpanoides* Grabau.........p. 84
4a. Polished section, showing the characteristic siphuncle, rate of tapering of shell, and filling of cameræ.
4b. Transverse section of same showing excentric position of siphuncle. Machiakou limestone, Shantung. (Cotype, G. S. Ch. Cat. No. 54). (See further plate IX).

Fig. 5. *Actinoceras submarginale* Grabau.........p. 86
5a. Polished section through the siphuncle showing distant septa with cameræ largely filled by stereoplasm. Also part of the endosiphuncle. Natural size.
5b. Transverse section of a part laterally displaced by a small fault, showing size and submarginal position of siphuncle. Natural size. Machiakou limestone, Tangshan, Chihli. (Cotype, G. S. Ch. Cat. No. 55). (See also plate IX).

Fig. 6. *Actinoceras curvatum* Grabau.........p. 88
A weathered specimen on rock showing curved form, septa with partial filling of cameræ, and siphuncle. Natural size. Machiakou limestone, Lincheng, Shantung. (Holotyye, F. F. Mathieu coll., G. S. Ch. Cat. No. 77)

Fig. 7. *Cyrtactinoceras frechi* Grabau.........p. 89
A weathered fragment near the apical end, showing siphuncle and septa, the cameræ scarcely obstructed by stereoplasm. The slight curvature scarcely appears in this view. Natural size. Machiakou limestone, Tangshan. Chihli. (Cotype, T. C. Wang coll. G. S. Ch. Cat. No. 2).

Fig. 8. *Cyrtactinoceras frechi* Grabau.........p. 89
A small fragment near the apical end, showing sutures. Enlarged × 2. Machiakou limestone. Chao-Kou-Chuang, Chihli. (Cotype, G. S. Ch. Cat. No. 88).

Fig. 9. *Cyrtactinoceras frechi* Grabau.........p. 89
9a. An apical portion somewhat weathered. Natural size.
9b. Section of same, showing excentric siphuncle. Natural size. Machiakou limestone, Shantung. (Cotype, G. S. Ch. Cat. No. 66).

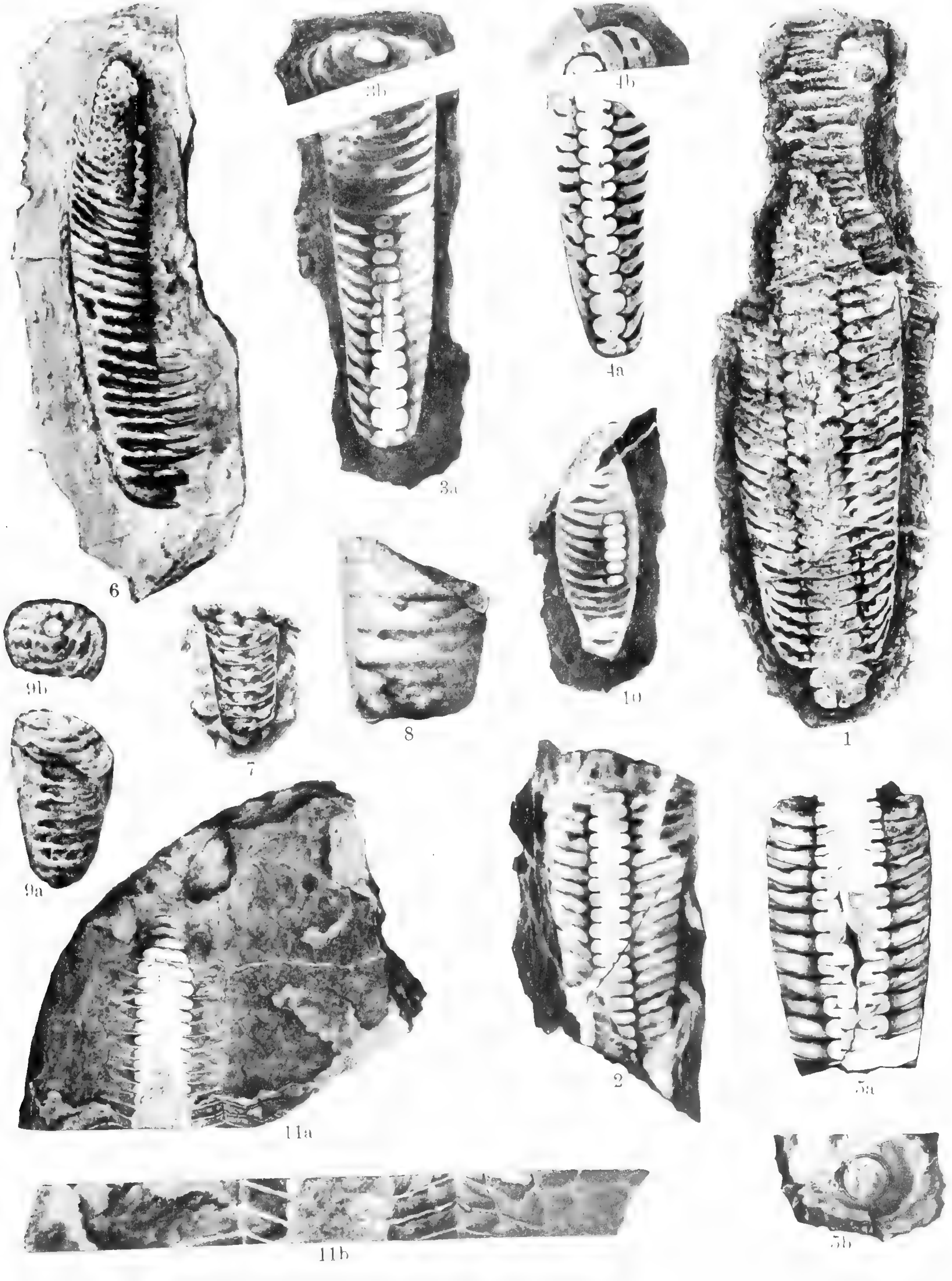

3b
4b
4a
3a
6
10
1
9b
7
8
9a
2
5a
11a
5b
11b

Fig. 10. *Cyrtactinoceras frechi* Grabau .... p. 89
A polished section showing part of the curved siphuncle. Natural size. Machiakou limestone, Ching-Chuang, Ning-Yang, Shantung. (Cotype, V. K. Ting coll. G. S. Ch. Cat. No. 72).

Fig. 11. *Gonioceras shantungense* Grabau .... p. 92

11a. Polished section of the holotype and only known specimen. Natural size. The section shows the siphuncle, empty cameræ and incomplete septa. In the lower right hand portion the lateral continuation of the septa is shown. Machiakou limestone, Seng-Chuang, Ning-Yang, Shantung. (Holotype, V. K. Ting coll., G. S. Ch. Cat. No. 10).

11b. The lower part of the same specimen enlarged twice to show more fully the geniculated portion ot the septa.

EXPLANATION OF

PLATE IX

PLATE IX.

Cephalopods from the Early Upper Ordovician:—Machiakou Limestone.

Drawings by K. C. Liu (劉光城)

Fig. 1. *Actinoceras suanpanoides* Grabau .... p. 84

1a. Lateral view of a characteristic specimen, showing rate of tapering and distance of septa. Natural size.

1b. End view of same. The right side is slightly crushed. Natural size. Machiakou limestone, Wên-Nan, Mon-Yin-Hsien Shantung, V. K. Ting coll. (Cotype, G. S. Ch. Cat. No. 111).

Fig. 2. *Actinoceras nanum* Grabau .... p. 87

A natural section, showing the very slight amount of stereoplasm. Natural size. Machiakou limestone, Tangshan, Chihli. (Paratype, Survey Expedition coll. G. S. Ch. Cat. No. 73).

Ftg. 3. *Actinoceras submarginale* Grabau .... p. 86

A weathered fragment showing the large submarginal siphuncle, and the septa and nearly empty cameræ. A small part of the shell is preserved in the upper left hand area. Natural size. Machiakou limestone, Tangshan, Chihli. (Cotype, G. S. Ch. Cat. No. 56).

Fig. 4. *Actinoceras richthofeni* Frech .... p. 75

A natural weathered section, showing the forward deflection of the lateral diverticula of the endosiphuncle. Natural size. (See text figure 19 p. 79). Machiakou limestone, Lincheng, Shantung, (F. F. Mathieu coll., G. S. Ch. Cat. No. 67).

Fig. 5. *Actinoceras richthofeni* Frech .... p. 75

Section of a part of a shell in which the filling of the cameræ has been unusually extensive. Natural size. Machiakou limestone, Huo-Luh-Hsien, Chihli. (G. S. Ch. Cat. No. 64).

Fig. 6. *Actinoceras richthofeni* Frech .... p. 75

Section showing part of endosiphuncle, and the moderate amount of filling characteristic of the cameræ. Natural size. Machiakou limestone, Chihli (?). (Coll. V. K. Ting, G. S. Ch. Cat. No. 52).

Fig. 7. *Actinoceras richthofeni* Frech .... p. 75

7a. Lateral view of a characteristic internal septate mold, showing rate of lateral tapering and flexuous character of suture. Natural size.

7b. Side view of the same specimen showing the compressed form. On the worn part the deep concavity of the septa is indicated. Natural size.

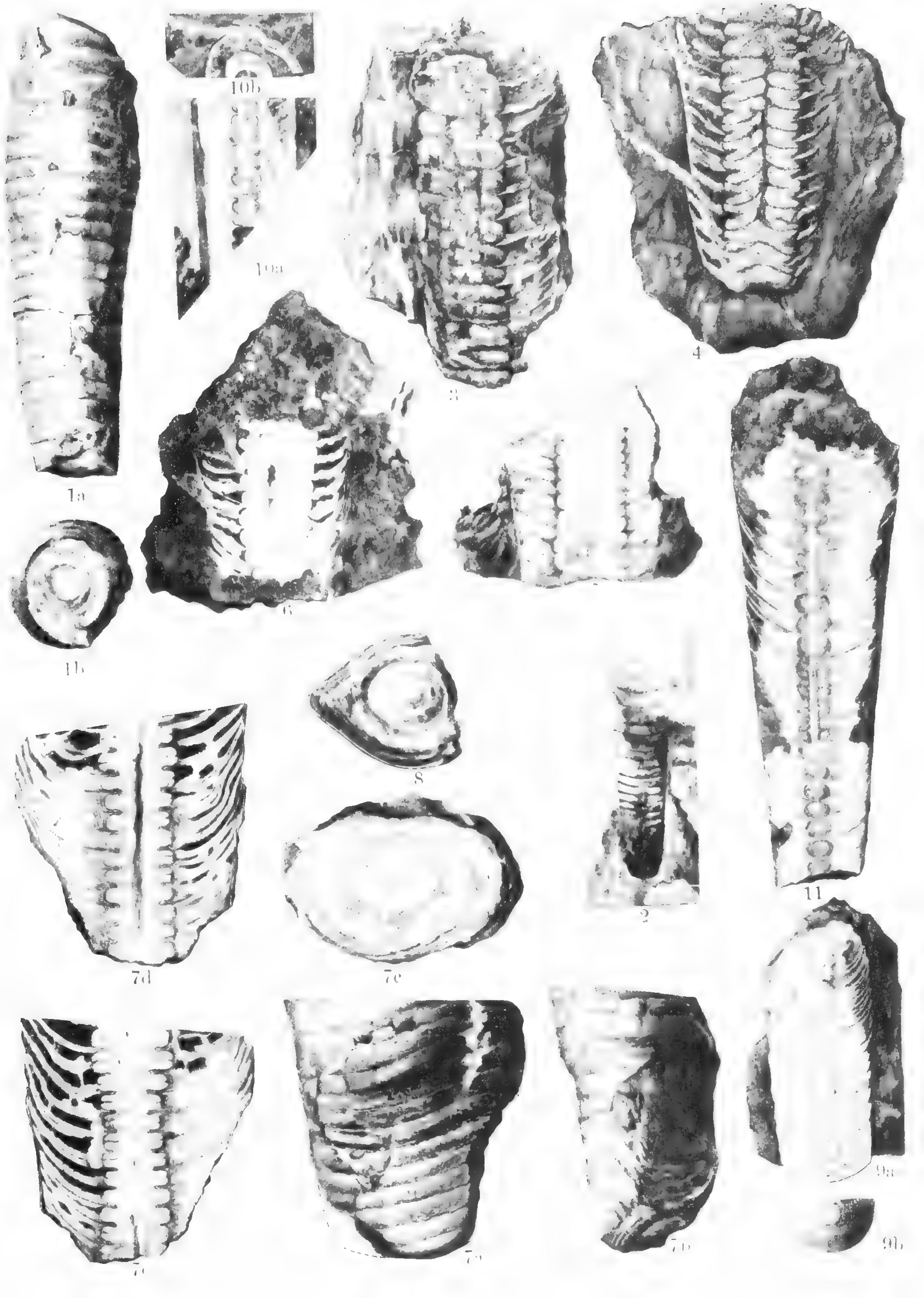
7c. View of the polished upper end of the same specimen, showing the oval form of the shell and the corresponding oval form and centran position of the siphuncle. Natural size.

7d. Median longitudinal section of the same specimen, showing the deep concavity of the septa, the character of the nummuli with the median endosiphuncle, and the lateral diverticula opening in pores on the outer surface of the nummuli. Natural size.

7e. Surface of the opposite half of the same specimen, separated from 7d by about 1 mm. Machiakou limestone, Wên-Nan, Mon-Yin-Hsien Shantung. V. K. Ting coll. (Geol. Survey Ch. Cat. No. 107).

Fig. 8. *Actinoceras richthofeni* Frech .... p. 75

End view of a fragment of an earlier part of the shell than that shown in fig. 7.


10b
10a
3
4
1a
6
11
1b
8
2
7d
7e
9a
9b

with part of outline restored. This shell shows a more acute lateral angle (slightly emphasized by compression, and a more nearly circular and proportionately large siphuncle. Machiakou limestone, Wên-Nan, Mon-Yin-Hsien, Shantung. V. K. Ting coll. (G. S. Ch. Cat. No. 108).

Fig. 9. *Stereoplasmoceras actinoceriforme* Grabau..p. 69

9a. Section through siphuncle, showiug the filling of crystalline limestoue, but without regular arrangement as in *Actinoceras.* Natural size.

9b. Lower end of the same specimen. Natural size. Machiakou limestone, Wên-Nan, Mon-Yin-Hsien, Shantung. (Cotype, V. K. Ting coll., G. S. Ch. Cat. No. 112).

Fig. 10. *Stereoplasmoceras actinoceriforme* Grabau...p. 69

10a. Longitudinal section of a specimen showing hollow nummuli of siphuncle below and filling with matrix in upper part. Also irregular pseudosepta and filling of stereoplasm. Natural size.

10b. Cross-section of the same. Natural size. Machiakou limestone, Kushan, Chihli. (Cotype, V. K. Ting coll. G. S. Ch. Cat. No. 60).

Fig. 11. *Stereoplasmoceras pseudoseptatum* Grabau..p. 66

Longitudinal section of an early portion of a conch, showing character of septa, cameræ and siphuncle. Natural size. Machiakou limestone, South of Wên-Nan, Mon-Yin-Hsien, Shantung. V. K. Ting coll. (Cotype, G. S. Ch. Cat. No. 112).

之上、此種石灰岩產 Suecoceras 化石兩種、其時代似屬中奧陶紀。是系與下奧陶紀岩層及上部馬家溝石灰岩之關係、尚難確定。

(四)馬家溝石灰岩

馬家溝產珠角石 Actinoceras 甚富、曾名之爲珠角石石灰岩。Actinoceras limestone 於此石灰岩中、共採得化石四十六種、(已經鑒定者僅有三十四種)茲分列之如左。

腕足類	六種
葉鰓類	一種
腹足類	十九種
錐石類	一種
頭足類	十六種
三葉虫	三種

產此類化石之岩層、與北美 Black River and Trenton 層系(上奧陶紀下部)相當、然究與中國南部之奧陶紀異也。

十三公尺以下有一薄層產化石極富、古盃珊瑚 Archaeocyathus 及頭足類等爲此系標準化石。古盃珊瑚 Archaeocyathus 形類海綿其內部之組織(如隔壁床板等)足以確定其爲珊瑚、爲寒武紀最常見之化石、然在奧陶紀岩層中極不多見。今于此系岩層中採得一種、北美雖曾發見一次、然在中國實爲最初之發現。其產地爲直隸、故定名爲直隸古盃珊瑚。Archaeocyathus chihliensis 頭足類化石之最著者爲 Proterocameroceras 屬、其殼之前端露出極長之體管、此種現象可用以解釋古代頭足類發育之原理、其學名爲 Proterocameroceras mathieui。直隸角石 Chihlioceras 屬直隸角石新科 Chihlioceratidae、爲本系主要化石、此類化石爲 Chihlioceras nathani 及 Chihlioceras chingwangtaoense 兩種。(見第二四五版各圖)此外腹足類之 Ophileta、亦爲常見之化石。是系與北美 Beekmantown 系相當、其時代當屬下奧陶紀。

(二)亮家山系

岩層爲灰色石灰岩、厚二百七十五公尺、下部爲厚約一百五十五公尺之石門寨頁岩及石灰岩(無化石)與亮家山系成不整一層。是系自五十三公尺以下有一薄層、產頭足類及腹足類兩類化石、頭足類有 Cameroceras 及 Piloceras 兩屬、與北美下奧陶紀上部所產者極相似。

是系與上部石炭紀岩層呈不整合之觀。

(三)冶里石灰岩

馬家溝北冶里村附近之石灰岩、名爲冶里石灰岩、是系底部有礫岩、Basal conglomerate 位於寒武紀岩層

中國北部奧陶紀之動物化石（節譯）

葛利普原著
孫雲鑄譯述

中國北部奧陶紀之化石、種類甚多、從前曾經鑒定者僅左列四種。

（一）Actinoceras richthofeni Frech

（二）Maclurea logani Salter

（三）Plectambonites sericeus (Sowerby)

（四）Asaphus boehmi Lorenz

前一種係滿洲所產、後三種發見於山東。此次鑒定結果、新增化石四十一種。（四十種爲新種）

中國北部奧陶紀之化石現已有五十八種之多、（共三十一屬）分佈于下列各系。

（一）北林子系（下奧陶紀）七種

（二）亮家山系（下奧陶紀）四種（其中一種與北林子系所產者同）

（三）冶里石灰岩（中奧陶紀?）二種

（四）馬家溝石灰岩（上奧陶紀）四十六種

以上各層系、維理士總稱之爲濟南石灰岩、李希霍芬誤認爲煤紀灰岩。Kohlenkalk 化石因層系互異、茲分論之如左。

（一）北林子系

是系爲石灰岩所組成、厚約九十五公尺、分佈於直隸東北臨榆縣石門寨一帶、其時代爲下奧陶紀。岩層自三

古生物誌乙種第一號

第一冊

葛利普著

中國北部奧陶紀動物化石

中華民國十一年四月

農商部地質調查所印行

GEOLOGICAL SURVEY OF CHINA;

THE MINISTRY OF AGRICULTURE AND MINES.

IN COOPERATION WITH

SECTION OF GEOLOGY, NATIONAL ACADEMY OF PEIPING

W. H. WONG, DIRECTOR

Palæontologia Sinica

EDITORS:

V. K. TING AND Y. C. SUN

Series B. Volume I.

Fascicle 2.

THE ORDOVICIAN CEPHALOPODA OF CENTRAL CHINA

BY

C. C. YÜ

CONTRIBUTED FROM THE NATIONAL RESEARCH INSTITUTE OF GEOLOGY, ACADEMIA SINICA.

WITH IX PLATES AND 7 TEXT FIGURES

PEIPING 1930.

For Sale at the Following Offices:

Peking: Geol. Surv. Library, 9 Ping Ma Sze, West City; French Bookstore, Grand Hotel de Pekin, Peiping; **Shanghai:** Kelly & Walsh, Ltd., 12 Nanking Road; Max Noraler & Co., G.M.B.H, 45B Kiangsu Road; **London:** Edward Goldston, 25 Museum St. (W. C. 1); **Tokyo:** Maruzen Co.; **Leipzig:** Max Weg, Königstrasse 3; **New York:** A. G. Seiler & Co. 1224 Amsterdam Ave.

Series B. *Vol. I. Fascicle* II

PALÆONTOLOGIA SINICA

Editors:

V. K. Ting and Y. C. Sun

The Ordovician Cephalopoda of Central China

BY

C. C. YÜ

Geologist to the National Research Institute of Geology

With IX Plates and 7 Text figures

Published by the Geological Survey of China;
Section of Geology, National Academy of Peiping.
Peiping 1930.

CONTENTS

CONTENTS (*Continued*)

CONTENTS (*Continued*)

THE ORDOVICIAN CEPHALOPODA OF CENTRAL CHINA

by

C. C. Yü.

INTRODUCTION

When I carried on the field work in Hsien-ning-hsien (咸寧縣), gathering many beautiful well-preserved Silurian fossils in May of the year 1928, Messrs C. Li and W. P. Shu had simultaneously made a collection of orthoceracone Nautilids in large numbers from the Ordovician beds at San-shan-yuan (三山原), He-chiao (黑橋), and some other localities of Ch'ung-yang-hsien (崇陽縣), distant about sixty li or a little more than twenty miles southwest of Hsien-ning-hsien. Moreover, the Ordovician cephalopods are also found in the regions to the south-west of Pu-chi-hsien (蒲圻縣), and the south-east of Hsien-ning-hsien. The specimens in this collection are mostly of large size, some attaining nearly one meter in length. Nevertheless, their preservation is rarely perfect. In the majority of cases these cephalopods are obtained from the polished slabs of the dark-gray limestone, where the shell has been partly weathered away on one side, while the remaining portion is seldom separable from the rock on the other side; and therefore no trace of the surface markings has been recognized. Thus the determination of these fossils is based entirely on the internal characters.

During October of the same year, Mr. Shu and I went to northern Hupeh, and in our field work covered the area of I-chêng (宜城), Chung-hsiang (鍾祥), Ching-shan (京山), Ching-men (荊門) and Nan-chang-hsien (南漳). In this trip we collected an abundance of delicate fossils from the different geological horizons ranging from Sinian to Jurassic, though the Devonian and the Triassic deposits have not furnished fossils so far. In this collection the Ordovician cephalopods appear to be one of the dominant types. They are very abundant and wide-spread over the region of northern Hupeh. As our journey required haste, the time was not sufficient to enable us to stay long enough at many of the localities to make more extended collections of fossils.

The specimens brought back to the Institute from the field during these trips amount to a large number. Unfortunately, the palæontological publications are not yet complete enough in our Institute library which was just established last year, so the palæontological work is not possible at present at the Institute. Therefore on the first of March of the year 1929, Prof. Lee granted me leave to bring this material to the Geological Survey in Peiping for the purpose of identification and description of these specimens under the direction of Prof. Grabau, the chief Palæontologist to the Surveys

After I had finished the work of describing the Ordovician cephalopods brought here from our Institute, Prof. Grabau asked me to continue to take up some other cephalopods collected by Prof. J. S. Lee and Mr. C. Y. Hsieh, and a similar collection presented to the Survey by the late J. Langford Smith. In 1924 Prof. Lee made an excursion to the Yangtze Gorges, collecting some cephalopods and many other fossil. from the Neichiashan formation. Mr. Hsieh also obtained very abundant Ordovician cephalopods, which were partly from the upper part of Tafang limestone at Yang-sing-hsien (陽新縣), eastern Hupeh in 1923, and partly from the western Hupeh in the autumn of the year 1924. Though these collections consist of a large quantity of specimens, the number of species is not very great. Besides, the majority of them are conspecific, not only congeneric, with those collected by myself, but some specimens such as *Cameroceras*, *Protocycloceras* etc. have not been met with in the localities of northern Hupeh.

First of all I would express my special indebtedness to Prof. A. W. Grabau for his courtesy in giving me much valuable suggestions and criticisms. To Prof. J. S. Lee Director of the Institute, Dr. W. H. Wong, Director of the Geological Survey, Dr. V. K. Ting, Editor of the Palæontologia Sinica of China and Dr. Y. C. Sun President of the Palæontological Society of China I am also indebted for furnishing me every facility for carrying on the palæontological work in the Survey laboratory. Finally, I particularly tender my deep appreciation to Mr. K. H. Hsü and Mr. Y. S. Chi for their help in the photographic work.

TERMINOLOGY

All Nautiloids are provided with an external shell, which may be termed *ceracone* or *conch*. When the shell is straight, it is called *orthoceracone;* when curved, *cyrtoceracone*. If the conch is curved in a loose coiling manner it is called *gyroceracone;* and closely coiled having the impressed zone, called *nautilicone*. The embryonal shell is known as the *protoconch*; and the septate shell, the *phragmacone*. The interior of the shell consists of many transverse partitions or *septa*. The spaces confined between the septa are the *chambers* or *cameræ*. The *chamber of habitation*, *body chamber* or the *living chamber* is the last chamber occupied by the body of the animal. There is a small hollow tube or *siphuncle*, which passes through all the septa, occupying a different position in different genera. The septa abruptly bend backward and continue to a certain extent around the siphuncle. Their prolongations, called *septal necks* or *septal funnels*, are either short as in Orthochoanites, or very long as in the Holochoanites.

In Holochoanites as usually described there is another small axial tube existing in the center of the siphuncle, which is called *endosiphotube* or *endosiphuncle* by Hyatt or *prosiphon* by Zittel. The siphuncle is more or less solidly filled with thin calcareous cones or *endosiphosheaths* around the endosiphuncle. There is a conical cavity formed by the last *endosiphosheath*, which is termed *endosiphocone* or *endocone by* Hyatt. It extends forward into the open space of the *siphuncle* known as the *endosiphocylinder* (*endoconal* or *siphuncular chamber* of Hyatt). The *endosipholining* is the additional covering on the inside of the siphuncular wall which is composed of the septal funnels.

Recently Prof. Grabau has shown that the so-called siphuncle of the Holochoanites is homologous with the shell of the Orthochoanites, the endosipholining of the former corresponding to the wall of the latter, and the endosiphosheaths to the septa. He has proposed the following terms[1] for use in the shells of Holochoanites, which are adopted in the present paper.

Ectoconch......................The outer shell of former authors (exclusive of siphuncle).

Endoconch....................The siphuncle of former authors.

Ectotheca......................The outer shell wall of authors.

Endotheca......................The inner shell wall or endosipholining of authors (often absent).

Ectosepta......................The septa of outer shell of authors.

Endosepta......................The septa of inner shell or the endosiphosheaths of authors.

Tubus (pl. *tubi*)..............The prolongations of the ectosepta homologized by former authors with the septal funnels of the Orthochoanites.

Endosiphuncle................The siphuncle of the endoconch or endosiphuncle of authors.

Endocone......................Terminal conical living chamber of endoconch or endosiphocone of authors.

Endocylinder.................The endosiphocylinder of authors.

1. These terms have been published in the Bulletin of the Geological Society of China, Vol. 8, No. 2, p. 118.

STRATIGRAPHY

COMPARISON OF THE ORDOVICIAN BEDS IN THE DIFFERENT LOCALITIES OF HUPEH.

Although the Ordovician beds at the different localities in Hupeh have been studied and the results published at various times by other geologists and by the author, nevertheless they will also be briefly summarized here for convenience in comparison. In the first place we shall take the Ordovician strata in western Hupeh into consideration, which region may be regarded as the type locality of Ordovician formations in Hupeh province or even in Central China.

1. WESTERN HUPEH:[1] At Nant'ou on the Yangtze River above I-chang, and on the Ta-ning-ho in Ki-sin-ling pass Willis and Blackwelder[2] found that there is a very thick massive limestone overlying the Nan-t'ou tillite and attaining a thickness of more than 1,200 meters in the Nant'ou section. They called it the Ki-sin-ling limestone and held that it represented the Cambro-Ordovician period. On the uppermost part of the Ki-sin-ling limestone, as described by them there are green calcareous shales alternating with nodular limestone about 60 meters thick, which directly underlie the Sint'an formation. In the spring of the year 1924, Prof. Lee carried on detailed stratigraphical work on the geology of the Yangtze Gorge[3]. He discovered that the so-called Ki-sin-ling limestone not only comprises the rocks of Cambrian and Ordovician periods, but also the entire Sinian system, the first period of the Palæozoic as proposed by Prof. Grabau[4]. Prof. Lee suggested another group name "Niukan Group" for the actual Cambro-Ordovician strata so well exposed in the Niukan Gorge instead of the so-called Ki-sin-ling formation. According to Prof. Lee's proposal the Niukan Group may also be, from the fossil fauna point of view, divided into the Shipai shale at the

---

1. Messrs. Hsieh and Liu had taken a geological trip to south-western Hupeh in April of 1925 (Bulletin of the Geological Survey of China, No. 9), and Mr. H. M. Meng to north-western Hupeh in the automn of 1928 (Memoir of Institute of Geology, No. 8. National Research Institute of China). According to their reports the Ordovician beds at these localities are quite similar to those of western Hupeh and numerous *Orthoceras* were also seen in the Neichiashan formation. Now we know that the so-called "Pagoda stone" at Hupeh province includes the orthoceracone Nautilids which are not only *Orthoceras chinense* Food, but also many other forms of different species or even of different genera as well. It is unfortunate that they did not bring any specimen back. So we can not discuss them here.

2. Willis and Blackwelder: Research in China, Vol. I, pt. I, pp. 269-272.

3. J. S. Lee: Geology of the Yangtze Gorge. Bulletin of the Geological Society of China, Vol. III, No. 3-4.

4. A. W. Grabau: The Sinian System. Bulletin of the Geological Society of China, Vol. I, p. 44.

lower part, and Ichang limestone as well as Neichiashan Series at the Upper, the former one denoting the Cambrian deposit and the latter two the Ordovician. The I-chang limestone attains a thickness of from 1250 m. to 1680 m. and yields fossils of Lower Ordovician age such as *Callograptus* cf *salteri* Hall, *Proterocameroceras mathieui* Grabau, *Eccyliopterus*. sp., *Asaphus sp. Archæocyathus chiliensis* Grabaú, *Girvanella sinensis* Yabe etc. The Ichang limestone is again disconformably overlaid by the Nei-chiashan Series, 110 m. thick, which consists of two parts. The lower part is an alternation of green, calcareous shales and brownish yellow or light gray limestone characterized by *Triplecia* (*Yangtzeella*) *poloi* (Martelli) Kolarova, and *Clitambonites giraldii* Martelli; and the upper one is a dense gray limestone crowded with abundant *Orthoceras*. This series has furnished besides *Triplecia* (*Yangtzeella*) *poloi* Martelli, and *Clitambonites giraldii* Martelli, the following: *Orthis calligramma* Dalm., *Eccyliopterus sinensis* Frech, *Vaginoceras duplex* Wahlenberg, *Discoceras eurasiaticum* Frech, *Endoceras* sp., *Cycloceras* sp., *Cyrtoceras* sp., *Asaphus* cf *expansus* Dalm., and many specimens of *Orthoceras*. A preliminary determination of the cephalopods in this collection was made by Prof. Grabau, but some are missing from the Geological Museum of Peking University except the specimens of *Orthoceras chinense* Foord, *Discoceras eurasiaticum* Frech and the so-called *Cyrtoceras* which now is known as *Meloceras asiaticum* Yabe. During the autumn of 1924 Messrs. C. Y. Hsieh and Y. T. Chao again carried on field work in the western part of Hupeh[1] and collected one species of cephalopod from the Ichang limestone and a lot of them mainly from the upper part of the Neichiashan formation at the places near Lo-jo-ping and Chien-yang-ping. Prof. Grabau asked me to make a thorough study of these cephalopods of which he has made a preliminary examination. The material includes the following species:

a. From Ichang limestone

Cameroceras cf. *styliforme* Grabau

b. From Neichiashan formation (upper part)

Cameroceras tenuiseptum Hall var. *ellipticum* Yü
Cameroceras hsiehi Yü
Cameroceras subtile Yü
Cameroceras sp.
Vaginoceras neichianense Yü
Vaginoceras reedi Yü
Vaginoceras multiplectoseptatum Yü

1. C. Y. Hsieh and Y. T. Chao: Geology cf I-chang, Hsing-shan, Tze-kuei and Pa-tung districts, W. Hupeh. Bulletin of the Geological Survey of China. No, 7.

Orthoceras chinense Foord
Orthoceras regulare Schlotheim
Orthoceras squamatulum Barrande
Orthoceras thyrsus? Barrande
Orthoceras yangtzeense Yü
Orthoceras? wongi Yü
Protocycloceras deprati Reed

2. EASTERN HUPEH: The stratigraphical work of eastern Hupeh had been done by Mr. Seijiro Noda[1], but his classification was found incorrect by Messrs. Hsieh and Liu who were sent by the Geological Survey of China to study the geology of Yang-sing and other districts[2] in the autumn of 1923. They reported that the Ordovician limestone at these localities is very thick and gray in colour. Because it was first found at Ta-fang village in Yang-sing district, the Ordovician formation is called Tafang limestone. Its actual thickness is unknown, because the basal part is not exposed. Some *Orthoceras* and brachiopods are found in the limestone, and are very abundant together with some trilobites in a layer of purple calcareous shale about 20 m. thick on the top of the formation, which is regarded as the equivalent of the upper part of the Neichiashan Series. The cephalopods of the collection now preserved in the laboratory of the Survey are:

Vaginoceras belemnitiforme Holm
Vaginoceras endocylindricum Yü
Vaginoceras uniforme Yü

3. SOUTH-EASTERN HUPEH: According to Mr. Li's Report[3] on the geology of Pu-chi, Hsien-ning etc., it is shown that the Ordovician exposed in that area is made up of limestone, which appears to be divided into two divisions. The lower division is a thick-bedded dark gray limestone, of which the exposed thickness amounts to about 500 m. The upper division consists of an alternation of reddish thin-bedded limestone and calcareous shale, which attain a thickness of 140 m. overlying a layer of the yellowish gray thin-bedded limestone 30 m. thick at its base. Many cephalopods of large size were obtained, especially from the basal bed of the upper division. A comparison of this upper division with the Neichiashan formation of western Hupeh brings out the fact that though other fossils than the cephalopods in

---

1. Geographical research in South China, Vol. II, pp. 241-281.

2. C. Y. Hsieh: Stratigraphy of south-eastern Hupeh. Bulletin of the Geological Society of China, Vol. III, No. 2.

3. C. Li: Geology of Pu-chi, Kia-yu, Hsien-ning, Chung-yang and Wu-chang districts, Hupeh Province. Memoir of the Institute of Geology, No. III, National Research Institute of China.

that formation have not been found in this upper division, and though their lithological characters also differ to some degree, nevertheless some cephalopods from this division are of the type of those common in the upper part of Neichiashan formation on the one hand and others correspond to those obtained from the top of Tafang limestone on the other. It is quite possible to say that this upper division may be compared with the upper part of Neichiashan formation. The cephalopods secured from this division include the following species :

Endoceras leei Yü
Vaginoceras wahlenbergi Foord. var. *cylindrica* Yü
Vaginoceras endocylindricum Yü
Vaginoceras peiyangense Yü
Vaginoceras shui Yü
Vaginoceras neichianense Yü
Vaginoceras uniforme Yü
Vaginoceras giganteum Yü
Vaginoceras sp.
Orthoceras chinense Foord var. *eccentrica* Yü
Orthoceras chinense Food var. *equiseptatum* Yü
Orthoceras rudum Yü
Orthoceras suni Yü
Orthoceras elongatum Yü
Orthoceras sp.
Lituites lii Yü

4. Northern Hupeh : In northern Hupeh[1] the Ordovician deposit is quite similar to that in the western part of Hupeh, comprising the so-called Ichang limestone in the lower part and the Neichiashan formation in the upper. The former attains a thickness of more than one thousand meters while the latter is rather thin in proportion, having only a total thickness of about eighty meters or a little more. The Neichiashan formation also consists of two parts. The lower part is yellowish green shale about twenty meters thick, and the upper is light greenish argillaceous limestone reaching a thickness of sixty meters or more. It is to be noted that this formation is distributed over a wide area in Hupeh province. As we travelled across these localities namely : Nan-chang, Chung-hsiang, I-cheng, Chingshan and the southern border of Hsiang-yang-hsien, the Neichiashan formation with its striking cephalopod fauna

1. C. C. Yü and W. P. Shu : Geology of Hsiang-yang, Nan-chang, I-cheng, Ching-men, Chung-hsiang and Ching-shan districts, North Hupeh. Memoir of the Institute of geology, No. VIII, National Research Institute of China.

was frequently met with here and there. Its upper part or the limestone bed is characterized by the different forms of Orthochoanites and Holochoanites, and its lower part or the shale bed yields the well-preserved specimens of Graptolites, Trilobites, Brachiopods and some others, but not the characteristic *Yangtzeella poloi* (Martelli) which, however, occurs very abundantly in western Hupeh. This formation has so far furnished the following fossils :

a. In the upper part of the Neichiashan formation.

Endoceras grabaui Yü
Vaginoceras (*Endoceras*) *wahlenbergi* Foord
Vaginoceras chientzekouense Yü
Orthoceras chinense Foord
Orthoceras chinense Foord var. *kuangchiaoense* Yü
Orthocecas chinense Food var. *equiseptatum* Yü
Orthoceras cf. *politum* M'Coy
Orthoceras remotum Yü
Orthoceras densum Yü
Orthoceras sp.
Cycloceras sp.

b. In the lower part of the Neichiashan formation.

Didymograptus murchisoni Beck
Orthis calligramma Dalm.
Dalmanella sp.
Leperditia sp.
Asaphus gigas var. *hupehensis* Sun
Taihungshania shui Sun
Illænus nanchangensis Sun
Bathyurus minor Sun
Bronteus sp.

The Geological Horizon of the So-Called Neichiashan and Ichang Formations.

So far as we know, the upper part of the Ichang limestone belongs to the Lower Ordovician, for Prof. Lee and Mr. Hsieh had collected, in beds not far from the base of overlying Neichiashan formation, some fossils, which, according to Prof. Grabau's determination, are of Lower Ordovician age. But the age of the lower part of Ichang formation already discussed by Yabe, Hsieh and others is quite uncertain. Prof. Grabau, however, believes it is more likely of Lower Ordovician rather than Cambrian age. Unfortunately, Mr. Shu and I also have not discovered, in our extensive journey in northern Hupeh, any characteristic fauna other than the so-called *Archæocyathus* from the basal part of Ichang formation, which could throw more light on this unsettled question.

The geological horizon of the Neichiashan formation has been considered by many previous authors to be Middle Ordovician or lowest Upper Ordovician. Mr. Shu and I obtained from the lower part of this formation just underlying the cephalopod-bearing bed at Tai-hung-shan, 3 li west of Nan-chang district, many specimens of a well-preserved characteristic graptolite, namely *Didymograptus murchisoni* Beck, which had not been found by any former traveller in Hupeh province and its neighbouring localities. From this characteristic graptolite we may readily conclude that the lower part of the Neichiashan formation actually corresponds to the *Didymograptus murchisoni* zone of the British Ordovician rocks, while the cephalopods contained in the upper part of the formation and described in the present paper show approximate equivalency to the Orthoceras limestone of Sweden and the Vaginoceras limestone of the Baltic province of Russia.

The Relationship Between The Ordovician Cephalopods From Hupeh, Central China And Those From The Corresponding Horizon In Northern As Well As Southern China.

Before comparing the cephalopod faunas of North and Central China, we must summarize the distribution of the Ordovician cephalopods collected at various times from the different localities in China.

1. In Manchuria.

   a. From Hsiau-sörr, Fengtien, Richthofen collected the following form which was described by Frech[1] and referred by him to the Upper Ordovician. Prof. Grabau, however, recognized that this bed is of the same horizon as the Machiakou limestone in Chihli.

   Actinoceras richthofeni Frech

   b. In the year 1928 T. Kobayashi described many Ordovician cephalopods from Corea and South Manchuria.[2] Those collected from the Tofango fossil bed at To-fan-go and Niu-shin-tai of Fengtien province are of the same horizon as the Machiakou limestone. The species are as follows:

1. F. Frech: In Richthofen's China, Vol. V, p. 8.

2. T. Kobayashi: Ordovician Fossils from Corea and South Manchuria. Japanese Journal of Geology and Geography, Vol V, No. 4.

Cycloceras (?) *peitoutzense* Grabau
Stereoplasmoceras pseudoseptatum Grabau
Stereoplasmoceras submarginale Kobayashi
Stereoplasmoceras subcentrale Kobayashi
Tofangoceras pauciannulatum Kobayashi
Tofangoceras irregulare Kobayashi
Actinoceras richthofeni Frech
Actinoceras tani Grabau
Actinoceras coulingi Grabau
Actinoceras manchurense Kobayashi
Actinoceras submarginale Grabau
Actinoceras nanum Grabau
Actinoceras harioi Kobayashi
Actinoceras suanpanoides Grabau
Actinoceras curvatum Grabau
Actinoceras murakamii Kobayashi
Cyrtactinoceras mitsuishii Kobayashi
Discoactinocras multiplexum Kobayashi
Cyrtoceras (*Meloceras*) aff. *asiaticum* Yabe

2. In Chihli.

a. Many cephalopods were obtained by different individuals from the Machiakou limestone and the Lower Ordovician beds at Kai-ping basin, Shih-mun-chai and some other places, and described by Prof. Grabau.[1]

(a). Machiakou limestone

Vaginoceras tsinanense Grabau
Cycloceras? peitoutzense Grabau
Stereoplasmoceras pseudoseptatum Grabau
Stereoplasmoceras machiakouense Grabau
Stereoplasmoceras actinoceriforme Grabau
Actinoceras richthofeni Frech.
Actinoceras tani Grabau
Actinoceras coulingi Grabau
Actinoceras submarginale Grabau
Actinaceras nanum Grabau
Cyrtactinoceras frechi Grabau

1. A. W. Grabau: Ordovician Fossils from North China. Palæontologia Sinica, Ser. B., Vol. I. fasc. 1.

(b). Lower Ordovician limestone

Proterocameroceras mathieui Grabau.
Cameroceras styliforme Grabau
Chihlioceras nathani Grabau
Chihlioceras chingwangtaoense Grabau
Piloceras platyventrum Grabau
Suecoceras yehliense Grabau
Suecoceras attenuatum Grabau.

b. Mr. T. K. Huang had gathered some cephalopods from Hsi-shan or Western Hills of Peking[1].

(a) Machiakou limestone

Stereoplasmoceras pseudoseptatum Grabau
Actinoceras coulingi Grabau
Actinoceras suanpanoides Grabau

(b) Peilintze limestone

Proterocameroceras minor Grabau
Proterocameroceras mathieui Grabau
Piloceras platyventrum Grabau
Chihlioceras nathani Grabau
Chihlioceras sp.

3. In Shantung

Many cephalopods have been obtained. These were described by several authors.

a. Samuel Couling had collected from the locality near Ching Chow Fu, Kiaochow, two different forms of cephalopods which G. C. Crick[2] described as those named below. Prof. Grabau,[3] however, considered them the same as the forms in brackets from the Machiakou formation.

Actinoceras (*Ormoceras*) aff. *tenuifilum* Hall (=*Actinoceras coulingi* Grabau).

Gonioceras sp. (cf. *Gonioceras shantungense* Grabau).

---

1. T. K. Huang: On the Cambrian and the Ordovician Formations of Hsishan or Western Hills of Peking. Bulletin of the Geological Society of China, Vol. VI, No. 2.

2. G. C. Crick: Straight shelled Nautiloidea from North China. Geol. Mag. London., N. S., dec. IV, Vol. X, P. 481.

3. A. W. Grabau: Loc. cit, pp, 83, 84, 91-93.

b. Frech[1] reported that there are in the British Museum some specimens of Upper Ordovician cephalopods from Shantung, but the exact locality is unknown. These fossils seem to be equivalent in horizon to those of Couling's collection.

Actinoceras sp.
Trochoceras sp.

c. Willis and Blackwelder collected some cephalopods from the Tsinan limestone of Middle Ordovician age at the following localities. Chau-mi-tien, seven and a half miles S.S.E. of Sin-tai-hsien, NE of Tsai-kia-chuang, two and seven-tenths miles SW of Yen-chuang and some other places near Tsi-nan. These cephalopods were only generically identified by Weller[2] .

Orthoceras sp. (several)

d. Prof. Grabau described the following forms[3] and considered them from the same horizon as the Machiakou limestone.

Stereoplasmoceras pseudoseptatum Grabau
Stereoplasmoceras machiakouense Grabau
Actinoceras richthofeni Frech.
Actinoceras tani Grabau
Actinoceras coulingi Grabau
Actinoceras suanpanoides Grabau
Actinoceras curvatum Grabau
Cyrtactinoceras frechi Grabau
Gonioceras shantungense Grabau

4. In Honan

One species of Actinoceras has been obtained from the Machiakou limestone of Hsi-hsien[4]

Actinoceras coulingi Grabau

5. In Kiangsu Province

a. One form of cephalopod from Richthofen's collection at Lun-shan had been identified by Frech[5] with the following species apparently representing the

1. F. Frech: In Richthofen's China, Vol. V, p. 14.

2. S. Weller: A Report on Ordovician Fossils collected in Eastern Asia in 1903-4. In Research in China, Vol. III, pp. 279-280.

3. A. W. Grabau: Ordovician Fossils from North China. Palæontologia Sinica, Ser. B. Vol. I., fasc. 1.

4. A. W. Grabau: Loc. cit.

5. Frech: Richthofen's China, Vol. V. p. 2.

same geological horizon as those beds from the neighbourhood of I-chang which bear the fossils such as *Orthoceras chinense* Foord, *Discoceras eurasiaticum* Frech etc.

Endoceras duplex Wahlenberg.

b. Mr. K. Weimann Hsü also obtained some cephalopods[1] from the Lunshan limestone in the year 1924. According to Prof. Grabau's determination they are the same as the Lower Ordovician forms characteristic of the Peilingtze formation and Yehli limestone as follows :

Proterocameroceras mathieui Grabau
Suecoceras attenuatum Grabau

6. In Chekiang.

Messrs. C. C. Liu and Y. T. Chao[2] had found the following form existing in a bed of purple calcareous shale with limestone-lenses at the top layer of the Yenwashan formation of Middle Ordovician.

Orthoceras chinense Foord.

7. In Hupeh Province

Many collections of fossils were made by geologists, of which the cephalopods are the only ones concerning us here.

a. Frech considered the following cephalopods from western Hupeh[3] as referable to an Upper Ordovician fauna. However, they are now known to be of Middle Ordovician age.

Orthoceras chinense Foord
Cyrtoceras (*Meloceras*) cf. *ellipticum* Lossen
Lituites (*Ancistroceras*) *angelini* Boll.
Discoceras verbecki Frech.
Discoceras eurasiaticum Frech.

b. The following forms form Pan-tse-ya, Hu-hsi, Hsing-shan-hsien had been gathered by Noda[4] in a brownish marly limestone, which is thought to be the so-called Neichiashan formation.

---

1. See "Science". Science Society of China, Vol. X, No. 4, p. 452. The forms in Mr. Hsü's collection are entirely distinct from those found by Richthofen. The relationship between these beds, which yield the different forms fossils at these two collections, is quite unknown. In this respect further researches in that locality would be necessary for settling this question.

2. C. C. Liu and Y. T. Chao : Geology of south-western Chekiang. Bulletin of the Geological Survey of China, No. 9.

3. Frech : In Richthofen's China, Vol. V. pp. 4-10.

4. In Yabe and Hayasaka's Palæontology of Southern China, p. 36.

Actinoceras (Ormoceras) sp. undt.
Orthoceras chinense Foord.
Cyrtoceras (Meloceras) asiaticum Yabe

Grabau[1] identified a specimen of *Actinoceras* figured by Yabe[2] from No-lu-ping, Hu-hsi, Hsing-shan-hsien as *Actinoceras coulingi* Grabau.

c. At No-lu-ping, Tung-hu-hsien, S. Usui[3] found some cephalopods in the limestone, grey in colour and earthy in texture, which is directly overlain by the Silurian deposits. From the stratigraphical point of view the fossiliferous horizon of No-lu-ping seems without doubt to be the Neichiashan formation.

Lituites (Ancistroceras) angelini Boll. var.
Discoceras eurasiaticum Frech
Discoceras sp. undt.
Orthoceras sp. undt.
Orthoceras sp. undt.

d. Prof. Lee, Messrs. Hsieh, Liu, Chao, Li, Shu and I have collected from the upper part of Neichiashan formation and its corresponding beds at different localities in Hupeh province, numerous forms of cephalopods which have been listed above. Others have been supplied by the late Mr. J. Langford Smith.

8. In the province of Sze-chuan

Only one form of cephaloped was obtained from the uppermost Ki-sin-ling limestone of Middle Ordovician age at Sü-kia-pa along the Ta-ning-ho, and identified by S. Weller[4].

Vaginoceras sp.

9. Between Yang-ko-la, Chi-chiang-hsien, Sze-chuan province, and Chu-tien-ya, Kwei-chou province,

Yamada obtained two species of cephalopods[5] .

Orthoceras chinense Foord
Orthoceras sp.

1. Grabau: Ordovician Fossils from North China, Palæontologia Sinica, Ser. B, Vol. I, Fasc. 1. pp. 83, 84.
2. Yabe and Hayasaka: Palæontology of Southern China, pl. XIX, fig. 9.
3. Loc. cit. p. 37.
4. S. Weller: A Report on Ordovician Fossils collected in Eastern Asia in 1903-4. In Research in China, Vol. III, p. 281.
5. In Yabe and Hayasaka's Palæontology of Southern China, p. 38.

10. IN WESTERN YUNNAN

Middle Ordovician fossils have been obtained in three localities *i.e.* Pu-piao, La-meng and Shih-tien, of which the last named has furnished the largest number of species of cephalopods (ident. by Cowper-Reed[1]).

a. Pu-piao

Orthoceras sp.

b. La-meng

Orthoceras sp.

c. Shih-tien

Endoceras wahlenbergi Foord
Endoceras cf. *cancellatum* Eichw.
Endoceras aff. *reinhardi* Boll.
Orthoceras regulare Schl.
Orthoceras cf. *kinnekullense* Foord.
Orthoceras cf. *scabrium* Ang.
O. (*Protocycloceras* ?) *deprati* Reed.
Actinoceras cf. *bigsbyi* Brown
Jovellania sp.
Cameroceras ? sp.
Cyrtoceras sp.
Spyroceras ? sp.
Trocholites yunnanensis Reed
T. aff. *macromphalus* Schrod
Lituites sp.
Tarphyceras ? sp.

According to Reed the fossiliferous beds at Shih-tien is probably equivalent to the "Vaginatenkalk" of the Baltic province, but may represent the "Echinosphæritenkalk" of Scandinavia and of the Baltic province of Russia.

So far as these cephalopods listed above are concerned, we can immediately recognize the following facts: (1) in the Middle Ordovician the *Actinocers*, which is very characteristic and abundant in North China, is very rare in Central as well as South

1. Reed: Ordovician and Silurian Fossils from Yun-nan. Palæontologia Indica, N. S., vol. VI. No. 3, pp. 62-64.

China; (2) the cephalopods of Shih-tien[1] such as *Vaginoceras* (*Endoceras*) *wahlenbergi* Foord, *Orthoceras regulare* Schl., *Protocycloceras deprati* Reed, etc. are also found in the probably contemporaneous beds of the Neichiashan formation at Hupeh; (3) among these collections from Hupeh described in the present paper, only a few forms namely *Cameroceras tenuiseptum* Hall var. *ellipticum* Yü, *Cameroceras hsiehi* Yü, etc. may be compared with North American species, but the rest have characters in common only with European types, though they are not generally conspecific with them.

Prof. Grabau has suggested that the Sino-European Ordovician fauna was derived from the Indian Ocean[2] which invaded the southern part of the East Cathaysian geosyncline in China on the one hand, and penetrated to western Europe by way of the Himalayan trough on the other. He based this primarily on the apparent migration of the graptolites in the Lower Ordovician period[3]. According to Grabau's interpretation we can understand why the Middle Ordovician cephalopods from Hupeh province which was probably covered by the southern waters, are closely related to those from South China as well as Europe, and are quite distinct from the North Chinese and North American types which belong to another source, *i. e.* the Boreal province.

One may argue that if the Indian Ocean was the home of the Sino-European Ordovician faunas, why should the characteristic *Vaginoceras* (*End.*) *wahlenbergi* Foord, which according to Foord's description[4] was collected from the Orthoceras-Limestone (referred by him to the Arenig) at typical localities in Sweden, Norway, Russia etc., makes its first appearance in the Middle Ordovician beds of southern as well as central China where the distance from the Indian Ocean is much nearer than that in the western Europe. Now this question is easily answered if we have read over what is called "Comparison of American and European Lower Ordovician formations" by Prof. Grabau[5] in which he corrected the old misconception of the unity of the "Orthoceras limestone". In Kinnekulle, Sweden the general Ordovician succession is as follows:

---

1. Mr. S. S. Yoh had obtained many fossils, which are quite comparably to Brown's collection from the Middle Ordovician beds of Shihtien, from the Shihtzupu shale at Shih-tzu-pu, 10 li north of Tsung-yi district, Kuei-chow Province. But he did not find any cephalopod. (Bulletin of the Geol. Surv. of China, No. 11, p. 33.).

2. Grabau: China in the Ordovician Period. Bulletin of the Geological Society of the National University, Peking, Vol. III, pp. 9-22.

3. Grabau: Origin, Distribution, and Mode of Preservation of the Graptolites. Memoir of the Institute of Geology, No. VII, pp. 1-52. National Research Institute of China.

4. Foord: Catalogue of Fossil Cephalopoda, Pt. I., pp. 136-140.

5. See Bulletin of the Geological Society of America, Vol. 27, pp. 555-622.

Silurian

..........*Hiatus and disconformity*..........

Ordovician

Brachiopod shale

..........*Hiatus and disconformity*..........

Trinucleus shale

Chasmops beds, dark shales with graptolites and numerous concretionary limestone masses and beds of impure limestone containing *Chasmops sp.*, *Echinosphærites aurantinum* Gyllenh.

Orthoceras limestone

(d) Upper gray or Chiron limestone (c) Upper red limestone (b) Lower gray or Asaphus limestone	Upper Llandeilan
........*Hiatus and disconformity*....	....
(a) Lower red or Limbata limestone Lower Didymograptus shale Planilimbata limestone	Lower Arenigian
...............*Hiatus*?....................	....

Cambrian

Formerly the name of "Orthoceras limestone" was applied to a limestone series included within the graptolite-bearing shales of the Ordovician and since the Lower Didymograptus shale (Phyllograptus shale) is early Arenig, the Orthoceras limestone was also referred to the Arenig. Since there is a hiatus existing between the Lower gray or Asaphus limestone and the Lower red or Limbata limestone, the latter is now united (when the Lower Didymograptus shales are absent) with the Planilimbata limestone, the combined series being called "Megalaspis limestone". The name "Orthoceras limestone" is now restricted to the 3 limestones overlying the hiatus, namely the Lower gray limestone, the Upper red limestone and the Upper gray limestone, and these represent the later Llandeilan or late Middle Ordovician age. From the "List of the Fossil Faunas of Sweden" we find that the species *Vaginoceras* (*End.*) *wahlenbergi* Foord, *Vaginoceras* (*End.*) *vaginatum* Schloth, and some other forms were actually found in the Lower gray Orthoceratite Limestone,[1] in other words they occur in the same horizon as in China. Foord's statement, of course is not correct.

---

1. G. Lindström: List of the Fossil Faunas of Sweden, I., pp. 9-10.

DESCRIPTION OF SPECIES

Class **CEPHALOPODA**

Order **NAUTILOIDEA** Zittel

Suborder **Holochoanites** Hyatt

Family **ENDOCERATIDAE** Hyatt

Genus **CAMEROCERAS** Conrad (emend. Hyatt)

Cameroceras cf. **styliforme** Grabau

Plate I., Figs. 1-3

1922. *Cameroceras styliforme* Grabau: Ordovician Fossils from North China, p. 39, pl. IV, figs. 4-6.

There are a number of black, slender and cylindrical structures adhering to the weathered surfaces of dark gray limestone fragments, collected from western Hupeh by Mr. Hsieh. The exterior of the material has been so deeply eroded that one cannot distinguish in the field what types are represented. After separating it from the rock and slicing it into sections it becomes apparent that we are dealing with the endoconch of *Cameroceras*, or of *Proterocameroceras*. These structures are represented only by fragments. One of them (Plate I., Fig. 2) measures about 40 mm. in length. Its cross section is slightly oval, being 11.5 mm. in transverse, and 10 mm. in dorso-ventral diameter at the upper end. The ventral side is slightly flattened. The endoconch is provided with an endotheca, which has been partly preserved through protection from weathering by the country rock. The endotheca is rather thin, and its surface is clearly marked by the ectoseptal edges, which are oblique to the ventral side forming with it an angle of about 60°. Owing to the fact that the specimen is much eroded, the character of the ectoseptal annulations on the ventral side is entirely unknown, therefore the position of the endoconch is rather uncertain. The ectoseptal distances, as shown by these edges on the lateral side, are very uniform, reaching 2 mm. more or less. In the interior of the endoconch there are some endosepta. The spaces between them are wholly filled with the white crystalline deposit, but the endocone is empty, and assumes a semi-lunar section with a flat base, corresponding to the ventral side of the endoconch. In another specimen (Plate I., Fig. 3) the apical angle of the endosepta shown in the longitudinal section is about 25°. Endosiphuncle not observed.

REMARKS: The apical portion of the endoconch has not been preserved in the specimen now at hand, so its generic identification (either as *Cameroceras* or *Protero-cameroceras*) is not quite certain. According to its shorter length and other respects it may be compared with Grabau's species[1] collected from the Liangchiashan limestone of Liang-chia-shan near Ching-wang-tao, eastern Chihli.

HORIZON AND LOCALITY: From the upper part of Ichang limestone at Lo-jo-ping of I-chang-hsien (Coll. C. Y.Hsieh)

Cameroceras tenuiseptum Hall var. **ellipticum** Yü (var. nov.)

Plate II., Figs. 1 and 2.

1847. *Orthoceras tenuiseptum*, Hall. Palaeontology of New York, Vol. 1, p. 35, pl. VII, fig. 6.
1902. *Orthoceras tenuiseptum*, Raymond. Am. Pal. Bul. Vol. I, No. 14, p. 19.
1906. *Cameroceras tenuiseptum*, Ruedemann: New York State Museum. Bul. 90, p. 408, pl. 3, figs. 1,2; pl. 4, fig. 1; pl. 5, figs. 5, 6; pl. 6, fig. 2.

This form is only represented by fragments of the internal mold. Neither the apical end nor the larger extremity is preserved. It had suffered so deeply from weathering that the outer layer of the mold has turned into a very soft yellowish substance. The ectoconch is robust and cylindrical in form. It is elliptical in cross section, the ratio between the two diameters being 4:3. It tapers gently at the rate of nearly 1:13.

The ectoseptal distances are very closely arranged, varying from 4-5 mm., while the longer diameter of the ectoconch measures 43-50 mm. Roughly speaking the ectosepta are distant about one tenth the longer diameter. The depth of the ectosepta is very high, equalling that of three cameræ. The ectosepal sutures are slightly undulating. The ectoseptal chambers are more or less free from the organic deposit except a few of them, in which the stereoplasmic deposit extends from the margin of the shell toward the interior and stops at some distance from the endoconch.

The endoconch is situated in close juxtaposition to the outer shell. Its cross section too is elliptical. The endosepta have not been observed. The empty endocy-

---

1. loc. cit.

linder is very large and its major diameter is practically equivalent to 1/2 that of the ectoconch. In a favourable light the endotheca may be clearly seen along the inner side of the invaginated tubi.

COMPARISON: So far as we know, the form, which bears the closest resemblance to this specimen, is *Cameroceras tenuiseptum* Hall. The transverse sections of the ectoconch and the endoconch of Hall's species are circular, but those of the present form are both elliptical. Moreover, the ectosepta of the latter are comparatively more widely separated than are those of the former.

HORIZON AND LOCALITY: This variety was obtained by J. L. Smith and C. Y. Hsieh respectively from the upper part of Neichiashan formation at Nei-chia-shan near Sin-tan, Tze-kuei-hsien.

Cameroceras hsiehi Yü (sp. nov.)

Plate I., Figs. 4a-b.

Shell straight, slender, gradually tapering at the rate of 1 in 10. The cross section of the ectoconch is elliptical, having its two diameters at the ratio of 11:9. Neither extremity preserved. The septate fragment measures little less than 80 mm. in length.

The interspaces between the ectosepta are rather short, being about from 1/6 to 1/5 the longer diameter of the ectoconch. They are 3.5 mm. distant from each other in the lower preserved end and 6 mm. in the upper, while the corresponding longer diameters of the ectoconch are 22 mm. and 30 mm. respectively. The ectosepta are very deep, with a concavity equal to the depth of one and one half cameræ. The tubi have a length of more than one camera.

The endoconch is large, about one third the longer diameter. Under the magnifier we can clearly see that along the inner sides of the tubi the endotheca characteristic of the genus *Cameroceras* is present. The endoconch is perfectly circular in outline. Its position is in contact with the ectoconch. Only the last endoseptum is exposed, and the space below it is wholly filled with calcite. The sides of the endocone seem to be undulating.

In the empty cameræ there is a slight and irregular organic lime-filling deposited along the margins of some ectosepta. Test not preserved.

COMPARISON: This species agrees in some repects with *Cameroceras brainerdi* Whitfield[1] from the Fort Cassin beds along the shore of Lake Champlain, but our shell has an endoconch of circular section and the rate of tapering is much more rapid. Another one nearer to this is *Cameroceras tenuiseptum* Hall[2], but the present form differs from it in having an elliptical shell section, a smaller endoconch and the relatively more separated ectoseptal distances. From the preceding variety of that species the present shell differs in having the circular and smaller endoconch.

HORIZON AND LOCALITY: Only one specimen was obtained from the upper Neichiashan formation near Sin-tan by Mr. Hsieh, in whose honour the specific name is given.

Cameroceras subtile Yü (sp. nov.)

Plate I., Figs. 5 a-b.

This species is known only from a fragmentary phragmacone, which is straight and cylindrical in external form. Both the cross sections of the ectoconch and the endoconch are elliptical. The two diameters of the ectoconch have the proportion of 3:2. This fragment reaches a length of a little less than 60 mm. The rate of growth may be computed as 1:10 approximately.

The ectosepta are distant almost uniformly, being about 5 mm., while the ectoconch measures 28 mm. in longer diameter at the lower preserved end and 31 mm. at the upper. The ectoseptal sutures are flexuous with a strong concavity exceeding the depth of one camera. The latter are filled with yellowish red matrix. The ectosepta are lined by a thin layer of the organic stereoplasm about one half millimeter in thickness. The tubi are visible, extending a short distance beyond the preceding septum.

The endoconch is provided with an endotheca, which is clearly shown even to the naked eye. It attains a maximum width of about 1/3 that of the outer shell. It is subcentral in position but does not contain the endosepta in this fragment. The ectotheca has been completely weathered away and the surface of the internal mold only shows the undulating ectoseptal edges.

---

1. Ruedemann: Cephalopoda of the Beekmantown and Chazy formation of the Champlain Basin, p. 405, pl. 1, figs. 5, 6, pl. II, fig. 1.

2. loc. cit.

COMPARISON: This species somewhat approaches to *Cameroceras brainerdi* Whitfield[1] in some respects, but the former has the tapering more rapid and the endoconch not marginal as in the latter form. It may also be compared with *Cameroceras hsiehi*, but differs from it in having the subcentral and elliptical endoconch.

HORIZON AND LOCALITY: This form was obtained from the same horizon as the preceding species near Sin-tan. (C. Y. Hsieh Coll.)

Cameroceras sp.

Plate II., Fig. 3.

This form is too fragmentary for specific determination. The septal portion preserved only contains four cameræ, and has a length of 45 mm. Owing to the fact that the specimen is much eroded, the cross section of the ectoconch and the rate of tapering can not be determined.

Ectosepta gently concave, having a depth of nearly 2/3 that of the camera. The ectoseptal interspaces increase very slightly in distance, being nearly equal to 2/5 the diameter of the outer shell. The septate chambers are wholly empty. The organic stereoplasmic deposit occurs only along the interior sides of some cameræ.

The endoconch is marginal. Since it has also been greatly rubbed, neither the transverse section nor the size of the inner shell may be determined with any certainty. Nevertheless, from what remains we can tell that it is confined externally by the presence of an endotheca and filled internally with the calcite deposit. The tubi extend apically in an irregular manner and the endotheca also assumes the wavy appearance, following the direction of the tubi.

Undoubtedly the present specimen belongs to the genus *Cameroceras* in having the characteristic endotheca. But its other important properties are too little known, hence its specific determination is impossible

HORIZON AND LOCALITY: Upper part of Neichiashan formation near Sin-tan.

---

1. Ruedemann: Cephalopoda of the Beekmantown and Chazy Formations of the Champlain Basin. p. 405, pl. I, figs. 5,6; pl. 2, fig. 1.

Genus **ENDOCERAS** Hall

Endoceras leei Yü (sp. nov.)

Plate I., Figs. 6, 7a-b.

Ectoconch straight, cylindrical. Form of cross section unknown. Endoconch elliptical, of considerable size and filled with conical endosepta. Ectosepta crowded. Tapering of ectoconch very gentle. Endotheca absent.

This specimen is represented only by a portion of the ectoconch exposed on the surface of a polished slab. Its actual length is unknown. The width at the lower end of the preserved fragmentary part is 30.5 mm. At a point about 81 mm. from the lower end it has a breadth of 36.5 mm. This gives the rate of tapering about 1 mm. in a length of 13.5 mm.

The ectosepta are very numerous and strongly concave, with a concavity about one and a half times their distance apart at the center. The interspaces between them are nearly equal, averaging about 6.5 mm. apart. The ectosepta are provided with long tubi, which distinctly show that they extend from the ectoseptum where they originate to a distance of one camera toward the apex.

The endoconch is situated excentrically. Its size is remarkably large, having a maximum width of $^2/_3$ that of the ectoconch or more. The interior of the endoconch is occupied by endosepta tapering off at the center into a narrow endosiphuncle. From the cross section at the lower preserved end we find that the endosiphuncle is oval in outline, measuring 0.7 mm. and 0.9 mm. in the shorter and the longer diameter respectively. At the same stage the corresponding longer diameter of the endoconch is 14 mm. The endoconch bounded by the last endoseptum has a subtriangular section with an apical angle of 20°.

Both the cameræ of the ectoconch and the endoconch are filled with the red lime matrix, in which the shell of this specimen is embedded. Many of the ectosepta, however, show a slight stereoplasmic thickening on their upper, and more rarely on their under side as well.

There is another specimen (Plate I., Fig. 7.) probably of the same species. The endoconch attains a length of nearly 160 mm. The space below the final endoseptum of the endoconch has been wholly converted into the crystalline deposit, but the terminal endocone is empty. The ectoconch is partly crushed, preserving however ectosepta around the upper part of the endoconch. At the lower extremity a very small section of the endosiphuncle may be seen in the central part of the endoconch, being about 0.3 mm. in diameter and filled up with the red lime matrix. In the same place the endoconch is sub-elliptical in section, measuring 9 mm. in its major diameter, and 7 mm. in minor. The apical angle of the final endoseptum is nearly the same as that in the preceding specimen. The cameræ of the ectoconch are entirely free from any deposit except the ectosepta, which are also slightly thickened as in the preceding specimen.

COMPARISON: This species bears a close resemblance to *Endoceras* (*Cyclendoceras*) *annulatum* Hall[1] from the Trenton limestone at Watertown New York. But Hall's form has the ectosepta more approximate as compared with the diameter of its ectoconch. Moreover, the annulated ectotheca is not recognized with certainty in the present species, though there seems to be an indication of it in the undulating profile along the sides of the ectoconch in the polished longitudinal section.

HORIZON AND LOCALITIES: One specimen (Plate I., Fig. 6.) was collected from the red thin-bedded limestone of the upper division of Middle Ordovician age at San-shan-yuan (三山原) and the other (Plate I., Fig. 7.) from the same horizon at He-chiao (黑橋), Chung-yang-hsien. The specific name is given in honor of Professor J. S. Lee. (Coll. C. Li and W. P. Shu)

Endoceras grabaui Yü (sp. nov.)

Plate II., Fig. 4.

General form cylindrico-conical, more or less elongate, slightly arcuate, gradually diminishing toward the apex, and elliptical in cross section; endoconch very broad, enclosed by the continuous tubi, not forming a straight tube but giving the sides of the endoconch the appearance of an irregular undulation.

The ectoseptal intervals are slightly variable in their distance apart from one another, ranging from 9 to 11 mm. throughout the whole length of the fragment. The ectosepta are thin and very deeply concave, having a convexity of more than one septal distance. The ectoseptal tubi are continuous, but extend across the different ectoseptal spaces in different ways. Thus some of them are bent inwards; some nearly straight and slightly oblique toward the interior; and finally some tubi turn inwards at first and gradually backward as well as outwards.

---

1. J. Hall: Palæontology of New York, Vol. I, p. 207, pl. XLIV, figs. 1 a,b.

The endoconch is elliptical in transverse section, occupying the central position of the ectoconch in the preserved part of the specimen. It is readily seen that the interior of the endoconch is occupied by an endoseptum in the upper part of the preserved fragment and another one at the lower. The apical angle formed by these conical endosepta are nearly the same, or about 10°. The wall formed by the continuous tubi appears to have a zigzag outline in section and the width of the endoconch, as exposed in the longitudinal section, varies from 7 mm. to 15 mm. narrowing in one place and broadening in another.

Neither the larger nor the smaller extremity has been observed. The fragment measures more than one hundred and thirty millimeters in length. The longer diameter at the upper end of the shell is 45 mm., gradually contracting toward the smaller end which is 25 mm. in diameter. This gives the rate of tapering 1 in 6.5.

Ectotheca thin, but its surface characters unknown. No trace of any deposit is found within the ectoconch or the endoconch.

COMPARISON: This species is somewhat allied to *Endoceras magniven'rum* Hall [1] from the higher part of the Trenton limestone of New York State in the characters of the close, strongly concave ectosepta and the undulating wall of siphonal tubi, but differs from the latter in the slightly curved ectoconch, much narrower endoconch, and more rapid tapering of the outer shell. The same characters are also used for distinguishing it from the preceding species.

HORIZON AND LOCALITY: From the argillaceous limestone bed of the Neichia-shan formation at the small hill named Shih-lung-sze (石龍寺) about 10 li to the west of Wang-chia-chi (王家集), I-cheng-hsien. This species is named in honour of Professor A. W. Grabau, Chief Palæontologist to the Geological Survey. (Coll. W. P. Shu and C. C. Yü)

Genus **VAGINOCERAS** Hyatt

Vaginoceras (Endoceras) wahlenbergi Foord.

Plate III., Figs. 1a—b.

1888. *Endoceras Wahlanbergi*, Foord: Catalogue of Fossil Cephalopoda, part I, p. 136, Text figs. 11, 13, 14.

1895. *Endoceras Wahlenbergi*, Holm: Geol. Foren. Förh. i Stockholm, Bd. 17, Heft 6.

1917. *Endoceras Wahlenbergi*, Reed: Palæontologia Indica, New Series, Vol. VI, Mem. No. 3, p. 30, pl. V, fig. 11.

---

1. J. Hall: Palæontology of New, York, Vo.l I, p. 218, pl. LIII, figs. 1 a-e.

Shell large, somewhat slowly enlarging, with a large endoconch inside. It attains a size of 305 mm. preserving a part of the living chamber. Apical extremity unknown. Transverse section circular. Its rate of growth is computed about 1 in 11.5. Character of surface not observed.

The ectosepta are gently concave, their convexity being about two thirds the depth of the camera of the ectoconch or a little more. The distance between the ectosepta varies in an irregular manner. It measures 11 mm. at a point about 90 mm. from the apex, where the diameter of the ectoconch is 31 mm; and 16 mm., where the diameter is 40 mm. When the ectoconch increases its diameter to 50 mm., the ectoseptal distance is suddenly reduced to 13 mm. Nevertheless, the ectoseptal distances continue on the whole to increase upwards until close to the living chamber, where it retains the distance characteristic of the earlier stage (Five cameræ are contained in the space of 65 mm. including the last camera).

The endoconch is very large, marginal and circular in cross section. It is continucd upwards in a large endocylinder, which is empty and has a diameter of 12 mm, where the ectoconch measures 33 mm. in diameter, this being about one third that of the ectoconch. The organic stereoplasmic lining is clearly seen along the margins of the ectosepta. The cameræ are partly filled up with the crystalline deposit, but the upper-most ones close to the living chamber are entirely empty. Near the apical portion of the preserved part of the shell the final conical endoseptum (endocone) is shown. It has an apical angle of 10°. The rest of the endoconch has been converted into crystalline calcite with much mixing of black material. The invaginated tubi bend inwards, and then slightly outwards. When they reach the geniculations of the preceding ectosepta, they turn again inwards and backward.

Comparison: Hyatt proposed the generic name *Vaginoceras* for the form which differs from *Endoceras* proper in having the longer invaginated tubi and more numerous endosepta[1] From the text figure of *Endoceras wahlenbergi* Foord[2] we find

1. G. T. Troedsson considered, after the suggestion made by Foerste, the number of endosepta as the only distinguishing character between the *Endoceras* and *Vaginoceras*. (See Troedsson: On the Middle and Upper Ordovician Faunas of northern Greenland, p. 24). Of course, the length of the tubi can not be correlated with the number of the endosepta as Hyatt assumed. But in this paper the length of the tubi is taken as the distinguishing feature rather than the number of the endosepta. The reasons are: (1) The number of endosepta is sometimes unreliable, for they may not be wholly preserved. (2) The spaces between the endosepta are often completely filled with the crystalline calcite and the endosepta are not distinctly enough shown to determine their number. (3) In many forms the endoconch as well as endosepta, limited to the apical portion of the ectoconch, are often not preserved; and the empty, long endocylinder only remains. So far the length of the tubi is always clearly exposed, no matter whether the specimen is well preserved or very framentary. Therefore, the length of the tubi is chosen here as the important factor for distinguishing these two genera.

2. loc. cit.

that the long tubi extend beyond the space of one camera. According to the statement of Hyatt the generic name of Foord's species should be changed into *Vaginoceras*. As to the specific identification, the characteristics of our specimen strongly resemble Foord's species, but the ectosepta become more crowded in the adult stage, which is not the case in Foord's form. Nevertheless, this feature may be considered as a minor point due to senility, and can not serve to characterize a distinct species.

Horizon and Locality: Collected from the upper part of Neichiashan formation at the northern side of Tai-hung-shan (太 紅 山) about one mile or more to the west of the city of Nan-chang-hsien. According to Foord's description *Vaginoceras wahlenbergi* belongs to Arenig in Sweden, Norway, Russia and other localities in Europe, but this is incorrect, the horizon being late Middle Ordovician[1]. (W. P. Shu and C. C. Yü Coll.)

Vaginoceras wahlenbergi Foord var. **cylindrica** Yü (var. nov.)

Plate IV., Figs. 1, 2a-b.

Ectoconch robust, cylindrical. Endoconch large, situated nearly close to the margin of the outer shell. This variety is represented so far only by a fragment belonging to the upper part. The cross section of the endoconch is circular, but that of the ectoconch is quite obscure, though it is probably circular too. Rate of increase about 1 in 12. 6.

Ectosepta moderately concave with their depth scarcely exceeding two thirds of the camera. The ectoseptal intervals become gradually and slightly longer in distance apart as the ectoconch advances in age, measuring 15 mm. apart near the lower end and 17 mm. near the upper, or about two fifth the diameter of the outer shell.

The endoconch is prolonged into a nearly cylindrical endocylinder. Its diameter is a little less than one third as wide as that of the ectoconch. In the actual measurement the diameter of the ectoconch attains 40 mm. at the lower end, whereas the corresponding diameter of the endoconch is 12.5. The invaginated tubi are distinctly visible. No endoseptum has been found, the endoconch proper not being preserved. Stereoplasmic deposit often occurs on the margins of the ectosepta, this being about 1 mm. thick.

---

1. See stratigraphic part, pp. 20, 21.

Another individual (Plate IV., Fig. 2) is also known from a fragment of more than one hundred and thirty millimeters in length. The cameræ of the ectoconch increase their depth forward at a regular rate, ranging from 9 to 13 mm., where the corresponding diameter of the ectoconch is from 27-35 mm. Endocylinder circular, marginal, large, being about 2/7 the diameter of the ectoconch. Concavity of ectosepta about 2/3 the camera. The outer shell tapers at the rate of 1 in 12.5. The organic stereoplasm deposit is seen on the under side of the ectosepta more commonly than on the upper.

COMPARISON: This form is closely related to *Vaginoceras wahlenbergi* Foord, from which it may be slightly distinguished by the more regular increase of the ectoseptal distance and the smaller size of the endoconch and endocylinder. According to the diagnosis given by Foord, *Vaginoceras wahlenbergi* has a much larger endoconch, measuring "nearly half the diameter in the young shell" and "about one third the diameter" in the adult. Nevertheless, the other important characters of our shell are very similar to those of Foord's species, it is, therefore, preferable to refer it to a variety of *Vaginoceras wahlenbergi*.

HORIZON AND LOCALITIES: One specimen (Plate IV., Fig. 2) was found just below the thin-bedded red limestone in the vicinity of Liu-chia-sze south of Cha-ti-pu, Hsien-ning-hsien, and another specimen (Plate IV., Fig. 1.) was from the same formation near He-chiao, Chung-yang-hsien. (C. Li and W. P. Shu Coll.)

Vaginoceras endocylindricum Yü (sp. nov.)

Plate II., Figs. 5a-c; Plate III., Figs. 2a-d, 3a-b.

This specimen (Pl. III., Figs. 2a-d) is known by a large orthocone which attains a length of 280 mm. with a slender obtuse termination at the apical end. The section of the ectoconch is circular. Its diameter measures 42.5 mm. at the larger end, and 145 mm. at the smaller. It tapers at the rate of 1:9.8. Owing to the imperfection of the upper end of the specimen the original size of the living chamber has not been fully determined. Nevertheless, the length of its remaining part is more than twice the diameter of its base.

The ectosepta are rather closely set. Their convexity attains nearly the depth of one camera. The ectosepta are 5 mm. apart near the apical end and increase regularly slightly forward. There are three cameræ in the space of 20 mm. in the mature part of the phragmacone, where the ectoconch has a diameter of about 23 mm. Near the living chamber, the ectoseptal interspace is 9 mm. at the diameter of 35 mm.

The endoconch is not very large and situated in close juxtaposition to the flat ventral side of the outer shell. It is circular in cross section, its diameter being 6 mm. where the diameter of the ectoconch is about 26 mm. The continuation of the tubi is beyond the next preceding ectoseptum. The endosepta are confined to the apical end with a very small endosiphuncle exposed in the middle part of the endoconch. The endocylinder and endocone are empty, but all the cameræ are completely occupied by the crystalline calcite of secondary origin interspersed with some black material.

Another piece (Pl. III., Fig. 3) probably of the same species represents a fragment of the posterior part. Cross section circular Ectosepta crowded. At the smaller fragmentary end the ectotheca and ectosepta are detached and only the endoconch projects out. Ectosepta moderately concave. Ectoseptal distance about 4.5 mm. at the diameter of 18 mm. As the longitudinal section is normal to the dorso-ventral diameter, the endoconch at first sight seems to occupy a central position in the ectoconch, but in reality it is probably marginal to the outer shell. The ectoconch has a diameter of 16 mm. at the lower end, where the corresponding diameter of the endoconch is 4.5 mm. The endoconch and endocylinder are not preserved in the upper portion of the specimen because of the direction of the section.

There is a third specimen (Pl. II., Fig. 5.) which was procured from the Tafang limestone at Yang-sing-hsien. The apical portion is not preserved. The ectoseptal distances are less than 1/3 the diameter of the outer shell. The endoconch is circular, marginal and equal to 1/4 the diameter of the ectoconch. This specimen is similar to the preceding ones in all respects except the rate of tapering, which appears to be more rapid, measuring 1 in 16. The test is partly preserved. It conists of two layers. The interior layer is much thinner and covered by the very fine transverse striæ. The outer one is quite obscure, though it is probably smooth.

Comparison: This species is characterized by its fairly closely set ectosepta, relatively smaller endoconch and long empty endocylinder with the endosepta limited to the apical portion. It agrees in some aspects with *Vaginoceras wahlenbergi* Foord,[1] but is distinguished from the latter by its smaller endoconch and more approximate ectoseptal distance. From the description of *Endoceras reinhardi*? Boll[2] including *Orthoceras commune* Angelin-Lindström and some others, we find that the present species may be compared with Boll's form, but differs in having the shorter interspaces between the ectosepta, which are nearly half the diameter of the outer shell in Boll's species. Moreover, our shell has shown the considerably long tubi indicating a *Vaginoceras*, but those in Boll's form have not been characterized in the description.

1. loc. cit.
2. Foord: Catalogue of Fossil Cephalopoda, Pt. I, p. 145.

HORIZON AND LOCALITIES: The first two specimens (Pl. III,, Figs. 2 and 3) were collected by C. Li and W. P. Shu from the beds just below the red limestone near Ta-wu-shu, north of the western end of Pei-yang-shan (白羊山), Chung-yang-hsien. The last one (Pl. II., Fig. 5) was collected by Mr. C. Y. Hsieh from the uppermost purple calcarcous shale of the Tafang limestone at Ta-fang village in the Yang-sing-district.

Vaginoceras peiyangense Yü (sp. nov.)

Plate V., Figs. 1a-b, 2a-b.

This orthocone is fairly slender, elongate, reaching a length of 425 mm. The ectoconch terminates in an extremely acute point. It enlarges in diameter very slowly in the young part, but rapidly toward the apertural portion. The diameter of the ectoconch increases from 15 mm. at the lower part to 30 mm. at the upper, the distance being 289 mm. This gives a rate of expansion of 1 mm. in 19 mm. The remaining part of the living chamber is rather long, having a length of 60 mm. and a diameter of about 30 mm. at its base. Aperture not observed. The section of the outer shell is ovately elliptical with a moderately large endoconch close to the margin of the shell.

The ectosepta are very thin and gently concave. Their depth is about one half that of a camera. The ectoseptal interspaces or cameræ regularly increase in height toward the aperture, there being three cameræ in the space of 20 mm. at the apical portion and one camera or a little more in the same space at the stage next to the body chamber.

The endoconch is tubular, moderately large with an oval section. It measures 6 mm. in major diameter and 4.5 mm. in minor. In the same stage the transverse diameter of the ectoconch is 26 mm. It lies rather close to the outer shell, if it is not absolutely in contact with the latter. It is comparatively flatter on the ventral side. At a point 150 mm. from the apex, we find in section that the subtriangular endocone exists within the endoconch having an apical angle of nearly 17°. The endoconch of the earlier stage is solidly filled with the calcite deposit, leaving the endosiphotube open in the middle. Its diameter is more than 0.1 mm. and is plainly visible even to the naked eye. The endoconch is provided with the tubi, which continue apicad beyond the next preceding ectoseptum for a short distance further.

In another specimen (Pl. V., Fig. 2) the cameræ of the ectoconch are relatively shallower. The ectosepta regularly and slowly increase their distance upwards, varying from 5 mm. to 7 mm., where the corresponding width of the ectoconch is from 13-18 mm.

The endoconch is of large size, ovately elliptical in section, and nearly marginal to the outer shell (being 0.7 mm. distant from the ventral side). It measures 8 mm. in the longer diameter and 6 mm. in the shorter at the upper end of the fragment, where the actual diameter of the ectoconch can not be determined, but the ectoseptal distance is about 7 mm. This fragment is 123 mm. in length. At the lower part of the specimen, the ectotheca as well as the ectosepta have been crushed, and the endoconch remains protruding with some invaginated tubi preserved on its sides. Rate of increase 1:17.

In both of the specimens the cameræ are lined with the organic stereoplasm in moderate thickness, but some are perfectly empty. Test unknown.

COMPARISON: In its general form, this species may be compared with *Endoceras distans* Hall[1]. But our shell has a much smaller endoconch and an ovately elliptical section of the ectoconch, which is quite different from that of Hall's species. It is also distinguished from *Vaginoceras wahlenbergi* and *Vaginoceras endocylindricum* by its more distant ectosepta, ovately elliptical section of endoconch and less rapid tapering of the ectoconch.

HORIZON AND LOCALITIES: One specimen (Pl. V., Fig. 1) was obtained from the bed just above the massive blue limestone at the western end of Pei-yang-shan, and the other (Pl. V., Fig. 2) from the same horizon at He-chiao, Chung-yang-hsien. (Coll. C. Li and W. P. Shu.)

Vaginoceras (Endoceras) belemnitiforme Holm

Plate I., Fig. 8

1885. *Endoceras belemnitiforme* Holm: Palæontologische Abhandlungen, Bd. III, Heft I, p. 5, Taf. I, figs. 1-5.

Shell cylindrical, straight, embedded in the upper red Tafang limestone and without any trace of the test remaining. It tapers at the rate of about 1 in 10. The apical portion has not been observed, and the larger extremity is also incomplete. The ectoconch is subcircular (probably by compression) in transverse section with an endoconch lying at its margin.

The ectosepta are widely separated from each other, the distance equalling nearly half the diameter of the outer shell. In actual measurement it reaches 12 mm. at the diameter of 24 mm. When the ectoconch enlarges to 26 mm. in diameter, it is reduced to 10 mm. After that it assumes the original length again. Though the distances between septa vary slightly, on the whole they are fairly constant

---

1. Hall: Palæontology of New York, Vol. I, p. 220, pl. LVIII, figs. 1 a,b.

The interior of the cameræ are deprived of any deposit except the margins of the ectosepta, on which the stereoplasm is slightly and irregularly deposited. Ectosepta very thin, having a concavity a little less than one camera.

The endoconch is in contact with the outer shell. It is cylindrical in longitudinal section and circular in transverse. It appears to remain about 10 mm. in diameter throughout the whole length of the fragment preserved, so that it occupies nearly 1/2 the diameter of the ectoconch at the lower fragmentary end and 2/5 at the upper. No endosepta are seen. The endotheca is absent and the inner shell is confined by the continuation of the imbricating tubi, which in this specimen seem not so long as those in the form figured by Holm.

Remarks. This species is characterized by its remote and almost equal ectoseptal distances, and cylindrical and large endoconch. Even though we know nothing about the apical end of our shell, no form comes nearest to the present specimen other than *Vaginoceras belemniforme* Holm from the upper red Orthoceras Limestone on the island of Oeland.

Horizon and Locality: From the red limestone bed of middle Ordovician age in the upper part of the Tafang limestone near Ta-fang village, Yang-sing-hsien. The specimen was collected by Mr. C. Y. Hsieh.

Vaginoceras shui Yü (sp. nov.)

Plate IV., Figs. 3a-b.

Ectoconch of unknown size, slender, subcylindrico-conical. Cross section circular. Endoconch moderately large, submarginal. Both the apical end and the basal extremity unknown.

Ectosepta remarkably gently concave, about one third as deep as the cameræ. The ectoseptal distances slightly increase from 6 mm. at the lower preserved end to 8 mm. at the upper, while the corresponding width of the ectoconch are 14 mm. and 19 mm. respectively (The real diameter of the ectoconch would be greater than this, because the section is not in the median plane).

The endoconch is circular? and situated near the margin of the ectoconch. Its diameter is little less than one third that of the outer shell. It is completely surrounded by cameræ and distinctly marked by the tubi By the aid of a lens we can see the tubi are so long that they overlap backward beyond the preceding ectoseptum extending even to the third one. Inside the endoconch a concial funnel-shaped endoseptum is included with the deposit of crystalline lime below.

The diameter of the ectoconch measures 13 mm. at the smaller extremity of the fragment and 22 mm. at the larger. The distance between them is 108 mm. It tapers at the rate of about 1 in 12.

COMPARISON: This species appears to be related to *Vaginoceras belemnitiformis* Holm[1] in the extremely long tubi, but the former differs from the latter in having the comparatively narrower endoconch and shorter ectoseptal distance. Moreover, the ectosepta of our specimen become increasingly distant with the growth of the ectoconch, which is not the case in Holm's form. It is also distinguished from any of the foregoing species by its strikingly long tubi.

HORIZON AND LOCALITY: In the bed above, but not far from, the thick-bedded blue limestone near Wang-chia-sze, Chung-yang-hsien. The specific name is given in honour of Mr. Shu, by whom this species was collected.

Vaginoceras chientzekouense Yü (sp. nov.)

Plate V., Fig. 3.

Ectoconch straight, cylindrical, rather slowly enlarging at the rate of 1:12. Transverse section elliptical? Endoconch not very large, lying in contact with the outer shell.

This fragment reaches a length of more than 74 mm. Ectosepta moderately concave, having a depth of more than one half of a camera. The ectoseptal interspaces increase regularly and very slowly in length as they approach the basal extremity, ranging from 12 to 16 mm., where the corresponding diameters of the ectoconch are 32 and 38 mm. respectively.

The endocylinder only is shown. It is elliptical in section. From the longitudinal section we may see that the interior of the endocylinder does not reveal anything but the black lime matrix. The tubi are not well preserved, but from a few that remain it seems that the succeeding tubus is inserted into the next preceding one. The diameters of the endocylinder have a ratio of 8:5. Its longer diameter is nearly 1/4 that of the ectoconch. None of the organic stereoplasm exists in the cameræ except the deposit of secondary origin.

---

1. G. Holm: Palæontologische Abhandlungen, Bd. III, Heft 1, p. 5, Taf. I, figs. 1-5.

COMPARISON: At the first glance this species appears to show no difference from *Vaginoceras wahlenbergi* Foord var. *cylindrica*, but on careful examination its elliptical section and narrower size of the endocylinder as well as the absence of stereoplamic deposit on the ectosepta give it a distinctive appearance.

HORIZON AND LOCALITY: From the argillaceous limestone of Neichiashan formation at Chien-tze-kou (剪子溝), Nan-chang-hsien. (Coll. W. P. Shu and C. C. Yü.)

Vaginoceras neichianense Yü (sp. nov.)

Plate I., Figs. 9a-b; Plate II., Figs. 6a-b, 7a-b.

General form subcylindrical, cross section elliptical, ectosepta crowded, endoconch large, subcentral and circular in section.

This is a fragmentary specimen preserving the septate portion. It is about 100 mm. in length. No external character is perceptible except the regular, transverse ectoseptal edges exposed on the eroded surface of the cast. Rate of increase 1 in 8.5 approximately. The two diameters of the extoconch are roughly at the proportion of 4:3.

The ectosepta are closely set. The interspace between them slightly increases upward, being equivalent to 1/5 the longer diameter of the ectoconch at the lower part of the fragment and 1/6 at the upper. The concavity of the ectosepta is a little more than the distance of one camera at its center.

The endoconch is rather large, its diameter being nearly equal to 2/5 the longer diameter of the ectoconch. It is situated a short distance from the center of the conch. The continuous tubi extend apically to the point about one fourth the depth of the next preceding camera, or a little more. The ectosepta are gently bent backward before reaching the endoconch. The interior of the endoconch below the last endoseptum has been changed into a white crystalline deposit. The endocone shows a slightly elliptical outline in transverse section. Some cameræ are filled with the calcite deposit, and some ectosepta are also thickened by the stereoplasm to a very small amount.

There are numerous specimens belonging to the same species, though they are slightly different from one another. One specimen (Pl. II., Fig. 6) collected from Chung-yang-hsien reaches a length of about 31 mm. It consists of four cameræ embedded in the red limestone. It tapers more rapidly, about 1:6. The endoconch is relatively narrower, attaining a size of 1/3 the longer diameter of the ectoconch. Ectosepta distant about $^1/_4$ the major diameter.

Another one (Pl. II., Fig. 7) expands its shell more slowly, the rate being 1:10. The empty endocylinder is only preserved, indicating this fragment nearer the apertural end. Seven cameræ are present. The ectosepta are slightly lined by the stereoplasm. The size of the endocylinder and the ectoseptal intervals are similar to those in the preceding specimen (Pl. I., Fig. 9).

COMPARISON: In some respects this species is quite close to the *Endoceras proteiforme* Hall [1] from the Trenton formation of New York State, but our shell shows the invaginated tubi, which is not a character given in the description by Hall. According to Clarke's statment the tubi of *Endoceras proteiforme* are short. Foerste says: "Apparently they are only a single camera in length". But its diagrammatic sections figured by Hyatt[2] and Troedsson[3] indicate that the tubi are longer than the length of a camera. Even though the latter is the case in Hall's type, the present species may be distinguished from it in having the ectoconch elliptical and the endoconch subcentral and circular. In *Endoceras proteiforme* the ectoconch is circular and the endoconch is marginal and elliptical[4]. It also differs from *Vaginoceras vaginatum* Schlotheim [5] in having the more widely separated ectoseptal interspaces, smaller and subcentral endoconch; and from *Orthoceras* (*Endoceras*) *brongniarti* Troost [6] in having the ectoconch less elliptical, the endoconch comparatively larger, and the ectoseptal distance somewhat longer.

HORIZON AND LOCALITIES: One specimen (Pl. II., Fig. 6) was collected by C. Li and W. P. Shu from the reddish limestone of the Middle Ordovician age at San-shanyuan, Chung-yang-hsien. The rest came from the upper part of the Neichiashan formation near Sin-tan, western Hupeh. (Collected by J. L. Smith and C. Y. Hsieh respectively)

Vaginoceras reedi Yü (sp. nov.)

Plate I., Figs 10 a-c, 11 a-b.

1017. *Cameroceras?* sp. Reed: Ordovician and Silurian fossils from Yunnan. p. 35, pl. VI, figs. 1, la.
1920. *Orthoceras?* sp. Yabe and Hayasaka: Palæontology of Southern China, p. 49, pl, XVIII, figs. 3; pl. XXVII, figs. 2 a-e.

---

1. J. Hall: Palæontology of New York, Vol. I, p. 208, pl. XLVIII, pl. XLIX, pl. L, pl. LIII, figs. 2, pl. LVII.
2. Zittel-Eastman: Text Book of Palæontology, p. 595, fig. 1105.
3. G. T. Troedsson: On the Middle and Upper Ordovician Faunas of Northern Greenland, I. Cephalopods. p. 27, pl. 8, fig. 4.
4. G. T. Troedsson: On the Middle and Upper Ordovician Faunas of Northern Greenland. I. Cephalopods. p. 27, pl. 7, figs. 1, 2.
5. Foord: Catalogues of Fossil Cephalopoda, Part I, p. 140.
6. Blake: British Fossil Cephalopoda. Part I, p. 162, pl XVII, figs. 1, la.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1. *Vaginoceras reedi.* External view of a fragment of the ectoconch with a part of the endoconch exposed. Natural size.

Fig. 2. *Vaginoceras reedi.* Longitudinal section of the same, showing the large, empty endoconch and the closely set ectosepta. Natural size.

Fig. 3. *Vaginoceras reedi.* End view of the same. Natural size.

Associated with *Vaginoceras neichianense,* there are many specimens which are represented either by the fragmental phragmacone or the endoconch only. But some of them are known from a part of the septate portion with a large endoconch projecting out of the middle part. The ectoconch is straight, cylindrical and slightly elliptical in cross section. Owing to the fact that the fragment of the ectoconch is very short and not well preserved, the rate of increase can not be determined, nevertheless it appears to be very gentle.

The ectosepta are very closely arranged. The ectoseptal interspace measures 3 or 4 mm. apart, where the ectoconch has a longer diameter of nearly 30 mm. The ectoseptal sutures are slightly undulating. Cameræ entirely free from any deposit, and ectosepta strongly concave.

The endoconch is very large, having a diameter of 1/2 that of the ectoconch or more. It is slightly distant from the center. Its cross section is circular. The long tubi are prolonged backwards beyond the next preceding ectoseptum. Neither the deposits nor the endosepta are found inside.

In another fragmental specimen (Pl. I., Fig. 11) of 30 mm. in length the endoconch is larger, measuring 19 mm. in diameter, where the ectoconch has a longer diameter of 35 mm. At the same stage the ectosepta are 3 mm. apart.

Orthoceras sp.[1] described by Yabe and Hayasaka is apparently of the same species. They stated "The specimen is a fragment of a cylindrical shell, in state of internal cast, and 50 mm long; it is oblong in cross section, measuring 29 mm. and 24 mm. in larger and smaller diameter respectively. The surface of the stone nucleus is smooth,

1. loc. cit.

except for 6 sharply impressed annular lines which are 5-7 mm. apart; the impressions are somewhat wavy, probably owing to the secondary deformation of the entire shell. The lines at first sight appear to be the suture lines of the septa, but in reality coincide with them only partially." "The septa are traversed at the center by a broad (12 mm. in diameter) empty tubular space, which is completely shut off from the interior of the cameræ by means of the septal necks, these being very long and extending beyond the preceding septum. There is absolutely no organic deposit in the interior of the shell." Even though no such impressed annular lines are seen on the surface of our specimens as is the case in that of the Japanese authors, the large endoconch, long tubi, closely set ectosepta and some other properties show that Yabe and Hayasaka's form is really the same as the present species. Reed had described one specimen from the Ordovician bed of Shih-tien in Yunnan and called it *Cameroceras*.[1] In reality it also belongs to the present species. The original diagnosis given by Reed is as follows.

"The shell appears to have been straight, slightly elliptical in cross section, cylindrical, very slowly tapering. A large undivided body chamber seems to be present, and on it traces of fine concentric lineation are visible, this body chamber measures about 33 mm. in length and has a diameter of about 26 mm. The septate portion of the shell measures just 20 mm. in length and contains 11 septa. The septa, therefore are closely approximate, being rather less than 2 mm. apart; they are thin, horizontal, but very slightly undulated. A transverse section made of the lower end shows that the shell is elliptical with diameters of 21 mm. and 25 mm., and there is a very large siphuncle about 14 mm. in diameter, situated nearer the ventral than the dorsal margin."

COMPARISON: This species is quite similar to the previously described *Vaginoceras naichianense*, but after closely studying it we can see that the present form has the endoconch much larger and the ectosepta much closer. Moreover, the interior of this form is absolutely free from organic deposit, which is present in the other species. It also resembles *Vaginoceras vaginatum* Schlotheim, but may be distinguished from it by the position of the endoconch, which is marginal in Schlotheim's species.

HORIZON AND LOCALITY: From the upper part of Neichiashan formation near Sin-tan. (Coll. J. L. Smith and C.Y. Hsieh respectively)

Vaginoceras uniforme Yü (sp. nov.)

Plate II., Figs. 8a-b, 9; Plate V., Figs. 4a-b.

Outer shell straight, cylindrical, cross section elliptical with a moderately large endoconch submarginal to the ectoconch.

---

1. loc. cit.

The ectoseptal distances are nearly uniform, varying from 5-6 mm., or about 1/5 the longer diameter of the ectoconch. Ectosepta with a concavity nearly equal to the depth of one camera.

The endoconch is elliptical in section, being about 9.5 mm. and 8 mm. in its two diameters. At the same section the ectoconch measures 32 mm. in its major diameter. Tapering of endoconch very gentle. The continuous tubi are disposed in an imbricating arrangement. The endosepta are hardly visible in the stereoplasmic filling. The empty cameræ are lined with slight organic deposit, which occurs on the upper side of the ectosepta in the majority of cases.

The ectoconch gradually contracts from the longer diameter of 30 mm. at the upper extremity of the specimen to 23.5 mm. at the lower. The tapering may be roughly estimated to be at the rate of 1 in 11 mm.

Another fragment of this species (Pl. II., Fig. 9) was obtained from the same district. It is of smaller size. The ectosepta are also crowded, distant about 3-4 mm. from one another. The longer diameter of the ectoconch measures 16 mm. at the lower part and 20 mm. at the upper. Concavity of ectosepta about 1 camera. The elliptical endoconch lies submarginal to the outer shell. The stereoplasmic deposit usually occurs above the margins of the ectosepta in very small quantity. Neither the earlier portion nor the apertural end have been observed.

The third one (Pl. V., Fig. 4) was collected from the upper part of the Tafang limestone at Yang-sing-hsien. Its transverse section is also elliptical in outline, the two diameters being at the ratio of 3:2. The ectosepta are uniformly distant from one another, attaining an interval of 6.5 mm. in average, or about 1/4 that of the longer diameter. Endoconch marginal, elliptical, being about 1/3 the diameter of the ectoconch. So far as we know, this specimen is slightly differentiated from the preceding ones in the position of the endoconch, which lies not across the minor diameter but at the quadrant between the longer and shorter diameters.

COMPARISON: In the position of the endoconch, section of the ectoconch, and the rate of tapering this species may be compared with *Endoceras arctiventrum* Hall[1] from the higher part of the Trenton limestone near Middleville N.Y., but the endoconch of Hall's form is much smaller in size. Our shell has the long invaginated tubi, which are unknown either in the figure or the description of that form given by Hall.

HORIZON AND LOCALITIES: The last named specimen (Pl. V., Fig. 4) collected by C. Y. Hsieh was from the upper red bed of the Tafang limestone at Yang-sing, and the rest from the red limestone at San-shan-yuan, Chung-yang-hsien, (C. Li and W. P. Shu).

1. Hall: Palæontology of New York, Vol. I, p. 217, pl. 51, figs. 2 a,b.

Vaginoceras multiplectoseptatum Yü (sp. nov.)

Plate V., Figs. 5 and 6.

This species is represented by many specimens of the internal molds, which are badly preserved. Some of them reveal nothing in the longitudinal sections, but others show important internal structures. Shell subcylindrical, straight, elliptical in transverse section, having two diameters at the ratio of nearly 7:6. Larger extremity not observed. The expansion of the ectoconch is very slow, being 1 in 15 mm.

The ectosepta are very crowded, and nearly equally separated from one another, attaining a distance of 1/9 the major diameter of the ectoconch at the lower preserved end and 1/10 at the upper. They are provided with tubi which continue beyond the preceding septum. Concavity of ectosepta not more than the depth of two cameræ.

The endoconch is subelliptical in section, lying at the extremity of the longer diameter and close to the outer conch. It measures 14 mm. in the major diameter and 11 mm. in the minor, where the corresponding measurements of the diameters of the ectoconch are 33 mm. and 27 mm. respectively. In general the inner shell is about 2/5 as large as the outer one.

Both endoconch and the cameræ are absolutely free from the organic or even the inorganic deposit. The ectosepta are well preserved in some specimens, but partly crushed in others. The ectotheca has not been preserved.

Comparison: Our species bears much resemblance to *Vaginoceras uniforme*, but the latter has not the following characters which are characteristic of the former: 1, ectosepta being more closely set, at a very short distance in their separation; 2, phragmacone enlarging much more slowly; 3, concavity of ectosepta being much deeper; 4, endoconch lying at the end of the major diameter instead of the minor; 5, organic deposit absolutely absent. It may be also distinguished from *Vaginoceras reedi* by the subelliptical, marginal and smaller endoconch. Even though the numerous ectosepta and some other aspects of this species are quite like those of *Vaginoceras vaginatum* Schlotheim[1], our shell has the smaller and subelliptical endoconch as well as the slower tapering, which are readily differentiated from those of Schlotheim's form.

Horizon and Locality: From the upper Neichiashan formation near Sintan, western Hupeh. The specimens were collected by J.L. Smith and C.Y. Hsieh respectively.

1. Foord: Catalogue of Fossil Cephalpoda, Part I, p. 140.

Vaginoceras giganteum Yü (sp. nov.)

Plate III, Figs. 4 a-b.

Ectoconch straight, robust, cylindrical, enlarging very slowly. Endoconch rather large. As both the ectoconch and endoconch are much eroded, their cross sections are not quite certain, though they are probably circular. The apical portion is missing and the length of the incomplete body-chamber also can not be fully determined. This fragment has a length of 360 mm. comprising fourteen cameræ. At the two extremities it measures 67.5 and 48.5 mm. in diameter. It expands at the rate of 1 in 18.5.

Ectosepta thin, moderately concave, appearing much thickened on their upper marginal portion by the stereoplasmic deposit. They are distant from each other about one half the diameter of the ectoconch. Their concavity is about three fourths as deep as the camera. It is a noticeable fact that the ectoseptal distances are almost equal throughout the whole fragment. There are two cameræ within the space of 50 mm.

The endoconch lies ventro-centran. It is of large size, a little less than one third the diameter of the ectoconch. It is slightly contracted between the ectosepta. At the lower part of the fragment the endoconch is distant 11 mm. from the ventral side of the outer shell and 25 mm.from the dorsal,where the diameters of the ectoconch and endoconch are 52 mm. and 16 mm. respectively. It is only preserved in the lower portion and the upper end of the specimen, and the rest is completely worn away. The uppermost part of the endoconch encloses another smaller orthoceracone 10 mm. long. All the cameræ and the lower part of the endoconch are wholly filled with calcite deposit. No endosepta are seen, but the presence of the imbricating tubi and the enormous endoconch shows that this specimen should be referred to the genus *Vaginoceras*.

Comparison : This species may be related to *Vaginoceras wahlenbergi* Foord, but differs from that in the slower rate of tapering, equal ectoseptal intervals, and position of the endoconch. The same features also serve to differentiate this form from *Vaginoceras wahlenbergi* Foord var. *cylindrica*.

Horizon and Locality : Obtained from the fossiliferous bed underlying the red limestone near Ta-wu-shu, Chung-yang-hsien.

Vaginoceras? sp.

Plate VIII., Fig. 1.

This specimen consists wholly of the red lime matrix, in which the shell was embedded. It has a length of about 400 mm. On the surface of the stone nucleus the sharp impressed annular lines are clearly shown, each one probably representing an ectoseptum. They are very crowded, and the distances between them vary to an extremely small degree, ranging from 11.5 to 12.5 mm. Generally sixteen cameræ are present in a length of 200 mm, while the ectoconch has a diameter of 66.5 mm. The ectoconch gradually diminishes its diameter toward the apical extremity at the rate of 1 in 11.5. On examining its sections no other features may be recognized except the scar of the endoconch, which is more or less elliptical in shape and situated close to the outer shell. Test not preserved at all.

Since we know nothing about the tubi, the actual size of the endoconch and other features, specific and generic determination is impossible. On account of the large, marginal endoconch and the uniformly separated ectosepta, which are somewhat related to *Vaginoceras uniforme*, it is provisionally put in the genus *Vagni ceras.*

HORIZON AND LOCALITY: From the red bed north-east of Pei-hu-fu, Pu-chi-hsien.

Suborder **Orthochoanites** Hyatt

Family **ORTHOCERATIDAE** M'Coy

Genus **ORTHOCERAS** Breyn

Orthoceras chinense Foord

Plate III., Figs. 5a-b; Plate IV., Figs. 4a-b;

Plate V., Figs. 7a-c; Plate VI., Figs. 1a-b, 2a-c.

1856. *Orthoceras* sp., S. P. Woodward: Quart. Journ. Geol. Soc. Vol. XII, p. 378, pl. VI, fig. 1.
1888. *Orthoceras chinense*, Foord: Catalogue of Fossil Cephalopoda. British Museum. I. p. 100.
1911. *Orthoceras chinense*, Frech: Richthofen's China, Vol. V, p. 8, pl. II, figs. 2 a-c.
1920. *Orthoceras chinense*, Yabe et Hayasaka: Palæontology of Southern China, p. 48, pl. XXVII, figs. 3 a-b.

Shell (Pl IV., Fig. 4) straight, subcylindrical. Section circular. The preserved fragment tapers at the rate of 1:9. Both the initial portion and the larger end are wanting.

The septal interval gradually increases orad from the smaller extremity. After a certain distance it slightly reduces and immediately increases again. On the whole the cameræ become deeper as the shell expands in diameter, being approximately equal to one half the maximum width of the shell or even a little less. At a point not far from the living chamber the septa become more crowded toward the aperture. The septal necks are very long, extending apically for a distance equal to about one half the inter-space between the septa. Septa thin, direct, having a concavity of 1/2 the depth of a camera or more.

Siphuncle central, narrow, measuring about 1/10 the diameter of the shell. It is circular in transverse section. It is entirely empty in some specimens, but partly filled with the secondary crystalline deposit in others. The margins of the septa are either perfectly free from any deposit or lined with a layer of stereoplasm, which is sometimes very thick and sometimes rather thin as well as irregular. The cameræ are filled with crystalline calcite of secondary origin, but generally empty.

A very small part of the test has been preserved, showing the transverse lines of growth.

There is another specimen (Plate V., Fig. 7), which was collected from the same locality and probably belongs to the same species. It is represented by a fragment of the apertural portion, having a length of 70 mm. The living chamber is partly preserved with three adjacent cameræ. The septal distance measures 15 mm. at the lowest camera of the fragment, and 10 mm. at the uppermost or last one, where the corresponding measurements of the diameter of the shell are 32 mm. and 36 mm. respectively. The surface is ornamentated by well marked transverse, flexuous, imbricating striæ, of which three are counted in a distance of 2 mm. The other internal characters of this individual are the same as those of the preceding one.

A third specimen (Pl. VI., Fig. 1.) is robust in form. It measure about 210 mm. in length. The living chamber is partly preserved and the apical portion is missing. The septal distances continually and gradually increase from the lower part of the shell toward the aperture, being little more than 1/2 the diameter. Up to the third camera from the living chamber, it stops to increase and gradually reduces upwards, where the depth of the cameræ is less than 1/2 the diameter. The septal necks are slightly shorter than 1/2 the septal intervals. Test not observed.

The body chamber in a fourth specemers (Pl. VI., Fig 2) is rather large. Because of the incomplete state of preservation its full length can not be made out, but the portion remaining reaches a length of 48 mm. or more than $1\frac{1}{2}$ times the diameter of its base. The septal distances of the mature portion seem to be greater than those in the preceding specimens, measuring about 4/5 the shell diameter. The septa also become crowded as they approach the outer chamber. The test is not preserved, but the surface character may be seen on the mold of the interior, which is marked by regular, flexuous transverse lines of growth. The actual surface had its striæ arranged similarly, but they appear to have been much closer together. There is another small specimen (Pl. III, Fig.5.) which indicates the young stage of the same species.

Remarks. In the collection about ten specimens of this species are found, but there is a great variation in tapering between them. Some taper at the same rate as that of Foord's specimen, and others much more rapidly, varying from 1:6 to 1:8.

Horizon and Localities: This species is very common in the argillaceous limestone bed of the Neichiashan formation at Nei-chia-shan near Sin-tan of Tze-kuei-hsien (J. S. Lee), Lo-jo-ping of I-chang-hsien (C. Y. Hsieh) and Tai-hung-shan of Nan-chang-hsien (Coll. W. P. Shu and C. C. Yü).

Orthoceras chinense var. **kuangchiaoense** Yü (var. nov.)

Plate VII., Figs. 1 a-c and 2.

Shell straight, slender, subcylindrical, regularly and gradually augmenting its diameter toward the chamber of habitation at the rate of 1:8.5. The preserved part of the living chamber measures 40 mm. long, the diameter at its base being 25 mm. Owing to the fact that the larger extremity is poorly preserved, the aperture is unknown. Shell section circular in outline.

Only two complete cameræ are preserved, increasing from 14 mm. in depth at the lower camera to 17 mm. at the upper or last one. At this stage the shell diameter ranges from 22 mm. to 24 mm. The septa are distant about 2/3 the diameter from each other. Concavity of the septa about 1/2 the depth of a camera or more.

Siphuncle central, circular in section, having a diameter of 2 mm., where the shell is 21 mm. in diameter. The septal necks are prolonged apicad only about 1/3 the interspace between the septa. The cameræ are lined with the stereoplasmic deposit about 1 mm. thick and filled with yellowish crystalline calcite inside.

The test is about one half millimeter thick. Its surface is covered by the broad, undulating lamellose growth lines without any longitudinal striæ. By the aid of a lens the transverse ridge are seen to be arranged in imbricating form, steepening at the anterior side and sloping very gently in the other direction. They are distant about 1 mm.

Another individual (Pl. VII, Fig. 2.) my probably be of the same form. It is represented by a perfectly preserved internal mold. It has a remarkable length of about 800 mm. with an acute apical termination. Transverse section unknown. It contracts toward the posterior end at the rate of 1 in 7.5. The body chamber is of considerable size, measuring 314 mm. in length and 93 mm. in width at its base. The depth of the cameræ increases from 18 mm. at the diameter of 30 mm., to 35 mm. when the diameter is 58 mm. The septa have a concavity equal to about 1/2 a camera height. The siphuncle is entirely eroded away, but near the smaller end there is some indication of the siphuncle showing its situation to be in the middle of the natural longitudinal section. This specimen appears to be compressed to a certain extent, presenting a greater diameter of shell than the original maximum width. The cameræ are filled with the fine yellow matrix of calcilutyte except the initial portion, which has turned into calcite.

COMPARISON: This form agrees in all respects with *Orthoceras chinense* Foord, but differs slightly in having shorter septal necks, longer septal distances and the gradual increase of camera depth towards the aperture, these features serving to separate it as a variety of Foord's species. It may be compared with *Orthoceras evanescens* Barrande[1], but is easily distinguished by its more rapid tapering, its surface ornamentation, its broader siphuncle and the regular increase of its septal distance. *Orthoceras penetrans* Barr.[2] and *Orthoceras cavum* Barr.[3] also come nearer to this form in general aspect, but our shell has longer septal necks and surface striation, which are very different from those of Barrande's species. It is also allied to *Orthoceras giebeli* Barr.[4], but that shell has different surface ornamentation and longer septal necks.

HORIZON AND LOCALITIES: The specimen (Pl. VII., fig. 1.) is from the same formation as the preceding species in the region about 1 li to the east of Chiang-chia-chi (將家集), and about 10 li north east of Kuang-chiao-pu, King-shan-hsien. (W. P. Shu and C. C. Yü). The last specimen (Pl. VII., Fig. 2) was obtained in the bed between the reddish limestone and the thick-bedded blue limestone at the place close to Wang-chia-sze, Chung-yang-hsien. (C. Li and W. P. Shu).

Orthoceras chinense var. **eccentrica** Yü (var. nov.)

Plate VIII., Fig. 2.

Shell cylindrico-conical, regularly enlarging. Transverse section circular. Chamber of habitation not perfectly preserved. This specimen is about 210 mm. in length, measuring 40 mm. in diameter at the larger extremity. The apex terminates in an acute point with an apical angle of 25°, but this is probably not the true angle as the apical portion is displaced by faulting and the section not wholly median. The normal rate of tapering of the shell may be estimated at 1 in 7. Surface markings unknown.

---

1. Barrande: Système Silurien de la Bohême, Vol. II, Text III, p. 190, pl. 258, pl. 265; pl. 326, pl. 361.
2. J. Barrande: Système Silurian de la Bohême, Vol. II, Text III, p. 537, pl. 403, pl. 406.
3. J. Barrande: Système Silurian de la Bohême, Vol. II, Text III, p. 488, pl. 223, pl. 363, pl. 378, pl. 384.
4. J. Barrande: Système Silurian de la Bohême, Vol. II, Text III, p. 404, pl 304.

Septa gently concave, so far as observed, with a concavity equal to one half of the camera. The septal distance increases irregularly as the shell expands in diameter, having a depth varying from 12 mm. to 22 mm., where the corresponding diameters of the tube are 18 mm. and 35 mm. respectively.

The siphuncle is narrow, and equal to one tenth the diameter of the shell. It is eccentric, its border touching the central axis of the conch. It is enclosed by the septal necks, which, as determined from a few of them which are clearly shown in the longitudinal section, are comparatively short, about one third the depth of the camera. There is no trace of deposits in the siphuncle. All the cameræ contain the white crystalline lime in addition to the stereoplasmic lining.

COMPARISON: At first sight this specimen scarcely differs in aspect from *Orthoceras sp.*[1] figured by Woodward, but after close examination our shell may be distinguished from Woodward's shell by the excentric siphuncle, the shorter septal necks and the more remote septa. It closely resembles *Orthoceras chinense* Foord var. *kuang-chiaoense* except for the position of the siphuncle and some other minor features. There fore, I am inclined to regard this form as another variety of Foord's species.

HORIZON AND LOCALITY: This shell was collected from the bed just underlying the reddish limestone at a place not far from Wang-chia-sze, Chung-yang-hsien.

Orthoceras chinense var. **equiseptatum** Yü (var. nov.)

Plate VIII., Figs. 3-5; Plate IX., Figs. 1a-b.

Shell (Pl. VIII., Fig. 3) subcylindrical, robust, circular in cross section. Apical portion not observed. The diameters at the two extremities of this fragment are 34 mm. and 54 mm. respectively, the distance between them being 133 mm. The rate of increase is in the proportion of 1 to 6.5. Test not exposed,

The preserved part of the living chamber is about 70 mm. in length and 56 mm. in diameter at its base. Seven complete adjacent cameræ have been recognized, varying slightly in their depth. Thus each of the lowest two cameræ measures 20 mm. in length, while above these the septa are separated by a distance of 17 or 18 mm. Still higher up the cameræ assume again the same depth as the lowest one. In general they are of nearly the same depth, this being greater than 1/2 the diameter of the shell at the lower preserved end and less than 1/2 at the upper. The last camera is shallower than any of

1. S. P. Woodward: Quart. Journ. Geol. Soc., Vol. XII, p. 378, pl. VI, fig. 1.

the preceding ones, which is a common case occurring in the conchs of cephalopods. Septa moderately concave, having a depth nearly equivalent to one fourth the maximum width of the shell.

Siphuncle narrow, lying in the central part with a circular cross section. Its size is about 1/9 the diameter of the shell at the lower end, and 1/11 at the upper. The septal necks extend scarcely longer than 1/3 the septal interspace. The cameræ are mainly filled with crystalline calcite, though some are also filled with the material in which the specimen is embedded.

One specimen of a different individual (Pl. VIII., Fig. 4.) represents a young shell of smaller size. The septate portion has a length of 68 mm. excluding the living chamber, which is very large or more than 3 times the diameter at its base or nearly about 1/2 the total length of the fragment. Rate of tapering 1 in 7.5. The septa are equally separated, being 7 mm. in distance, while the diameter of the conch measures 13 mm. at the lower end and 19 mm. at the upper. Siphuncle narrow, central, cylindrical, preserved only in the smaller extremity of the naturally sectioned specimen. It is about 1/9 the diameter in size.

The third specimen (Pl. IX., Fig. 1) collected from Tung-chiao-cheng, attains a length of 132 mm. and expands its shell at the rate of 1 in 7. It terminates in a blunt end at an apical angle of 15°. Shell slightly curved, which may be regarded as accidental. Cross section subcircular (probably by compression). Near the apical portion the septal distances gradually increase from 5 mm. to 10 mm., where the shell has the corresponding longer diameter of 9 and 19 mm. Above this stage the septa are 12 mm. distant from each other. Still higher up they have been crushed, but from what remains we know that they are also equidistant at an interval of about 12 mm. throughout the upper portion, where the shell enlarges its diameter from 22-27 mm.

COMPARISON: This form has some affinities with the *Orthoceras epulans* Barrande[1], but the septa in the latter form are much closer together and the septal necks much shorter. It is similar to *Orthoceras chinense* Foord except for the shorter septal necks and the equal septal distances, the last feature also serving to distinguish it from the other varieties of Foord's species mentioned above.

HORIZON AND LOCALITIES: The specimens (Pl. VIII., Figs. 3-4) were found in the beds overlying the thick blue limestone and underlying the red bed near Pei-hua-pu, Pu-chi-hsien (C. Li and W. P. Shu). The last one described (Pl. IX., Fig. 1) is abundant in the upper Neichiashan formation at Mei-hua-ling (梅花嶺) 12 li east of Tung-chiao-cheng, King-shan-hsien. There is still another specimen (Pl. VIII., Fig. 5.) of the same species was colleced from Heh-chia-tzui-tze (侯家咀子) 6 li north-west of Chang-chia-chi, Chung-hsiang-hsien, (Coll. W. P. Shu and C. C. Yü).

---

1. J. Barrande: Syst. Sil. de la Bohême, vol. II., Texte III, p. 432, pl. 373, pl. 399.

Orthoceras regulare Schlotheim.

Plate IV., Figs. 5, 6 a-b.

1888. *Orthoceras regulare*, Foord: Catalogue of Fossil Cephalopoda, Part I, p. 6. (With literature references).

1917. *Orthoceras regulare*, Reed: Palæontologia Indica, New Series, Vol. VI, Mem. No. 3, p. 32, pl. V, figs. 13, 13a.

There is a small shell which can be identified with this species. The larger portion has not been observed and the part remaining attains 45 mm. in length. It is straight and cylindrical in general form and subcircular (probably compressed) in cross section. Rate of increase about 1 in 15. Septa strongly concave and separated from each other a distance of about 1/2 the diameter of the shell. Depth of the septa exceeding 1/2 that of the camera. Siphuncle central, circular, being about 1/9 the shell diameter. It is distinctly girdled by the septal necks, which are extremely short. The white calcareous deposit is present in the cameræ, but not in the siphuncle. No test remains, but the surface of the mould seems to be transversely striated. In another specimen (Pl IV,, Fig. 6) the shell has a circular section, tapering at the rate of 1 in 18.

COMPARISON: In the septal distances and the position of the siphuncle, the present shell is somewhat close to *Orthoceras chinense* Foord, but our shell has the septal necks much shorter and the tapering much slower, features readily distinguished from those of *Orthoceras chinense.*

HORIZON AND LOCALITY: Embedded in the upper limestone bed of the Neichia-shan formation, near Sin-tan (C. Y. Hsieh Collector).

Orthoceras cf. **politum** M'Coy

Plate III., Fig. 6

1888. *Orthoceras politum*, Foord: Catalogue of Fossil Cephalopoda, Pt. I, p. 7. (With literature references).

Shell straight, slender, embedded in the yellowish argillaceous limestone. Only the apical portion is recognized, with six cameræ remaining. The cross section is circular. Because the longitudinal section is oblique to the axis of the shell, the siphuncle is only partly exposed at the upper end. It tapers at the rate of 1 in 10. The distance between the septa slightly and gradually increases upwards, ranging from 2/5 the diameter at the lower end to 1/2 at the upper end of the fragment. Depth of septa about 1/4 the shell diameter. Siphuncle circular, central, having a diameter about 1/7—1/6 the diameter of the shell. Septal necks extending less than 1/4 the depth of the camera. The surface markings of the test are unknown.

COMPARISON: This fragment may be correlated with *Orthoceras chinense* Foord[1] and *Orthoceras regulare* Schlotheim[2], but differs from the former in having much shorter septal necks and from the latter in the more rapid tapering. So far as the visible characters of this fragment are concerned, it may be assigned to the present species. According to the description[3] given by Foord the siphuncle of M'Coy species is "central in the young shell, but becoming eccentric with growth" and the surface is covered "with fine transverse striæ of growth". But the specimen in our possession only represents the young stage, and the position of the siphuncle in the upper part as well as the surface character are quite obscure. The specific identification of this specimen, therefore, is made with a certain amount of hesitation.

HORIZON AND LOCALITY: From the limestone bed of the Neichiashan formation at Ta-hung-shan, Nan-chang-hsien.

Orthoceras squamatulum Barrande.

Plate IV., Figs. 7a-b.

1868. *Orthoceras squamatulum*, Barrande: Systèm Silurien de la Bohême, Vol. II, Texte III, 1874 p. 455, pl. 302, pl. 310, pl. 370.

Shell straight, cylindrical, represented by a fragment of the posterior end, which is 40 mm. long. Transverse section circular. It expands in diameter very gently, the rate being about 1 in 30. The diameters at the two extremities of the fragment are 13 and 14 mm., while that of the siphuncle is 1.5 mm. wide throughout the whole portion of the specimen.

The septa are very shallow, about 1/3 the depth of the cameræ. This fragmentary specimen contains four cameræ, which have a depth of 2/3 the diameter of the shell. In actual measurement the septa are 9 mm. apart at a diameter of 13 mm.

Siphuncle slightly excentric, narrow, being about 1/7 the diameter of the conch. Cross-section circular. Septal necks clearly shown and extremely short. The cameræ consist of the same material as the surrounding rock. Test not preserved, but the surface of the mould indicates that slightly oblique striæ are present, four occupying a distance of 1 mm.

COMPARISON: *Orthoceras michelini* Barr.[4] somewhat corresponds to the present specimen, but Barrande's species has the septal distance much longer. Our shell is

---

1. Foord: Catalogue of Fossil Cephalopoda, Pt. I, p. 100.
2. Foord: Catalogue of Fossil Cephalopoda, Pt. I, p. 5.
3. Foord: Catalogue of Fossil Cephalopoda, Pt. I, p. 7.
4. Barrande: Syst. Sil. de la Bohême, Vol. II, Texte III, 1874, p. 642, pl. 221, pl. 381, pl. 442, pl. 447.

also similar to *Orthoceras regulare* Schlotheim[1] and *Orthoceras politum* M'Coy[2], but differs from them in having a much slower rate of tapering and much longer septal intervals, It may be also distinguished from *Orthoceras scabridum* Angelin[3] and *Orthoceras sodale* Barrande[4] by the more gentle tapering and the siphuncle being not central in position.

HORIZON AND LOCALITY: Found in the upper Neichiashan formation near Sin-tan.

Orthoceras thyrsus? Barrande

Plate VII., Figs. 3a-b.

1870. *Orthoceras thyrsus* Barrande: Syst. Sil. de la Bohême, Vol. II, Texte III, 1874, p. 555, pl. 405, figs. 15-18.

A fragment has been obtained with only three air chambers preserved. The transverse section of the shell is circular. The rate of expansion is very gentle, measuring about 1 in 20.

The septa are provided with septal necks, which extend backwards to a very short distance. The depth of the septa is apparently about 1/2 that of the cameræ. The distance between the septa is approximately equivalent to 4/5 the diameter of the conch.

The siphuncle occupies the position between the periphery and the center of the shell, being nearer to the latter than to the former. It is circular in section, having a size of about 1/10 the diameter.

The test is partly preserved. Its surface seems to be covered by an ornamentation of oblique striæ, which, however, are not very clearly shown.

COMPARISON: This specimen may be related to *Orthoceras pleurotomum* Barrande[5], but differs from it in the possession of a circular shell, in a different character of surface markings, and in some other points. The only species which can be identified with the present specimen is *Orthoceras thyrsus* Barrande. But Barrande's species was collected from the Silurian rocks, while our shell makes its appearance in the upper Neichiashan formation of Middle Ordovician age. Therefore, if this species did not originate in pre-Silurian time, then this correlation may be wrong.

HORIZON AND LOCALITY: Upper division of Neichiashan formation near Sin-tan.

---

1. Foord: Catalogue of Fossil Cephalopoda, Pt. I, p. 5.
2. Foord: Catalogue of Fossil Cephalopoda, Pt. I, p. 7.
3. Angelin-Lindström: Fragmenta Silurica, p. 4, t. IV, figs. 6-9; t. VII, figs. 8-10.
4. Barrande: Syst. Sil. de la Bohême, Vol. II, Texte III, 1874, p. 453, pl. 417, figs. 9-21.
5. Barrande: Syst. Sil, de la Bohême, Vol. II, Texte III, 1874, p. 412, pl. 224, pl. 296, pl. 366.

Orthoceras remotum Yü (sp. nov.)

Plate VII., Figs. 4 a-b.

Shell slender, elongate, cylindrical. Transverse section elliptical. It tapers very slowly, about 1 in 19. The fragmentary specimen has a length of 225 mm. embracing 10 cameræ. The two extremities have not been observed.

Septa strongly concave and very distant from each other. Their concavity is nearly equivalent to two fifths of the interspace between the septa. The cameræ regularly increase in depth as the shell expands in diameter, measuring 18 mm. in the smaller portion and 26 mm. in the upper, while the shell is 21 mm. and 29 mm. in dorso-ventral diameter respectively. The obliquity of the septal lines makes an angle of 70° with the median axis of the siphuncle and meets the side of the shell at 40°.

The siphuncle is strongly excentric, being 9 mm. distant from the nearer side of shell at the upper end and 6 mm. at the lower. It is narrow and elliptical in cross section. Its major and minor diameters are 3.5 and 2.5 mm., while the corresponding diameter of the shell are 30 mm. and 23 mm. respectively. The septal necks are not clearly exposed, but at the smaller end they may be perceived to have a very slight length.

Test smooth, being 0.5 mm. in thickness.

COMPARISON: This species is characterized by the strong concavity of its septa and the great depth of its cameræ. It may be compared with *Orthoceras pleurotomum* Barrande[1] and *Orthoceras thyrsus* Barrande,[2] but is readily distinguished from the latter by the great septal distance, the elliptical section of shell and the absence of the surface ornamentation; and from the former by the fact that the shell is covered by delicate oblique striations, while the septal intervals become crowded upwards.

HORIZON AND LOCALITY: It occurs in a polished slab collected from the upper bed of the Neichiashan formation at Chai-tze-shan (寨子山) about 10 li south of Fang-chia-chi (方家集), Hsiang-yang-hsien (襄陽縣).

Orthoceras rudum Yü (sp. nov.)

Plate IV., Figs. 8a-c.

Shell straight, cylindrical, enlarging very slowly. Transverse section slightly elliptical. In this imperfect specimen only the basal portion of the body-chamber is preserved together with three adjacent ordinary cameræ. The entire length of the fragment is 70 mm. The rate of increase may be computed as 1 in 20.

1. Barrande: Syst. Sil. de la Bohême, Vol. II, Texte III 1874, p. 412, pl. 224, pl. 296, pl. 366.

2. Barrande: Syst. Sil. de la Bohême, Vol. II, Texte III, 1874, p. 555, pl. 405, figs. 15-18.

Septa strongly concave. They are widely separated, and slightly increase in distance apart toward the outer chamber. The concavity is about equal to one third of a camera which has a depth of 16 mm. in the last camera and 15 mm. in the next preceding one, while the dorso-ventral diameters of the tube at the corresponding stages are 20 mm. and 18 mm. respectively.

Siphuncle excentric, nearer to the center than to the side. It is encircled by the septal necks, which contract at the septa and gradually enlarge backwards, extending to a distance of about one third the septal interval. Transverse section ovately elliptical. It has a longer diameter of 3 mm. and a shorter of 2 mm. At the same place the shell measures 17. 5 mm. and 17 mm. in the dorso-ventral and transverse diameters.

The test is well preserved, having a thickness of 0.5 mm. The surface is marked by coarse, transverse, elevated, flexuous lines of growth, 6 in the space of 5 mm. On close examination under the magnifier we find that either the elevated ridges or the depressed interspaces are wholly composed of the fine striæ, slightly arching forward on the dorsal side.

COMPARISON: It is similar to the preceding species in all respects except in its striking surface ornamentation. This species may be compared with *Orthoceras pleurotomum* Barrande,[1] but differs from that by its gradual increase of septal distance and by the character of the transverse undulating striæ. It may be distinguished from *Orthoceras thyrsus* Barrande[2] by the fact that the latter has a circular section of the shell, and the oblique, straight striae on its surface.

HORIZON AND LOCALITY: From the bed immediately underlying the red limestone at the region not very far from He-chiao, Chung-yang-hsien (C. Li and W. P. Shu Coll.)

Orthoceras suni Yü (sp. nov.)

Plate V., Figs. 8a-b, 9.

Shell straight, cylindrico-conical. Transverse section subelliptical. The only preserved part is the apical portion of 82 mm. in length, gradually expanding toward the apertural end. Mature phragmacone and body chamber not preserved. Apical angle 20°. Rate of incrase about one millimeter in a length of four millimeters.

---

1. Barrande: Syst. Sil. de la Bohême, Vol. II, Texte III, 1874, p.412, pl. 224, pl. 296, pl. 366.
2. Barrande: Syst. Sil. de la Bohême, Vol. II, Texte III, 1874, p.555, pl. 405, figs. 15-18.

Septa thin, having a concavity exceeding one half the depth of a camera. The septa are 5 mm. distant from each other at the point where the longer diameter of the shell is 14 mm., and gradually increase their interspaces to 9 mm. where the diameter of the shell is 23 mm.

Siphuncle central, being ovately elliptical in section. Its major diameter measures 2 mm. at the smaller and 3 mm. at the larger end of the preserved fragment. At the corresponding place the conch varies in its diameter from 16 to 26 mm. The sides of the siphuncle are distinctly marked by the septal necks, which are a little longer than one third the septal distance.

Near the smaller extremity the cameræ seem to have been separated horizontally into two nearly equal parts by a process directed toward the anterior angle on each side of the camera. This feature is apparently similar to that seen in the specimen of *Orthoceras sp.* Woodward.

Another fragment of smaller size was also obtained. It has a length of 40 mm. containing 11 cameræ with an apical angle of 20°. The apex is more pointed and the rate of tapering is more rapid, being 1:3.

COMPARION: This species closely resembles *Orthoceras thomsoni* Barrande [1], but differs from it in the shorter septal distances, narrower siphuncle, and sub-elliptical sections of both the siphuncle and the shell. This form also bears some degree of resemblance to *Orthoceras* sp.[2] figured by Woodward, but the former has a more rapid rate of tapering and a subelliptical section of shell.

HORIZON AND LOCALITY: In beds just overlying the blue thick-bedded limestone at the western end of Pei-yang-shan, Chung-yang-hsien. The specific name is given in honor of Dr. Y. C. Sun of the Geological Survey.

Orthoceras elongatum Yü (sp. nov.)

Plate VII., Fig. 5.

This species is well shown in a natural polished longitudinal section. Shell elongate, slender, and conical, having a length of 275 mm. The initial portion is pointed with an apical angle of 8°. It expands slowly toward the larger end. At a stage 262 mm. distant from the apex, it has a diameter of 22.5 mm. Rate of increase 1 in 14. Cross section of shell circular. Body chamber and surface character unknown.

1. Barrande: Syst. Sil. de la Bohême, Vol, II, Texte III, 1874, p. 684, pl. 214, figs. 4,5.
2. Woodward: Quart. Journ. Geol. Soc., Vol. XII, p.378, pl. VI, fig. 1.

Septa gently concave, increasing in their distance from 3/4 to 4/5 the diameter of the shell. At the stage where the shell is 11 mm. in diameter, the camera is 9 mm. in depth, while at the uppermost preserved end the septa are 19 mm. distant from each other, being little less than the shell diameter which is 21 mm. at this place. Concavity of septa approximately equal to one third the depth of a camera.

The siphuncle is very slightly eccentric, cylindrical, and very narrow. Its diameter is about 1/14 that of the shell. The septal necks do not show very clearly, but seem to be very short. The organic deposit is well developed along the margins of the septa.

COMPARISON: This form is characterized by its great septal distances. It comes very near in aspect to *Orthoceras currens* Barrande,[1] but is differentiated from it by the much narrower siphuncle, slower rate of tapering and much shorter septal necks. The same characters in addition to the longer septal distance also distinguish this species from *Orthoceras chinense* Foord.

HORIZON AND LOCALITY: This specimen was procured from the bed underlying the reddish limestone near Ta-wu-shu, Chung-yang-hsien.

Orthoceras densum Yü (sp. nov.)

Plate VI., Figs. 3a-b; Plate IX., Fig. 2.

Shell cylindrico-conical with transverse section subcircular. Tube regularly enlarging in diameter upwards. Apical angle about 8°. The larger extremity as well as the surface character not observed. Tapering at the rate of 1 in 9.

The cameræ are extremely closely arranged in the apical portion, fourteen being counted in a distance of 20 mm. commencing from the apex. They are six in number in the next succeeding space of 20 mm. higher up. During the mature stage the cameræ greatly increase their depth, ranging from 10 to 17 mm., while the corresponding diameter of the shell is from 14.5 to 20 mm. Near the upper end where the shell has a diameter of from 20 to 30 mm., the septal distance scarcely increases, remaining about 16-17 mm. high.

Septa smooth, thin, having a convexity nearly equal to one half the depth of one camera, or a little more. Siphuncle narrow, central, circular in section, and apparently enclosed by the septal necks which extend not less than one third the septal distance. Its diameter is about 1/7 that of the shell.

---

1. Barrande: Syst. Sil. de la Bohême, Vol. II, Texte III, 1874. p. 628, pl. 221, pl. 222, pl. 407, pl. 411.

Another small specimen (Pl. IX., Fig. 2) of the same species was found. Its body chamber has only a small part of the base preserved. It gradually decreases in diameter apicad, to an acute point with an apical angle of 10°. Rate of increase 1 in 7.5. The septa at the smaller end are very numerous, being more than 10 cameræ within the length of 20 mm. After the rapid increase of the septal distances in the middle part of the conch, the cameræ apper to be retarded in the rate of increase in depth as compared with its diameter. Near the larger extremity where the diameter is 13 mm. the septa are distant about 7 mm.

Remarks: This species is distinct from any of the preceding ones in its extremely crowded cameræ at the apical portion and the irregular increase of the septal distance. I have not found any related form, with which this species may be identified.

Horizon and Localities: One speciemen (Pl. VI., Fig. 3) was obtained from the upper part of the Neichiashan formation at Chien-tze-kou about 3 li to the west of Nan-chang-hsien, and the other (Pl. IX., Fig. 2), from the same bed at Liu-chia-chung (劉家冲) about 15 li west of Kueng-chia-wang, I-cheng.

Orthoceras yangtzeense Yü (sp. nov.)

Plate III., Figs. 7, 8a-b.

There are three specimens of internal moulds which are cylindrico-conical and slightly curved. The cross section is elliptical, its two diameters being at the ratio of 3:2. Its tapering is rather rapid, about 1 in 6. Larger extremity not preserved.

It is to be noted that the septal sutures are slightly undulating and form on the convex side the V-shaped lobes, which are very characteristic of this species. The septal distances are very uniform and are about three millimeters apart on the average, while the longer diameter of the shell is 8 mm. at the lower end and 14 mm. at the upper end of this fragment, which is little less than 40 mm. in length.

The position of the siphuncle is rather uncertain. But the upper end of one specimen (Pl. III., Fig. 8) shows that it is small, circular, submarginal to the shell wall opposite the side which bears the V-shaped lobes.

Comparison: In the closer septa and the V-shaped lobes the present species somewhat resembles *Orthoceras* sp.[1] figured in Angelin-Lindström's *Fragmenta Silurica*. Since no description of that form was given, we are not able to make any accurate comparisons.

1. Angelin-Lindström: Fragmenta Silurica, t. IV, fig. 16.

Horizon and Locality: The upper Neichiashan formation yields this form near Sintan, Tze-kuei-hsien (Collections: J. L. Smith and C. Y. Hsien respectively)

Orthoceras? wongi Yü (sp. nov.)

Plate V., Figs. 10a, b.

The weathered surface of this specimen appears to be annulated outside. But after a careful study we find that all the transverse depressions are just in the positions of septal sutures. In another smaller shell probably belonging to the same species, the surface is rather smooth, though it also slightly exhibits a longitudinal undulation to some extent. It may be concluded that the annulation-like sculpture is probably the result of the weathering. Shell straight, cylindrical, having a length of about 40 mm. It has a sub-elliptical section. The expansion of the conch is slow, about 1 in 10 or more. Both the extremities are missing.

The septal sutures are slightly undulating. The septal distances are approximate and uniform, being about 1/8 the shell diameter, which is also the concavity of the septa. In actual measurement the septa are 3 mm. apart throughout the whole fragment, which has a longer diameter of 20 mm. at the lower end and 24 mm. at the upper.

The siphuncle is subcentral, cylindrical, being 3.5 mm. in diameter. It is circular in section. It is a remarkable thing that the septal necks assume the character of those in Holochoanites, extending beyond the preceding septa for a little distance. The interior of the siphuncle is empty. A few cameræ are partly filled with the crystalline calcite.

Remarks: The siphuncle of this form is not very large, suggesting the ordinary size of an *Orthoceras*, though having such long septal necks. I hesitate to consider this as another distinct genus. The generic name, now applied to our shell is only provisional.

Horizon and Locality: Same as the preceeding species, with which the present form is associated.

Orthoceras sp.

Plate IX., Fig. 3.

Shell small, slender, slightly curved, enlarging very slowly. The transverse section is nearly circular. The initial portion as well as the body-chamber unknown. Rate of increase 1:27.

The thin septa are rather oblique, sloping back more than 20° and dying away on the convex side. No trace of the siphuncle can be recognized though it seems to be marginal to the convex side. The distances between the septa vary from 8 to 10 mm., where the shell increases in diameter from 15 mm. at the lower to 18 mm. near the upper end. The cameræ are entirely occupied by the dark gray lime-mud. The total length of the imperfectly preserved specimen is 108 mm.

The test is preserved in some places. It is rather thin, showing a thickness of 0.1 mm. Its surface is apparently smooth.

COMPARISON: This specimen is remarkable because of the obliquity of its septa, a feature not seen in any of the preceding specimens described. It comes very close in general aspect to *Orthoceras durinum* Blake,[1] from the Lower Llandeilo Limestone of Durness, but in the latter form the rate of tapering is less rapid and the septal distances are shorter than they are in the present form. It may also be separated from *Orthoceras baculoides* Blake[2] by its much slower tapering and by the apparently eccentric position of its siphuncle, which is central and large in Blake's species.

HORIZON AND LOCALITY: At Pei-ting-tze (碑亭子) 15 li west of Hu-chia-chi, Chung-hsiang-hsien, where the upper part of the Neichiashan formation is very prominently developed.

Orthoceras sp.

Plate IX., Fig. 4.

Shell straight, cylindrico-conical and of moderate size. It rapidly tapers backwards to an acute point with an apical angle of 15°. The shell section is elliptical? Test not observed. The siphuncle has been completely rubbed away.

The septa are thin, direct and numerous. They are 3 mm. distant from each other near the initial part. At the last camera 140 mm. from the apex, the septal interval increases to 9 mm. while the diameter of the shell is 21 mm. The rates of increase are different at the different stages of the conch. Thus, it is rapid at the apical portion, being about 1 in 4. Above this place 40 mm. from the apex, the shell tapers less rapidly at the rate of about 1 in 8.5. Near the larger end the tapering is reduced to 1 in 11. Since the polished section is not a median one, neither the diameter nor the tapering of the specimen can be taken as accurate.

REMARKS: This specimen is characterized by its numerous septa and its variable rate of increase in the different stages of the same individual. Since it is only in part preserved, its characters are insufficiently shown for specific determination.

---

1. Blake: British Fossil Cephalopoda, Pt. I, p. 83, pl. III, figs. 3, 3a.
2. Blake: British Fossil Cephalopoda, Pt. I, p. 82, pl. III, fig. 2.

HORIZON AND LOCALITY: From a polished slab on the pavement along the road from Cha-ti-pu to Chang-chia-chiao, Hsien-ning-hsien, where the country rock is grey thin-bedded limestone corresponding to the reddish limestone in Chung-yang.

Family **CYCLOCERATIDAE** Hyatt

Genus **PROTOCYCLOCERAS** Hyatt

Protocycloceras deprati Reed

Plate VI., Figs. 4a-b, and 5.

1917. *Orthoceras* (*Protocycloceras?*) *deprati*, Reed: Palæontologia Indica, New Ser. Vol. VI, Mem. No. 3, p. 33, pl. V, fig. 15.

1928. *Protocycloceras* (?) *deprati*, Kobayashi: Japanese Journal of Geology and Geography, Vol. V, No. 4, p. 184, pl. XIX, fig. 5.

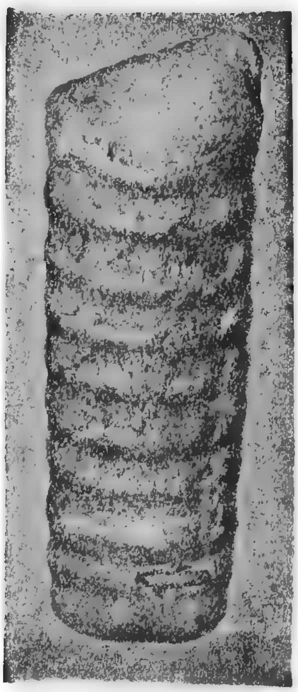


Fig. 4

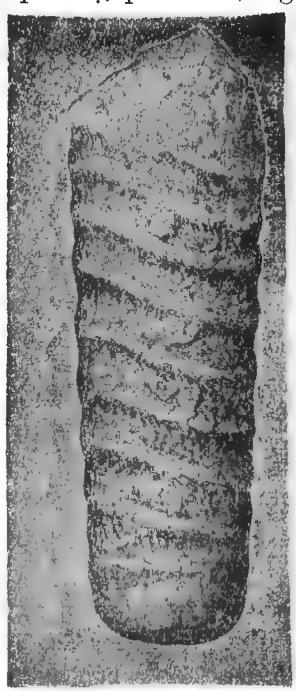


Fig. 5

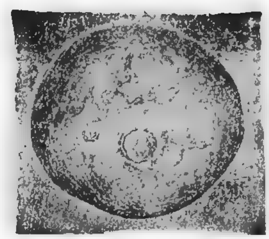


Fig. 6

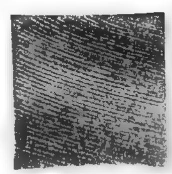


Fig. 7

Fig. 4. *Protocycloceras deprati.* Front view of an internal mould, showing the annualations. Natural size.

Fig. 5. *Protocycloceras deprati.* Side view of the same. Natural size.

Fig. 6. *Protocycloceras deprati.* End view of the same, showing the eccentric siphuncle. Natural size.

Fig. 7. *Protocycloceras deprati.* Portion of the test of another smaller individual. Enlarged five times.

This species is represented by numerous specimens, which are all internal moulds but belong to the same species. In taking the longitudinal section the interior of the specimen is wholly empty without any trace of the internal structures. Nevertheless, the characteristic surface annulations and the position of the siphuncle are cleary shown on the exterior of the moulds.

Shell straight, annulated, with a slightly elliptical section. Owing to the moulds not being well preserved the rate of tapering can not be precisely determined, but in general the conch enlarges in diameter very slowly, about 1 in 20 or even less. Its surface is encircled by coarse, concentric annulations, which are oblique to the axis of the shell and nearly uniformly separated from each other. In some smaller specimens they are distant about 5 mm., but in the larger ones the distance is 6 or 7 mm. from the summit of one ridge to that of the other. The oblique annulations are arched on the opposite side to form broad saddles, which ascend about equal to the space separating them. They occur as ridges with round edges. The interspaces between them are concave and round. In one specimen (Pl. VI., Fig. 5) the annulations and the interspaces between them are again covered with very regular, fine striæ, of which more than ten are contained in a length of 1 mm. No longitudinal striæ are seen at all.

The siphuncle is subcentral and slightly subcircular. It is nearer to the center than to the side of the shell. Its diameter is 4 mm., where the shell measures 21 mm. in minor diameter and 24 mm. in major. It occupies the position across the dorso-ventral diameter and opposite the side bearing the broad saddles.

REMARKS: According to Reed's description[1] the rate of tapering is "at about 1 in 40" and the annulations are "arched up strongly to form a broad high ventral saddle on the siphonal side." I think that Reed only obtained one piece of the broken shell, so the measurement of the tapering may be misleading. Regarding the siphuncle he stated: "The position of the siphuncle is rather obscure", while our specimens indicate the siphuncle lying at one side of the center just opposite the saddles. In any case our shell is undoubtedly the same as Reed's species.

HORIZON AND LOCALITY: This species prevails in the upper part of the Neichiashan near Sin-tan, western Hupeh. Many specimens were collected by J. L. Smith and C. Y. Hsieh respectively.

Genus **CYCLOCERAS** M'Coy

Cycloceras sp.

Plate VI., Fig. 6

Shell straight, cylindrical, and annulated. Section unkown. Only a part of the conch is preserved, being 23 mm. in length. Even though no test remains, yet the surface markings may be examined on the surface of the internal mould. Siphuncle and septa also unknown.

---

1. loc. cit.

The mold is covered by six transverse prominent annulations, which are separated by concave interspaces about 3.5 mm. wide. The annulations are slightly oblique and moderately sharp. Near the uppermost end of the fragment the depressed space is ornamented by numerous fine subimbricating striae, running parallel to the projecting annulations. Besides these, there are a few indistinct longitudinal ridges across the fine transverse striæ.

REMARKS: This specimen is very poorly preserved and the data available are not sufficient for specific identification, even though in external character it is somewhat allied to *Cycloceras peitoutzense* Grabau[1] to a certain degree.

HORIZON AND LOCALITY: From the Yellowish-green shale of the lower Neichiashan formation at Tai-hung-shan, Nan-chang-hsien.

Family **TROCHOLITIDAE** Hyatt

Genus **DISCOCERAS** Barrande

Discoceras eurasiaticum Frech.

Plate IX fig. 5, 6 a-b.

1911. *Discoceras eurasiaticum* Frech: Richthofen's China, Vol. V, p. 5, pl. I, figs. 1a-2b.

1920. *Discoceras eurasiaticum*, Yabe and Hayasaka; Palæontology of Southern China, p. 54, pl. XVIII, figs. 2a-b.

Shell (Pl. IX., Fig. 6) discoidal, consisting of about four volutions, which expand in height very slowly. The diameter of the shell measures 45 mm. from the apertural portion to the opposite periphery passing through the middle part of the umbilicus. The dorsal side of the volutions is slightly impressed by the preceding one. The cross section of the whorl is subquadrate in outline. Near the apertural end it is 15 mm. in breadth and 10 mm. in height. The siphuncle is very small and marginal to the internal side. The surface of the shell is covered by oblique transverse sharp costæ, which bend backward from the internal side toward the external.

There is another well-preserved specimen (Pl. IX., Fig. 5) which is somewhat larger. A part of the test is broken, and the septa are distinctly exposed. The septal distance is greater at the ventral side than at the dorsal. The cameræ are very shallow and increase in depth very slightly. In the gerontic stage the septa are 3.5 mm. distant at the center, while the whorl is about 14 mm. high. The costæ are very numerous, three occurring in a space corresponding to the depth of one camera.

HORIZON AND LOCALITY: The specimens were found in the upper part of the Neichiashan formation at Nei-chia-shan near Sin-tan of Tze-kuei-hsieh, western Hupeh. (J. S. Lee Coll.)

---

1. Grabau: Palæontologia Sinica, Ser. B, Vol. I, fasc. 1, p. 63, pl. VI, Figs. 1-4.

Family **LITUITIDAE** Noetling

Genus **LITUITES** Brogniart

Lituites lii Yü (sp. nov.)

Plate IX., Fig. 7.

The shell is a gyroceracone in the young and becomes straight in the adult stage. Section subcircular. This form is represented by only one specimen which occurs in a natural longitudinal section and can not be separated from the enclosing rock. Therefore, nothing is known of the surface ornamentation of the shell. Apertural portion not preserved.

The coiled part of the conch includes about two volutions. The whorls are separable about 1 mm. or a little more near the apical part, and 2.5 mm. at the place where the second or last volution ends and the shell begins to straighten. The diameter of the coiled part measures about 35 mm. from the larger end of the last whorl to the opposite side across the volutions. In the central part of the first volution there is an open space with a diameter of about 7 mm. The straight part of the shell is slightly bent inwards and attains about 70 mm. in length, expanding slowly at the rate of 1 in 22.

Septa simple, thin, moderately concave. They are more curving forward on the internal or the dorsal side. The intervals between the septa gradually increase toward the aperture. They are about 1/2 the diameter of the shell. At the second volution there are eleven septa in the distance of half a whorl or a length of about 44 mm. Near the larger preserved end they are 9 mm. apart, where the shell has a diameter of 15 mm.

Siphuncle narrow, tubular, lying dorsal of the center. At the upper portion it is 2 mm. distant from the internal side and 11 mm. from the external. In the same stage the widths of the siphuncle and the conch are about 2 mm. and 15 mm. respectively. It is apparently empty, and the septa appear thickened on both upper and lower marginal portion with white organic deposit.

REMARKS: Owing to the fact that the specimen is not well preserved, the generic determination of this form is somewhat doubtful. Foerste said.[1] "It is well known at present, however, that the chief characteristic of true *Lituites* consists of the presence of deep ventral and dorsal sinuses, shallow lateral sinuses and intermediate crests." In our shell the apertural end has not been preserved, whether it is provided with such sinuses and crests or not is not known. Furthermore, the coiled part of this form is also different from that of the genotype *Lituites lituus* Montfort, which has the volutions entirely in contact. Foerste proposed in 1925 the new generic name

1. Foerste: Notes on Cephalopod Genera; chiefly coiled Silurian forms, p. 18.

Bickmorites, taking *Lituites bickmoreanus* Whitfield as its genotype. According to the description[1] given by Foerste *Bickmorites* is a gyroceracone in the early stages with strongly marked transverse rib-like annulations and some other important surface ornamentations, and its siphuncle lies slightly ventral of the center. Although our specimen closely resembles *Bickmorites* in some aspects, its siphuncle is located near the dorsal side and its inner side shows a fairly straight profile in the longitudinal section, indicating that there are no annulations at all. It is not desirable to make a new genus for our shell until we obtain other specimens of the same form which show the external characters.

From the specific point of view, the present form may be related to *Lituites latus* Angelin[2], but the more slender, more slowly tapering, and less bent, straight portion sufficiently distinguishes our shell from Angelin's species.

HORIZON AND LOCALITY: This specimen came from the bed just below the reddish limestone at He-chiao, Chung-yang-hsien. The specific name is given in honor of Mr. C. Li, geologist to the Institute of Geology, National Research Institute of China (C. Li and W. P. Shu Coll.)

Suborder **Cyrtochoanites** Hyatt

Family **ONCOCERATIDAE** Hyatt

Genus **ONCOCERAS** Hall

Subgenus **MELOCERAS** Hyatt

Meloceras asiaticum Yabe

Plate IX., Figs. 8, 9a-c.

1911. *Cyrtoceras* (*Meloceras*) cf. *ellipticum*, Frech: Richthofen's China, Vol. V, p. 6, pl. II, figs. 3a-c.

1920. *Cyrtoceras* (*Meloceras*) *asiaticum*, Yabe: Palæontology of Southern China, p. 52, pl. XVIII, fig. 14; pl. XXVII, figs. 7a-b.

This species is represented by several fragments, which enlarge in diameter very gently. In one of the smaller specimens (Pl. IX., Fig. 9) it is uniformly arcuate and about 40 mm. long along its convex side. The cross section is ovately elliptical. The internal side seems to be thicker than the external. The siphuncle is situated nearly marginal to the external side. It is circular in section and very small in size, measuring 1 mm in diameter, where the corresponding measurements of the shell are 15 mm. in the dorso-ventral diameter and 12.5 mm. in the transverse.

---

1. Foerste: loc. cit. p. 47.
2. Angelin-Lindström: Fragmenta Silurica, p. 9, Tab. XI, figs. 1-4.

The septa are very closely arranged. The septal distance is about 1.3 mm. at the initial portion and very slightly increases to 1.8 mm. at the upper part of the fragment. The septa are more separated along the convex side than on the concave. The cameræ have been filled with white calcite, but the siphuncle is completely empty, except for the mud filling.

The test is rather thick, being about 0.5 mm. Its surface is covered with transverse striæ, which are very fine.

Horizon and Locality: Same as *Discoceras eurasiaticum* Frech, with which the present specimens are associated. (J. S. Lee Collector).

BIBLIOGRAPHY

Angelin, N. P. and Linström, G. 1880—, Fragmenta Silurica.

Barrande, J. 1867—1877—Système Silurien du centre de la Bohême, Vol. II.

Blake, J. F. 1882—British Fossil Cephalopoda, Pt. I.

Brown, J. Coggin 1913—Contributions to the Geology of the province of Yunnan in western China. III. Notes on the stratigraphy of the Ordovician and Silurian beds of western Yunnan. Records of the Geological Survey of India, Vol. XLIII, pt. 1, pp. 327-337.

Clarke, John. M. 1897—The Lower Silurian Cephalopoda of Minnesota. Geol. of Minn., Vol. III., Pt. II.

Crick, G. R. 1903—Notes on some specimens of straight-shelled Nautiloidea collected by the Rev. Samuel Couling, M. A. Ching-Chow-fu, Kiochow, North China, Geol. Mag., N. S., Dec. IV, Vol. X, pp. 481-485, pl. XXII.

Dewitz, H. 1880—Ueber einige ostpreussische Silur-cephalopoden. Zeitschr. d. Deutsch Geol. Gesellsch. Bd. 32, pp. 371—93, Tafel XVI-XVIII.

Etheridge, R. 1878—Palæontology of the coasts of the Arctic Lands visited by the late British Expedition under Captain Sir George Nares. Quart. Journ. Geol. Soc., Vol. XXXIV.

Foerste, Aug. F. 1921—Notes on Arctic Ordovician and Silurian Cephalopods, chiefly from Boothia Felix, King William Land, Bache Peninsula, and Bear Island. Journal of the Scientific Laboratories of Denison University. Vol. XIX.

Foerste, 1924 (B)—Notes on American Palæozoic Cephalopods. Journal of the Scientific Laboratories of Denison University. Vol. XX.

Foerste, 1924 (C)—Upper Ordovician Faunas of Ontario and Quebec. Geol. Surv. Canada. Mem. 138. Ottawa.

Foerste, 1925 (A)—Notes on Cephalopod Genera; Chiefly coiled Silurian forms. Journal of the Scientific Laboratories of Dension University. Vol. XXI.

Foord, A. H. 1887—On "Orthoceras (Endoceras) duplex" Wahlenberg et auctt., with Descriptions of three new species of Endoceras from the Ordovician of Sweden and Russia contained in the British Museum. Ann. and Mag. Nat. Hist., Ser. 5, Vol. XX, pp. 393-402.

Foord, 1888—Catalogue of the fossil Cephalopda in British Museum. Pt. I, Nautiloidea.

Foord, 1891—Ibid. Pt. II, Nautiloidea.

Frech, F. 1895—Ueber Palaeozoische Faunen aus Asien und Nord-afrika. Neues Jahrbuch für Minerologie Geologie und Palaeontologie 1895, Bd. II, pp. 48-51.

Frech, 1911—Das Silur. von China. Richthofen's China, Vol. V, pp. 1-17.

Grabau, A. W. and Shimer, H. W. 1910—North American Index Fossils. Invertebrates. Vol. II.

Grabau A. W. 1916—Comparsion of American and Eurpean Lower Ordovician Formation. Bull. Geol. Soc. am. Vol. 27 pp. 555-622.

Grabau, A. W. 1922—Ordovician Fossils from North China. Pal. Sin. Ser. B, Vol. I, Fasc. I.

Grabau, 1923-24—Stratigraphy of China. Pt. I. Palæozoic and Older. Geological Survey of China.

Grabau, 1928—China in the Ordovician Period. Bulletin of the Geological Society of the National University, Peking. Vol. III, pp. 9-22.

Grabau, 1929—Terms for the Shell-elements in the Holochoanites. Bulletin of the Geological Society of China. Vol. VIII, No. 2, pp, 115-123.

Grabau, 1929—Origin, Distribution, and Mode of Preservation of the Graptolites. Memoir of the Institute of Geology, No. VII, pp. 1-52. National Research Institute of China.

Hall, J. 1847—Palæontology of New York. Vol. I. New York State Geological Survey.

Holm, G. 1885—Ueber die Innere Organisation einiger silurischer Cephalopoden. Paläeont. Abhand. Bd. III, Heft I.

Holm, 1892—Om mynningen hos Lituites. Sveriges Geologiska Undersökning. Ser. C. N:O 121.

Holm, 1892—Om tvenne Gyroceras-formigt böjda Endoceras—arter. Sveriges Geologiska Undersökning. Ser. C. N:O 153.

Holm, 1895—Om de endosifonala bildningarna hos familjen Endoceratidae. Sver. Geol. Und. Ser. C. N:O 153.

Holm, 1896—Om apikaländan hos Endoceras, Sver. Geol. Und. Ser. C. N:O 163.

Holm, 1898—Palaeontologiska notiser. Sver. Geol. Und. Ser. C. N:O 176.

Hsieh, C. Y.1924—Stratigraphy of South-eastern Hupei. Bulletin of the Geological Society of China. Vol. III, No. 2, pp. 91-97.

Hsieh, C. Y. and Chao, Y. T. 1926—Geology of I-chang, Hsingshan, Tzekuei and Pa-tung districts, W. Hupeh. Bulletin of the Geological Survey of China. No. 7.

Hsieh, C. Y. and Liu, C. C. 1927—Geology and Mineral Resources of South-western Hupeh. Bulletin of the Geological Survey of China. No. 9.

Kingsmill, T. W. 1868—Geology of China. Quart. Journ. Geol. Soc. Vol. XXV, p. 119.

Kobayashi, T. 1928 -Ordovician Fossils from Corea and South Manchuria. Japanese Journal of Geology and geography. Vol. V, No. 4, National Research Council of Japan.

Lee, J. S. 1924—Geology of the Gorge District of the Yangtze (From I-Chang to Tze-kuei) with special reference to the development of the Gorges. Bulletin of the Geological Society of China. Vol. III, No. 3-4, pp. 351-391.

Li, C. 1928—Geology of Pu-chi, Kia-yu, Hsien-ning, Chung-Yang, and Wu-chang Districts, Hupeh Province. Memoir of the Institute of Geology. No. III. National Research Institute of China.

Lindström, G. 1888.—List of the Fossil Faunas of Sweden. I. Cambrian and Lower Silurian. Palaeontological Department of the Swedish State Museum (Nat. Hist.).

Lossen, C. 1860.—Ueber einige Lituiten. Zeitschrift der Deutschen Geologischen Gesellschaft. Bd. 12, p. 15.

Nöetling, F. 1882—Ueber Lituites lituus. Zeitschr. d. Deutsch Geol. Gesellsch. Bd. 34, p. 156.

Phillips, J. 1841—Figures and Descriptions of the Palaeozoic Fossils.

Reed, F. R. Cowper 1917—Ordovician and Silurian fossils from Yunnan. Palæont. Indica, New Ser. Vol. VI, Mem. No. 3.

Roemer, F. 1861—Die Fossile Fauna der Silurischen Diluvial-Geschiebe von Sadewitz.

" 1876—Lethaea geognostica. I Theil. Lethaea Palaeozoica. Atlas, Taf. 6.

" and Frech, F. 1880—97—Ibid. Text.

" 1884—85—Lethaea erratica. Dames and Kayser's Palaeontologische Abhandlungen. Bd. II, Heft V.

Ruedemann, R. 1904—Structure of some primitive cephalopods. Report of the New York State Palaeontologist 1903. N. Y. State Museum. Bull. 80, pp. 296—384, pls. 6-13.

" 1906—Cephalopoda of the Beekmantown and Chazy Formation of the Champlain Basin. New York State Museum. Bull. 90, pp. 393-605, 38 plates.

Salter, J.W. 1851—Silurian Fossils of Ayrshire. In Murchison's on the Silurian Rocks of the South of Scotland. Quart. Journ. Geol. Soc. Vol. VII, p. 173.

Salter 1858—Fossils of the Durness Limestone. In Murchison's On the succession of the Older Rocks in the Northermost Countries of Scotland., etc. Quart. Journ. Geol. Soc., Vol. XV, p. 374.

Sedgwick and M'Coy, 1855—British Palæozoic Rocks and Fossils.

Troedsson, G. T. 1926—On the Middle and Upper Ordovician Faunas of Northern Greenland, I. Cephalopods. Jubilaeumsekspeditionen Nord om Grønland, 1920-23, Nr. 3.

Weller, Stuart 1913—A report on Ordovician Fossils collected in Fastern Asia in 1903—04. In "Research in China". Vol. III, pp. 279-294.

Willis, B. and Blackwelder, E. 1912—Research in China. Vol. I, pt. I.

Woodward, S. P. 1856—On an Orthoceras from China. Quart. Journ. Geol. Soc. Vol. XII.

Yabe, H and Hayasaka, I. 1920—Palaeontology of Southern China. Geographical Research in China, Vol. III.

Yü, C. C. and Shu. W.P. 1929—Geology of Siang-yang, Nan-chang, I-cheng, Ching-men, Chung-hsiang and Ching-shan Districts, North Hupeh. Memoir of the Institute of Geology, No. VIII. National Research Institute of China.

Zittel, Karl A. v. = Eastmann, Charles R. 1913—Text Book of Palæontology, Vol. I.

EXPLANATION OF

PLATE I

PLATE I.

Fig. 1. *Cameroceras* cf. *styliforme* Grabau. Nat. size...................... p. 23

View of a portion of the endoconch embedded in rock.

Loc:—Lo-jo-ping, I-chang-hsien, W. Hupeh. (G. S. C. Cat, No. 2826)

Fig. 2. *Cameroceras* cf. *styliforme* Grabau. Nat. size...................... p. 23

2a. External view of endoconch, showing the oblique ectoseptal edges on the external surface of the endotheca.

2b. Cross section of the same specimen, showing older endosepta, the aperture of the endocone and the form of the endoconch.

Loc:—Lo-jo-ping, I-chang-hsien, W. Hupeh. (G. S. C. Cat. No. 2827)

Fig. 3. *Cameroceras* cf. *styliforme* Grabau. Nat. size...................... p. 23

Longitudinal section of an endoconch, showing the endosepta.

Loc:—Lo-jo-ping, I-chang-hsien, W. Hupeh. (G. S. C. Cat. No. 2828)

Fig. 4. *Cameroceras hsiehi* Yü. Nat. size.............................. p. 25

4a. Longitudinal section, showing the endotheca, last endoseptum, endocone and ectosepta.

4b. Cross section of same, showing the circular endoconch which is in juxtaposition with the ectoconch.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2831)

Fig. 5. *Cameroceras subtile* Yü. Nat. size.............................. p. 26

5a. Longitudinal section of a mature portion, showing the endotheca and the nature of stereoplasmic deposit in the cameræ.

5b. Cross section, showing the excentric endoconch.

Loc:—near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2832)

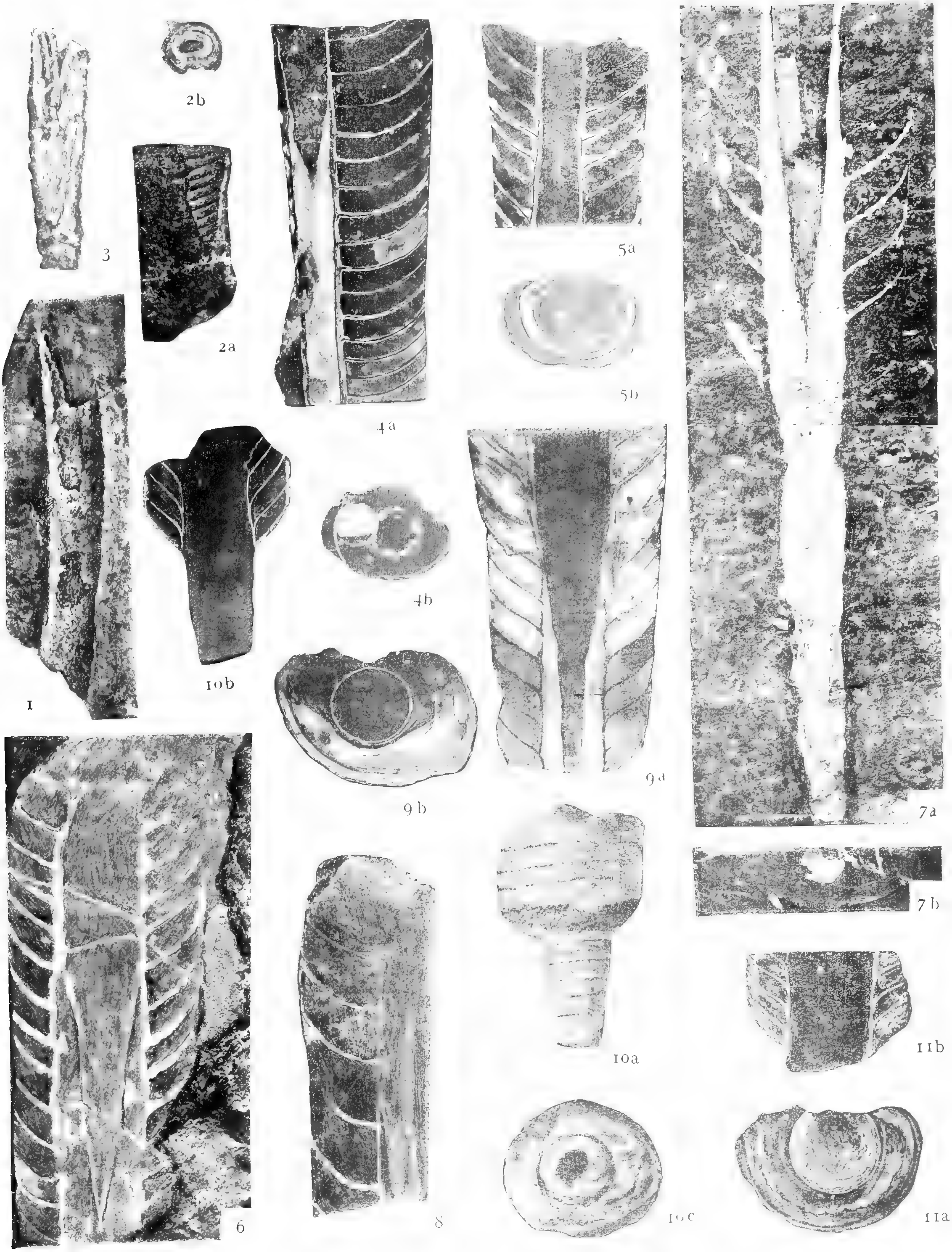
Fig. 6. *Endoceras leei* Yü. Nat. size.................................. p. 28

A natural weathered section, showing the tubi, one camera in length, and the acute apical angle formed by the endosepta.

Loc:—San-shan-yuan, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 1)

Fig. 7. *Endoceras leei* Yü. Nat. size.................................. p. 28

7a. Natural polished section, showing the length of tubi and the last endoseptum. The endoconch is wholly filled with calcite deposit.


3
2b
2a
4a
5a
5b
1
10b
4b
9b
9a
7a
7b
6
8
10a
11b
10c
11a

7b. Cross section at the apical end of endoconch of the same specimen, showing the excentric endosiphuncle and the form of endoconch.

Loc.:—He-chiao, Chung-yang-hsien, SE. Hupeh. (N.R.I. Cat. No. 2)

Fig. 8. *Vaginoceras belemnitiforme* Holm. Nat. size........................ p. 36

Longitudinal section, showing the tapering of shell, the ectoseptal distances and the position and the size of the endoconch.

Loc:—Near Ta-fang village, Yang-sin-hsien, E. Hupeh. (G.S.C. Cat. No. 2835)

Fig. 9. *Vaginoceras neichianense* Yü. Nat. size........................ p. 39

9a. Longitudinal section, showing the ectoseptal distances, the rate of tapering and the endoconch with the stereoplasmic filling.

9b. Cross section.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2836)

Fig. 10. *Vaginoceras reedi* Yü. Nat. size................................ p. 40

10a. Portion of a weathered individual, showing the ectoconch with a part of endoconch exposed.

10b. Longitudinal section of same, showing the closely set ectosepta and the entirely empty endoconch.

10c. End view of same, showing the form and position of endoconch.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2838)

Fig. 11. *Vaginoceras reedi* Yü. Nat. size................................ p. 40

11a. Longitudinal section of a portion of the shell, showing the size of endoconch and the ectoseptal distances.

11b. Cross section.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2839)

EXPLANATION OF

PLATE II

PLATE II.

Fig. 1. *Cameroceras tenuiseptum* Hall var. *ellipticum* Yü. Nat. size......... p. 24

Polished section, showing the endotheca, size of endoconch, and the closely set ectosepta.

Loc:—Nei-chia-shan, near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2829)

Fig. 2. *Cameroceras tenuiseptum* Hall var. *ellipticum* Yü. Nat. size.......... p. 24

View of a portion of speçimen weathered so as to show the protruding endoconch.

Loc:—Nei-chia-shan near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2830)

Fig. 3. *Cameroceras* sp. Nat. size.. p. 27

Polished section of a fragment of the specimen. The endotheca is clearly shown.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2833)

Fig. 4. *Endoceras grabaui* Yü. Nat. size.............................. p. 29

A natural weathered section, showing the length of tubi, the last endoseptum and endocone.

Loc:—Shih-lung-sze, Wang-chia-chi, I-chang-hsien, N. Hupeh. (N.R.I. Cat. No. 3)

Fig. 5. *Vaginoceras endocylindricum* Yü. Nat. size .... p. 33

5a. External view of a natural weathered specimen, showing the rate of tapering and the ectosepta.

5b. Longitudinal section, showing the long empty endocylinder. The section is taken nearly normal to the dorso-ventral diameter of the shell.

5c. Cross section of same, showing the form of ectoconch and the position, form and size of endoconch.

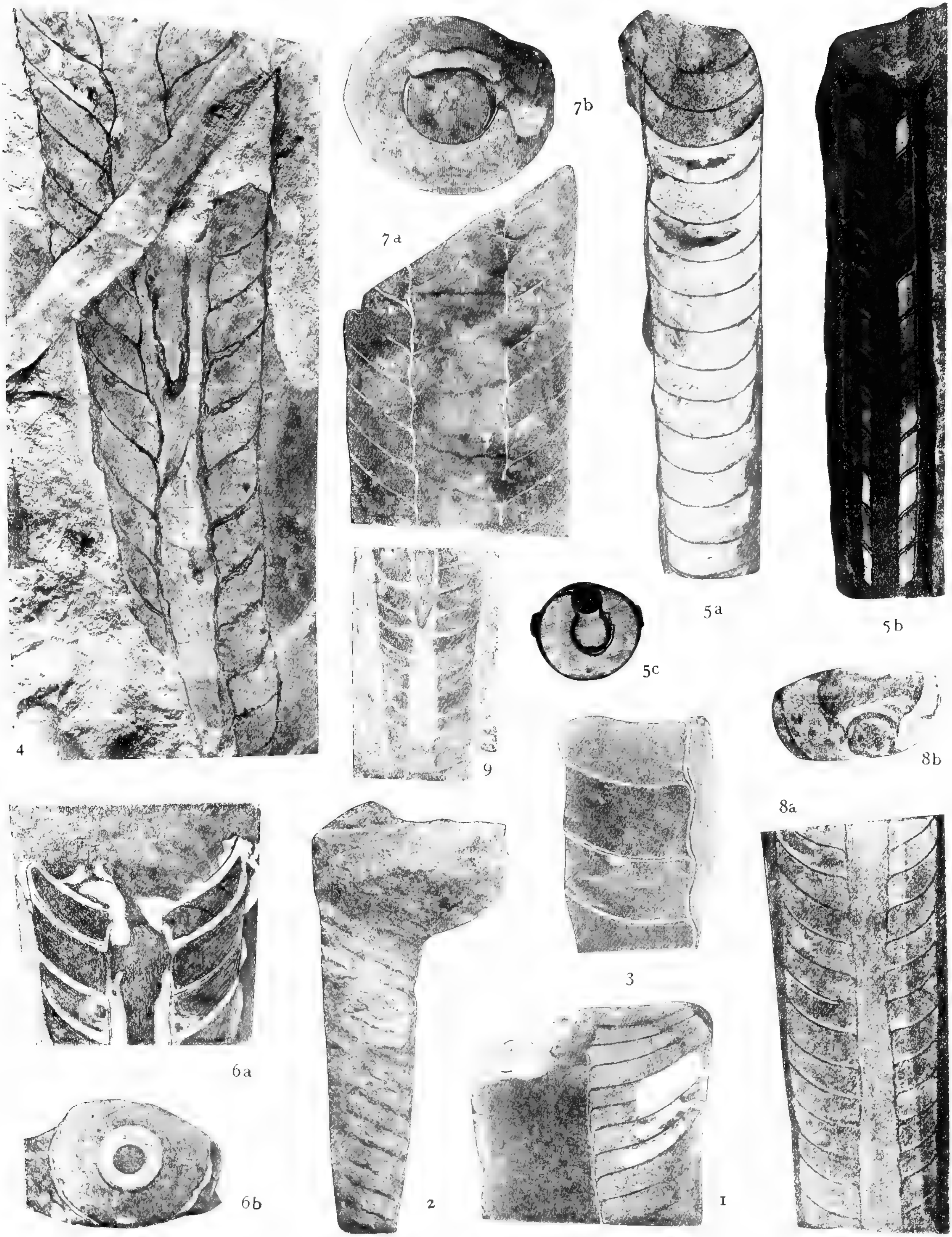
Loc:—Near Ta-fang village, Yang-sin-hsien, E. Hupeh. (G.S.C. Cat. No. 2834)

Fig. 6. *Vaginoceras neichianense* Yü. Nat. size.......................... p. 39

6a. Longitudinal section of the large end of a shell with the last endoseptum and endocone.

C. C. Yü: Ordovician Cephalopoda of Central China

Pl. II.



6b. Cross section, showing the position and form of endoconch, and the shape of endocone.

Loc:—San-shan-yuan, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 13)

Fig. 7. *Vaginoceras neichianense* Yü. Nat. size.......................... p. 39

7a. Polished section of the superior part of the specimen, showing the endocylinder and the ectosepta with a very small amount of stereoplasmic deposit.

7b. Cross section, showing the form and position of endoconch.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2837)

Fig. 8. *Vaginoceras uniforme* Yü. Nat. size............................ p. 42

8a. Longitudinal section of a mature portion of a shell showing the uniform ectoseptal distances and the rate of tapering.

8b. Cross section, showing the form of the marginal endoconch.

Loc:—San-shan-yuan, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 14)

Fig 9. *Vaginoceras uniforme* Yü. Nat. size............................ p. 42

Longitudinal section of a fragment of the specimen. showing the ectoseptal distances and the size of endoconch.

Loc:—San-shan-yuan, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 15)

EXPLANATION OF

PLATE III

PLATE III.

Fig. 1. *Vaginoceras wahlenbergi* Foord. $\times \frac{1}{2}$ . . . . p. 30

1a. A natural polished section, showing the rate of tapering and the ectoseptal distances of the borken lower portion of the specimen.

1b. Longitudinal section, showing the endoconch, the endocylinder, and the ectosepta. The section is transverse to the dorso-ventral diameter of the shell.

Loc:—Tai-hung-shan, Nan-chang-hsien, N. Hupeh. (N.R.I. Cat No. 4)

Fig. 2. *Vaginoceras endocylindricum* Yü. $\times \frac{7}{10}$ . . . . p. 33

2a. A natural section, showing the rate of tapering.

2b. Cross section at the stage f of the same specimen, showing the forms of ectoconch and the submarginal endoconch.

2c. Longitudinal section of a fragmentary portion of the same shell, showing the long endocylinder, endocone and the last endoseptum.

2d. Cross section at the stage h of same, showing the submarginal endoconch with a very small endosiphuncle at its middle part.

Loc:—Ta-wu-shu, Chung-yang-hsien, SE. Hupeh. (N.R.I. Cat. No. 7)

Fig. 3. *Vaginoceras endocylindricum* Yü. Nat. size . . . . p. 33

3a. View of a natural section weathered so as to show a part of the endoconch preserved at the apical part of the fragment.

3b. Cross section at the lower end of the shell, showing the form of ectoconch and the position of the endoconch.

Loc:—Ta-wu-shu, Chung-yang-hsien, SE. Hupeh. (N.R.I. Cat. No. 8)

Fig. 4. *Vaginoceras giganteum* Yü. $\times \frac{1}{2}$ . . . . p. 45

4a. Natural polished section, showing the rate of tapering, the depth of septa and the endoconch. The endoconch at the middle part of the specimen has been partly weathered away.

4b. Cross section with an excentric endoconch.

Loc:—Ta-wu-shu, Chung-yang-hsien, SE. Hupeh. (N.R.I. Cat. No. 16)

Fig. 5. *Orthoceras chinense* Foord. Nat. size . . . . p. 46

5a. Longitudinal section, showing the length of septal necks, the depth of cameræ and the rate of tapering.

5b. Cross section, showing the position of the rounded siphuncle.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2843)

C. C. Yü: Ordovician Cephalopoda of Central China

Pl. III.

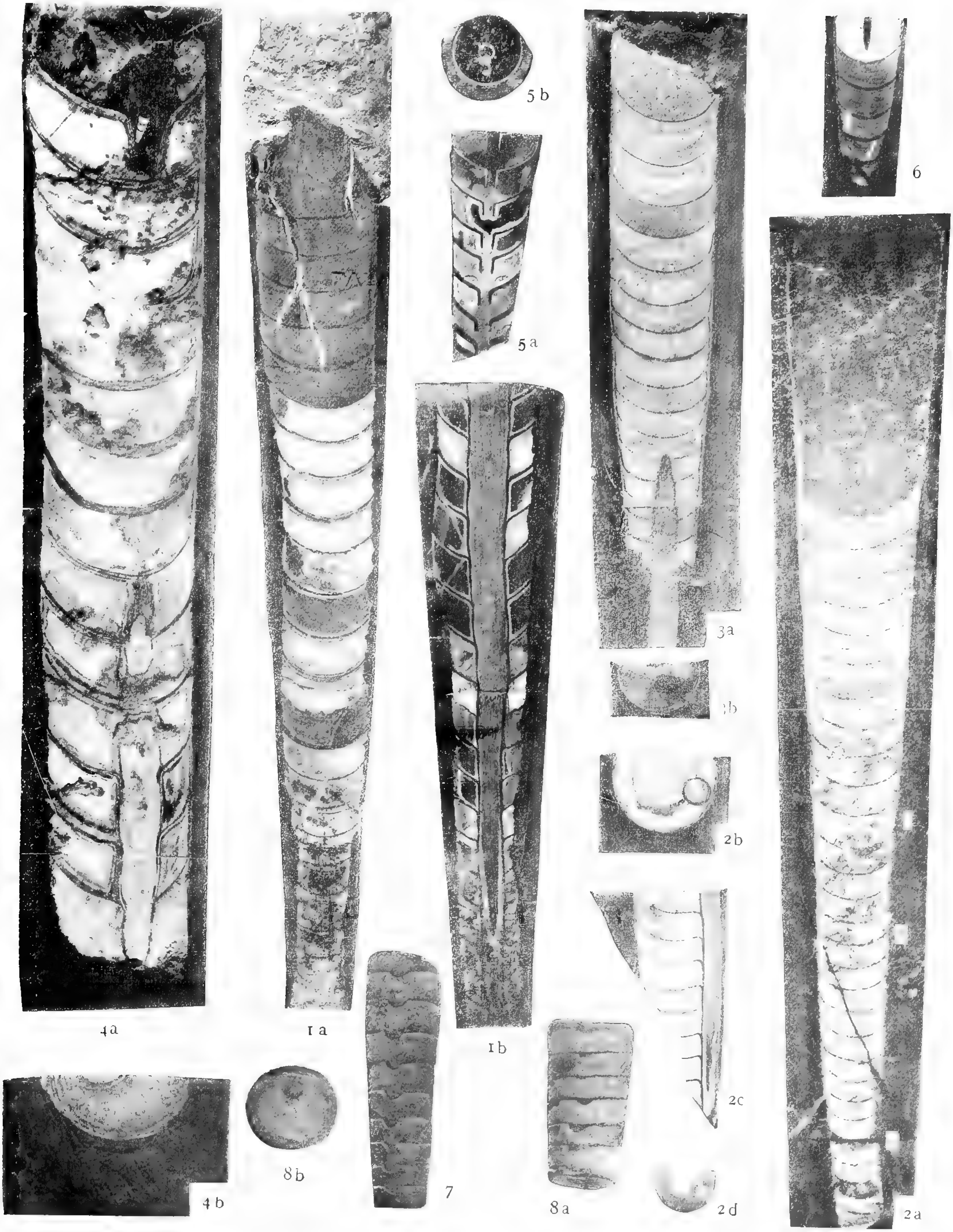


Fig. 6. *Orthoceras* cf. *politum* M'Coy. Nat. size.......................... p. 52

A natural weathered section with a part of siphuncle preserved at the upper end of the specimen.

Loc:—Ta-hung-shan, Nan-chang-hsien, N. Hupeh. (N.R.I. Cat. No. 32)

Fig. 7. *Orthoceras yangtzeense* Yü. Nat. size............................. p. 59

External view of an internal mould of the shell, showing the V-shaped lobes formed by the septal sutures.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2851)

Fig. 8. *Orthoceras yangtzeense* Yü. Nat. size............................. p. 59

8a. External view of an internal mould, showing the V-shaped lobes.

8b. End view of the same specimen, showing the size and form of the submarginal siphuncle at the opposite side of the V-shaped lobes.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2852)

EXPLANATION OF

PLATE IV

PLATE IV.

Fig. 1. *Vaginoceras wahlenbergi* Foord var. *cylindrica* Yü. Nat. size........ p. 32

Longitudinal section, showing the endocylinder, the ectosepta and the rate of tapering.

Loc: –He-chiao, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 5)

Fig. 2. *Vaginoceras wahlenbergi* Foord var. *cylindrica* Yü. Nat. size........ p. 32

2a. Natural polished section, showing the rate of tapering and the depth of ectosepta.

2b. Longitudinal section with a large endocylinder. The section does not pass through the middle part of the endocylinder in the upper part of the specimen.

Loc:—Liu-chia-sze, Hsien-ning-hsien, SE. Hupeh. (N.R.I. Cat. No. 6)

Fig. 3. *Vaginoceras shui* Yü. Nat. size.................................. p. 37

3a. A natural polished longitudinal section, showing the very long tubi, endosepta, depth of ectosepta and the rate of tapering.

3b. Cross section with a submarginal endoconch.

Loc:—Wang-chia-sze, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 11)

Fig. 4. *Orthoceras chinense* Foord. Nat. size.......................... p. 46

4a. Longitudinal section, showing the tapering, the septal necks and the depth of cameræ.

4b. Cross section, showing the form of shell and the size of the central, circular siphuncle.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No 2844)

Fig. 5. *Orthoceras regulare* Schlotheim. Nat. size........................ p. 52

Longitudinal section, showing the septal necks, septal distances and the rate of tapering.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2848)

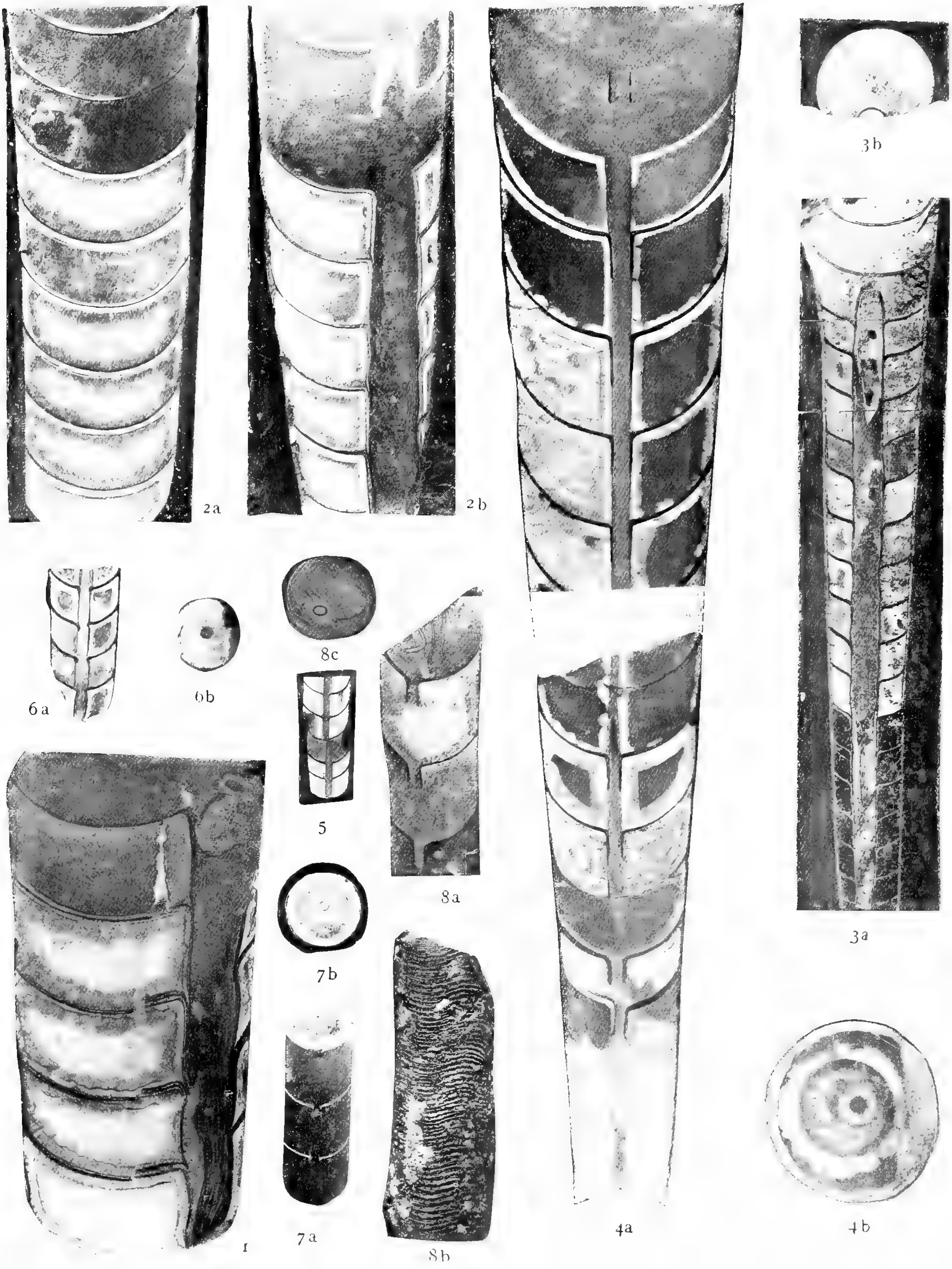
Fig. 6. *Orthoceras regulare* Schlotheim. Nat. size........................ p. 52

6a. Longitudinal section, showing the tapering, the septa and septal necks.

6b. Cross section, showing the form of shell and the position of siphuncle.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2849)

Fig. 7. *Orthoceras squamatulum* Barrande. Nat. size..................... p. 53


2a
2b
3b
3a
6a
6b
8c
5
8a
7b
7a
8b
1
4a
4b

7a. Longitudinal section, showing the deep cameræ, the short septal necks and the gentle rate of tapering.

7b. Cross section.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2850)

Fig. 8. *Orthoceras rudum* Yü. Nat. size.................................. p. 55

8a. Longitudinal section, showing the septal necks and the septal distances.

8b. External view of the same specimen, showing the lines of growth.

8c. Cross section.

Loc:—Near He-chiao, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 26)

EXPLANATION OF

PLATE V

PLATE V.

Fig. 1. *Vaginoceras peiyangense* Yü. $\times \frac{1}{2}$ .... p. 35

1a. Natural polished section, showing the rate of tapering and the ectoseptal distances.

1b. Longitudinal section of the broken apical portion of the same specimen, showing the endoconch and the endocylinder. The section is slightly oblique to the dorso-ventral diameter.

Loc:—Pei-yang-shan, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 9)

Fig. 2. *Vaginoceras peiyangense* Yü. Nat. size........................... p. 35

2a. Longitudinal section with a portion of endoconch and some tubi adhering to it at the lower part of the specimen.

2b. Cross section, showing the position and form of endoconch.

Loc:—He-chiao, Chung-yang-hsien, SE. Hupeh. (N.R.I. Cat. No. 10)

Fig. 3. *Vaginoceras chientzekouense* Yü. Nat. size........................ p. 38

Longitudinal section, showing the endocylinder and the ectosepta. The section is nearly normal to the dorso-ventral diameter of the shell.

Loc:—Chien-tze-kou, Nan-chang-hsien, N. Hupeh. (N.R.I. Cat. No. 12)

Fig. 4. *Vaginoceras uniforme* Yü. Nat. size.............................. p. 42

4a. Longitudinal section, showing the uniformity of the ectoseptal distances.

4b. Cross section with a submarginal endoconch.

Loc:—Near Ta-fang village, Yang-sin-hsien, E. Hupeh. (G.S.C. Cat. No. 2840)

Fig. 5. *Vaginoceras multiplectoseptatum* Yü. Nat. size..................... p. 44

Longitudinal section, showing the numerous ectosepta and the marginal endoconch.

Loc.:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2841)

Fig. 6. *Vaginoceras multiplectoseptatum* Yü. Nat. size.................... p. 44

External view of a weathered specimen, showing the multiple ectoseptal sutures and the rate of tapering.

Loc:—Near Sin-tan. Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2842)

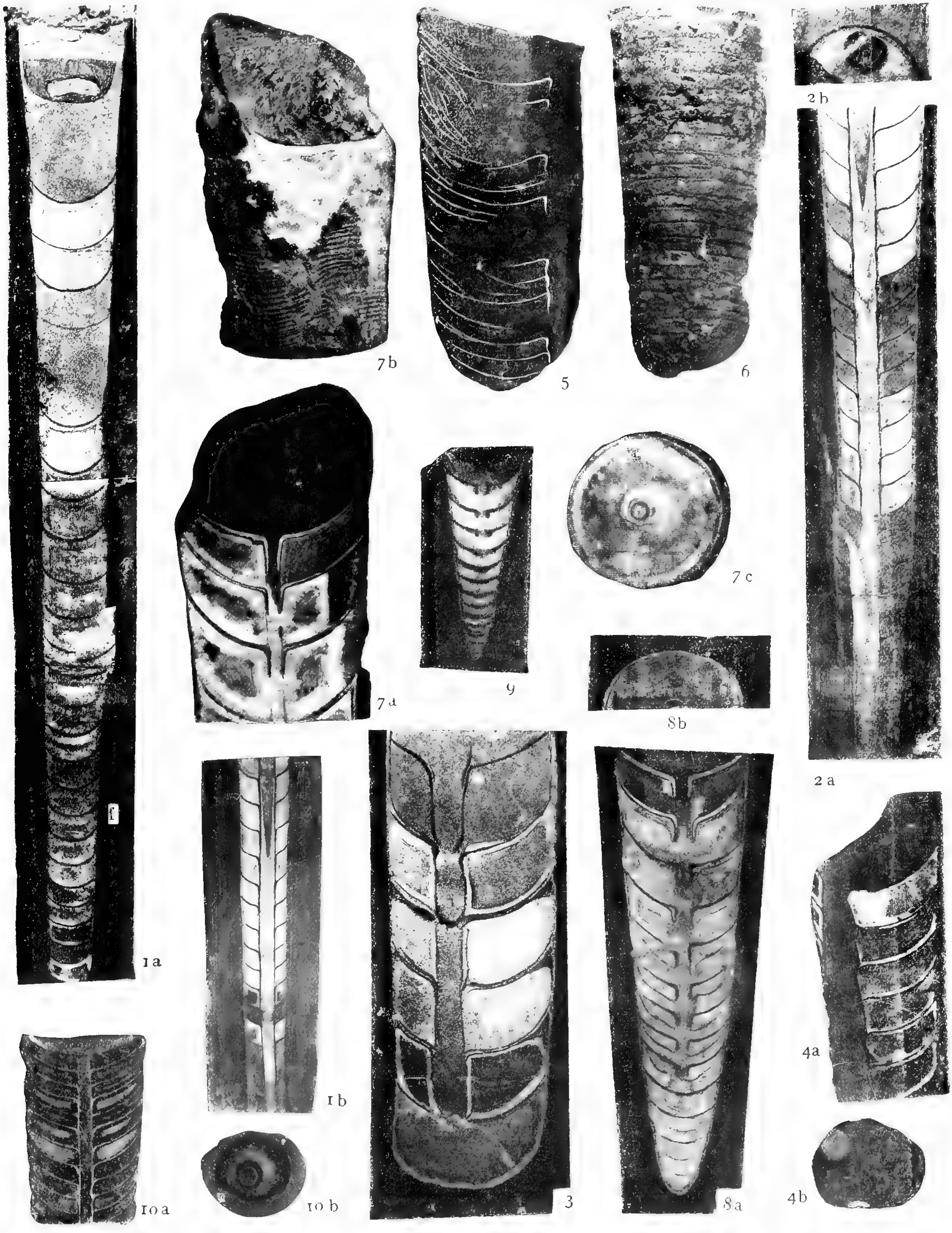

7b
5
6
2b
2a
1a
f
7a
9
7c
8b
1b
3
8a
4a
4b
10a
10b

Fig. 7. *Orthoceras chinense* Foord. Nat. size.............................. p. 46

7a. Longitudinal section of the large end of the shell, showing the septal necks, septal distances and rate of tapering.

7b. External view of same. The regular, flexuous, transverse striæ are plainly shown.

7c. Cross section, showing the form of the shell and the position of the siphuncle.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2845)

Fig. 8. *Orthoceras suni* Yü. Nat. size.................................. p. 56

8a. Longitudinal section of the apical portion of the specimen, showing the rate of tapering and septal distances.

8b. Cross section, showing the sub-elliptical form of shell and the position of the siphuncle.

Loc.:—Pei-yang-shan, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 29)

Fig. 9. *Orthoceras suni* Yü. Nat. size.................................. p. 56

Natural section, showing the rate of tapering, septal necks and the depth of cameræ.

Loc:—Pei-yang-shan, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 30)

Fig. 10. *Orthoceras? wongi* Yü. Nat. size................................ p. 60

10a. Longitudinal section, showing the continuous septal necks.

10b. Cross section, showing the forms of both the shell and the siphuncle.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2853)

EXPLANATION OF

PLATE VI

PLATE VI.

Fig. 1. *Orthoceras chinense* Foord. Nat. size.............................. p. 46

1a. Longitudinal section showing the septal necks, septal distances and rate of tapering.

1b. Cross section, with a central rounded siphuncle.

Loc:—Lo-jo-ping, I-chang-hsien. W. Hupeh. (G. S. C. Cat. No. 2846)

Fig. 2. *Orthoceras chinense* Foord. Nat. size.............................. p. 46

2a. Longitudinal section, showing the rate of tapering and septal distances.

2b. External view of same, showing the fine transverse striæ.

2c. Cross section. The small dark ring is not a siphuncle. It is formed by cutting the septa just above the septal neck.

Loc:—Tai-hung-shan, Nan-chang-hsien, N. Hupeh. (N.R.I. Cat. No. 17)

Fig. 3. *Orthoceras densum* Yü. Nat. size.................................. p. 58

3a. Longitudinal section, showing the very crowded septa at the apical portion of the shell.

3b. Cross section.

Loc:—Chien-tze-kou, Nan-chang-hsien, N. Hupeh. (N.R.I. Cat. No. 27)

Fig. 4. *Protocycloceras deprati* Reed. Nat. size........................... p. 62

4a. Front view of an internal mould, showing the annulations and the rate of tapering.

4b. Lateral view of same, showing the annulations arched on the backside.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2854)

Fig. 5. *Protocycloceras deprati* Reed. Nat. size........................... p. 62

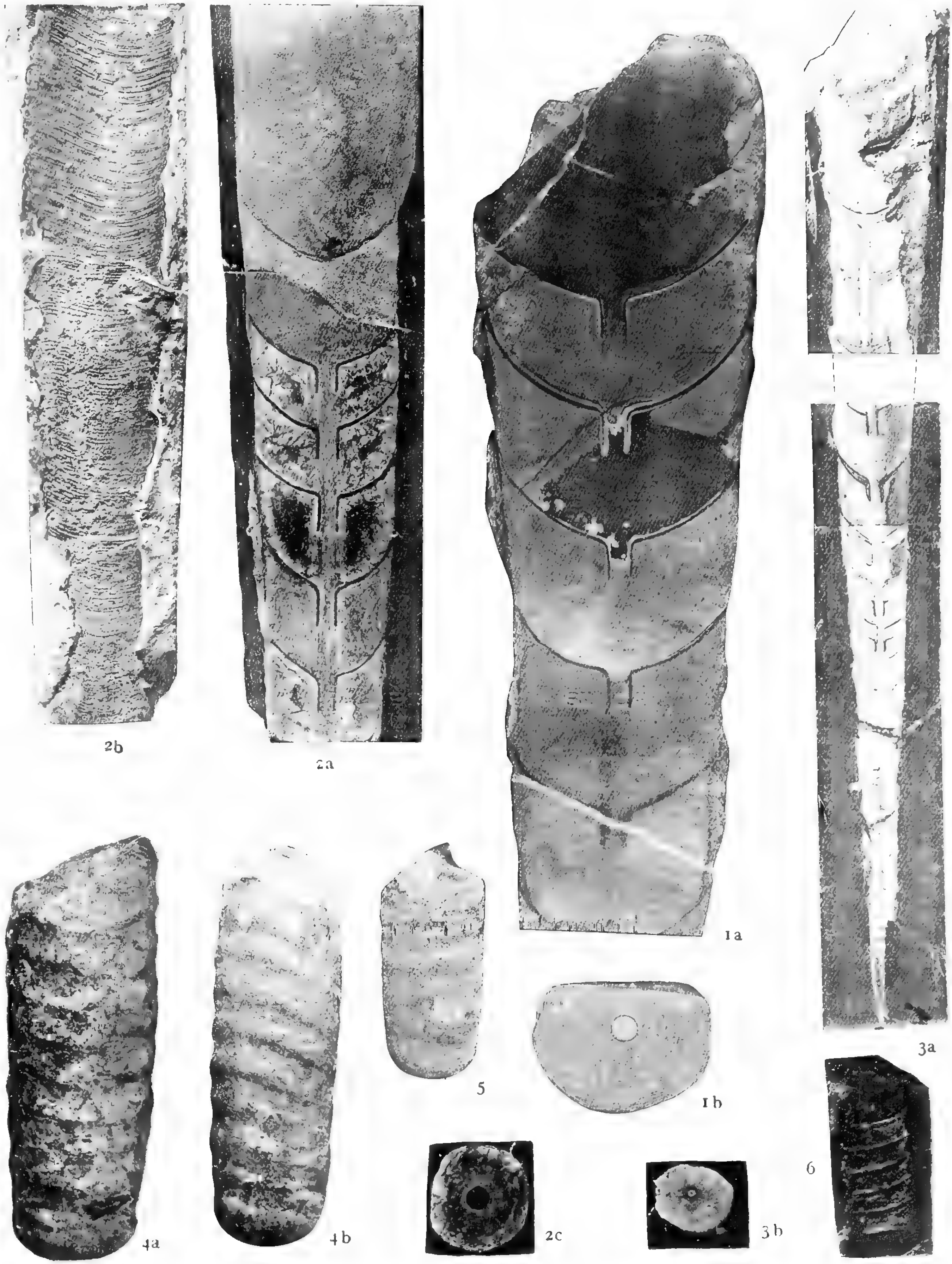
External view of a portion of the mould with fine striæ on the annulations and the interspaces between them.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No.2855)

Fig. 6. *Cycloceras* sp. Nat. size....................................... p 63

Portion of a mould, showing the oblique annulations and the longitudinal and transverse striæ near the upper end of the fragment.

Loc:—Tai-hung-shan, Nan-chang-hsien, N. Hupeh. (N.R.I. Cat. No. 35)


2b
2a
1a
3a
5
1b
6
4a
4b
2c
3b

EXPLANATION OF

PLATE VII

PLATE VII.

Fig. 1. *Orthoceras chinense* Foord var. *kuangchiaoensc* Yü. Nat. size........ p. 48

1a. Polished section, showing the septal distances and the rate of tapering. The last camera below the living chamber is free from any deposit.

1b. External view of the same, showing the growth-lines.

1c. Cross section.

Loc:—Near Chiang-chia-chi, Kuang-chiao-pu, King-shan-hsien, N. Hupeh. (N.R.I. Cat. No. 19)

Fig. 2. *Orthoceras chinense* Foord var. *kuangchiaoense* Yü. $\times \frac{1}{5}$ .... p. 48

A natural weathered section, showing the rate of tapering and the septal distances.

Loc:—Near Wang-chia-sze, Chung-yang-hsien, SE. Hupeh. (N. R. I. Cat. No. 20)

Fig. 3. *Orthoceras thyrsus*? Barrande. Nat. size......................... p. 54

3a. Longitudinal section of a superior portion, showing the rate of tapering, septal necks and the septal distances.

3b. Cross section.

Loc:—Near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2847)

Fig. 4. *Orthoceras remotum* Yü. Nat. size............................. p. 54

4a. A natural polished section, showing the depth of camerae, the concavity of septa and the rate of tapering.

4b. Cross section, showing the form of shell and the position of siphuncle.

Loc:—Chai-tze-shan, Hsiang-yang-hsien, N. Hupeh. (N. R. I. Cat. No. 25)

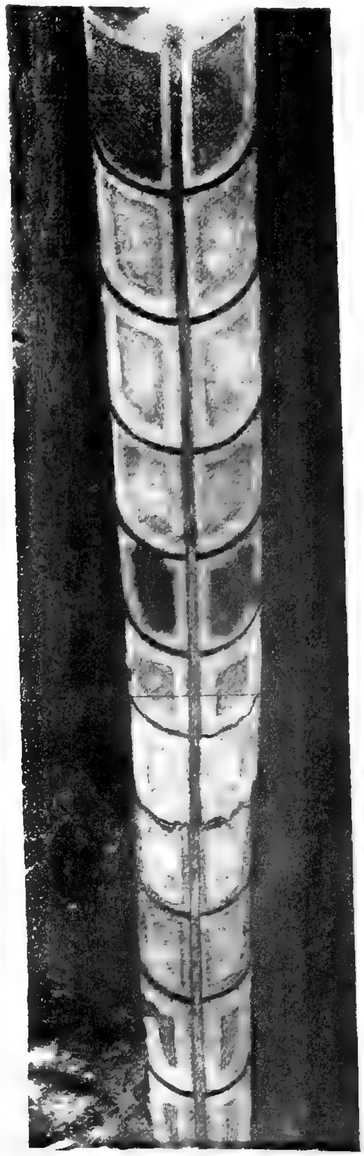
Fig. 5. *Orthoceras elongatum* Yü. Nat. size............................ p. 57

Longitudinal section, showing the long septal distances and the rate of tapering.

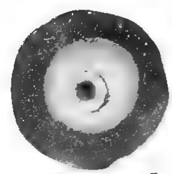
Loc.:—Ta-wu-shu, Chung-yang-hsien, SE. Hupeh. (N.R.I. Cat. No. 31)

C. C. Yü: Ordovician Cephalopoda of Central China

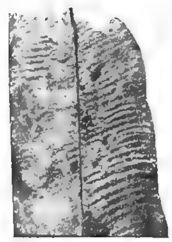
Pl. VII.



1a



1c



1b

EXPLANATION OF

PLATE VIII

PLATE VIII.

Fig. 1. *Vaginoceras*? sp. $\times \frac{2}{5}$ .... p. 45

External view of an internal mould embedded in rock with sharp impressed annular lines on its surface.

Loc:—Pei-hu-pu, Pu-chi-hsien, SE. Hupeh. (N.R.I. Cat. No. 35)

Fig. 2. *Orthoceras chinense* Foord var. *eccentrica* Yü. Nat. size............ p. 49

Longitudinal section, showing the excentric siphuncle, the rate of tapering and the septal distances.

Loc:—Wang-chia-sze, Chung-yang hsien, SE. Hupeh. (N. R. I. Cat. No. 18)

Fig. 3. *Orthoceras chinense* Foord var. *equiseptatum* Yü. Nat. size.......... p. 50

Natural polished section, showing the septal necks and the nearly equidistant septa toward the apertural end.

Loc:—Pei-hua-pu, Pu-chi-hsien, SE. Hupeh. (N.R.I. Cat No. 21)

Fig. 4. *Orthoceras chinense* Foord var. *equiseptatum* Yü. Nat. size.......... p. 50

A natural section weathered so as to show a part of siphuncle and the septal distances.

Loc:—Pei-hua-pu, Pu-chi-hsien, SE. Hupeh. (N.R.I. Cat. No. 22)

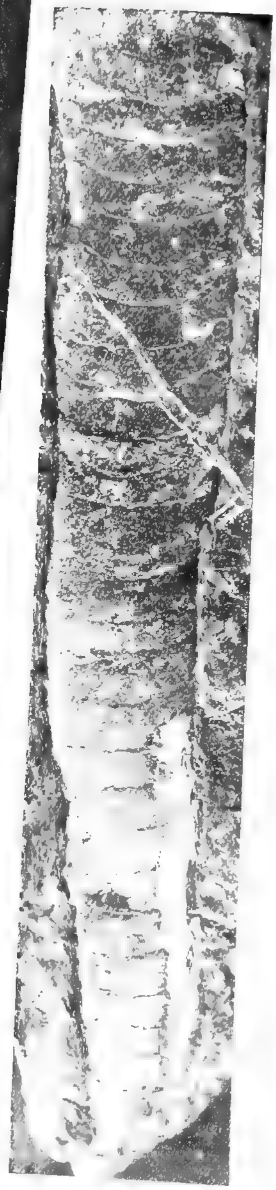
Fig. 5. *Orthoceras chinense* Foord var. *equiseptatum* Yü. Nat. size.......... p. 50

Longitudinal section, showing the septal distances and the septal necks.

Loc:—Mei-hua-ling, Tung-chiao-cheng, King-shan-hsien, N. Hupeh. (N.R.I Cat. No. 23)

2

3



1

4

5

EXPLANATION OF

PLATE IX

PLATE IX.

Fig. 1. *Orthoceras chinense* Foord var. *equiseptatum* Yü. Nat. size.......... p. 50

1a. Longitudinal section, showing the septal distances and the septal necks.

1b. Cross section, with a central circular siphuncle.

Loc:—Heh-chia-tzui-tze, Chang-chia-chi, Chung-chei-hsien, N. Hupeh. (N.R.I. Cat. No. 24)

Fig. 2. *Orthoceras densum* Yü. Nat. size.............................. p. 58

A natural weathered section of a young stage of the shell, showing the numerous septa at the apical portion.

Loc:—Lin-chia-chung, Kung-chia-wang, I-cheng, N. Hupeh. (N.R.I. Cat. No. 28)

Fig. 3. *Orthoceras* sp. Nat. size.................................... p. 60

Lateral view of the specimen, showing the oblique septal sutures.

Loc.:—Pei-ting-tze, Hu-chia-chi, Chung-hsiang-hsien, N. Hupeh. (N.R.I. Cat. No. 33)

Fig. 4. *Orthoceras* sp. Nat. size.................................... p. 61

A natural polished section. The siphuncle has been completely eroded away.

Loc:—Between Cha-ti-pu and Chang-chia-chiao, Hsien-ning-hsien, SE. Hupeh. (N.R.I. Cat. No. 34)

Fig. 5. *Discoceras eurasiaticum* Frech. Nat. size........................ p. 64

Side view of a characteristic shell, showing the costæ on the surface of the shell and the septal sutures as exposed at the last half volution where the test has been broken away.

Loc:—Nei-chia-shan near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2856)

Fig. 6. *Discoceras eurasiaticum* Frech. Nat. size........................ p. 64

6a. Side view of a small specimen, showing the volutions and the costæ on the surface of the shell.

6b. Transverse section of same, showing the whorls subquadrate in section and the siphuncle marginal to the internal side. The section is taken across the middle part of the umbilicus.

Loc:—Nei-chia-shan near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2857)

C. C. Yü: Ordovician Cephalopoda of Central China

Pl. IX.

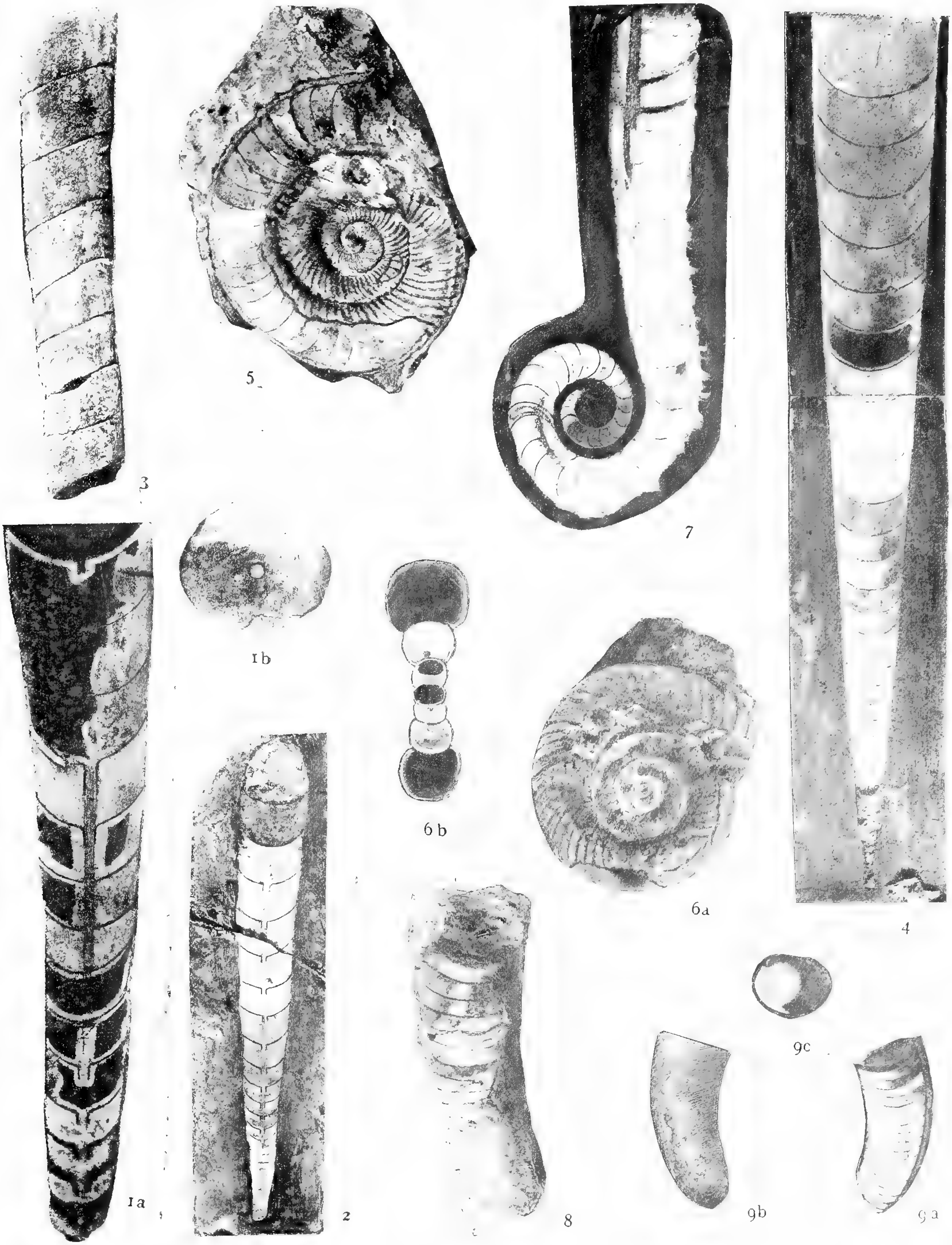


Fig. 7. *Lituites? lii* Yü. Nat. size.................................... p. 65

Side view of natural section, showing the separable volutions, the straight part of the shell and the position of siphuncle.

Loc:—He-chiao, Chung-yang-hsien, SE. Hupeh. (N.R.I. Cat. No. 36)

Fig. 8. *Meloceras asiaticum* Yabe. Nat. size............................. p. 66

Lateral view of a large end of the specimen, showing the curvature of the shell.

Loc:—Nei-chia-shan, near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2858)

Fig 9. *Meloceras asiaticum* Yabe. Nat. size............................. p. 66

9a. Longitudinal section of an apical portion of the specimen along the dorso-ventral diameter, showing the empty, marginal siphuncle and the curvature of the shell.

9b. External view of same, showing the surface striæ.

9c. Cross section, showing the form of the shell and the position of the siphuncle.

Loc:—Nei-chia-shan near Sin-tan, Tze-kuei-hsien, W. Hupeh. (G.S.C. Cat. No. 2859)

4. 直角石 Orthoceras 外殼多爲長直形，體管小，其位置常居中，或微偏，壁襟短，外壁平滑，或具生長紋。（本屬共有十七種）

5. 原環節角石 Protocycloceras 形爲直角石狀，或弓角石狀，外壁具環節，幼殼或有直紋可見，體管大。（本屬只有一種）

6. 環節石角 Cycloceras 外殼頗似上屬，有不連續的直紋，至老年，環節漸消失。（本屬僅一種，因標本破碎，種名未能定。）

7. 薇石 Lituites 幼時形似盤角石，至中年，螺環忽鬆弛，成直角石狀，殼之口緣，常呈突起及低凹之象。（歸本屬者一種）

8. 盤角石 Discoceras 螺環皆依平面螺旋，彼此接觸，成鸚鵡螺狀，螺環放大頗速，外壁有凸狀脊，向後灣曲，與梯板方向相反，體管位置多在螺環內緣。（本屬僅一種）

9. 瓜角石 Meloceras 外殼爲弓角石狀，兩側微扁壓，體管似鏈狀，口部開張，其斷面長圓，畧具三角形。（本屬有一種）

爲最特殊，而產量亦極豐富，至中部及西南部，除日本野田氏在湖北興山縣得一未定種名之珠角石外，其他各地，則未一見其踪跡。(2) 中國南部施甸所產中奧陶紀之標準頭足類化石，如 Vaginoceras (Endoceras) wahlenbergi Foord, Orthoceras regulare Schl., Protocycloceras deprati Reed 等，復得之於湖北艾家山層。(3) 本篇所研究各種屬中，除 Cameroceras tenuiseptatum Hall var. ellipticum Yü, Cameroceras hsiehi Yü 數種，可與北美出產者相比較外，餘則極近似歐洲相當時期之頭足類動物，雖盡非同種，而重要性質，實多相同之處。葛利普先生近謂中國及歐洲之奧陶紀動物，均源出印度洋。自海水浸入大陸後，東向直入中國克薩與大內斜 Cathaysian geosyncline 之南部，西則經喜馬拉雅大內斜 Himalayan geosyncline 而達西歐，並述下奧陶紀筆石之分佈，以証明之。如引葛氏之說，則中國中部（湖北等處）之中奧陶紀頭足類，與西南部及西歐相當時期之頭足類種類所以相似之深，而與屬 Boreal Province 之中國北部及北美種類之所以有別，蓋亦有故矣。

六，頭足類各屬概說

本篇所論頭足類化石，凡九屬四十二種。茲將各屬特殊性質，畧述於次，至各種重要之點，請觀原文。

1. 壁角石 Cameroceras　外殼爲直角石狀，內殼甚大，中充內梯板，有內體管貫穿其間，壁襟長約達一氣房。具內壁，爲本屬動物之特徵。（歸本屬者有五種）
2. 內角石 Endoceras　殼之構造，似壁角石，但無內壁，壁襟長度，僅及一氣房，內梯板甚少。（本屬有二種）
3. 鞘角石 Vaginoceras　大致與內角石彷彿，惟壁襟特長，每越前外梯板而下伸，內梯板亦較多。（歸本屬者凡十三種）

a. 蒲縹

Orthoceras sp.

b. Lameng

Orthoceras sp.

c. 施甸

Endoceras wahlenbergi Foord
Endoceras cf. cancellatum Eichow
Endoceras aff. reinhardi Boll.
Orthoceras regulare Schl.
Orthoceras cf. kinnekullense Foord
Orthoceras cf. scabrium Ang.
Orthoceras (Protocycloceras ?) deprati Reed
Actinoceras cf. bigsbyi Brown
Jovellania sp.
Cameroceras ? sp.
Cyrtoceras sp.
Spyroceras ? sp-
Trocholites yunnanensis Reed
T. aff. macromphalus Schröd
Lituites sp.
Taephyceras ? sp.

由上述中國各處之奧陶紀頭足類化石觀之、可注意之點有三。(1) 中國北部中奧陶紀之頭足類、以珠角石

c. Cyrtoceras (Meloceras) asiaticum Yabe

東湖縣之 No-lu-ping（華名未詳）有志留紀岩層、層下為灰色土質石灰岩、含頭足類化石、以層位及岩石性質測之、或即艾家山系。（採集者日本 Usui ）

Lituites (Ancistroceras) Angelini Boll. var.
Discoceras eurasiaticum Frech
Discoceras sp. undt.
Orthoceras sp. undt.
Orthoceras sp. undt.

d. 李仲揆教授謝劉趙李舒諸先生及著者、在湖北各地之艾家山系及下奧陶紀所獲之頭足類化石、已分述於前、茲不復贅。

7. 四川　威理士等經過川境大寧河之徐家壩、發現化石於中奧陶紀之雞心嶺石灰岩頂部、中有頭足類化石一種、魏雷氏鑑定之。

Vaginoceras sp.

8. 黔川間　四川綦江縣揚哥老與貴州酒店埡之間、日本 Yamada 採有頭足類二種。

Orthoceras chinense Foord
Orthoceras sp.

9. 雲南　本省西部產中奧陶紀化石者、計有三處、蒲縹、施甸、及 Lameng。（華名未詳）施甸為產頭足類化石特多之地。據鑑定人李特氏 Reed 之意見、謂施甸頭足類化石層之時期、實相當於俄波羅的海省之鞘角石石灰岩、或斯堪察加及波羅的海省之海刺球石灰岩。

5. 江蘇

a. 佛萊希氏謂崙山石灰岩之化石、與鄂西所產 Orthoceras chinense Foord, Discoceras eurasiaticum Frech 等之地史時期相同、屬上奧陶紀。（現知確屬中奧陶紀）彼鑑定化石中、有頭足類一種。

Endoceras duplex Wahlenberg

b. 徐淵摩先生調查鎮江高資一帶地質、採有頭足類二種於崙山、據葛利普先生之觀察、謂爲下奧陶紀之動物、與李希霍芬氏在崙山所得者、種屬迥不相同、究竟兩者是否來自同層、尙待他日之覆勘。

Proterocameroceras mathieui Grabau
Suecoceras attenuatum Grabau

6. 湖北　鄂省地質、迭被中外地質家所測勘、頭足類化石之發見、有如下列。

a. 李希霍芬氏在長江三峽及宜昌北東湖縣之中奧陶紀、採獲下述各種。（佛萊希氏鑑定）

Orthoceras chinense Foord
Cyrtoceras (Meloceras) cfr. ellipticum Lossen
Lituites (Ancistroceras) angelini Boll.
Discoceras verbecki Frech
Discoceras eurasiaticum Frech

b. 日本野田氏在興山縣戸溪播子埡等處、得有下列化石、該處岩層爲棕色泥質石灰岩、殆卽鄂西之艾家山系。

Actinoceras (Ormoceras) sp. undt.
Orthoceras chinense Foord

b. 佛萊希氏稱英國陳列館內有上奧陶紀標本數種、只知來自山東、而眞確地點不可考、此類化石、或亦與高林氏所採得者同層歟。

Actinoceras sp.

Trochoceras sp.

c. 威理士氏及布賴克韋塔氏在糙米店、新太縣東南、耿家庄東北、顏庄西南等處、及濟南附近之濟南石灰岩（中奧陶紀）層中、均尋有頭足類化石、經魏雷氏 (Weller) 鑑定、謂爲同屬之直角石。（其種名缺。）

Orthoceras sp.

d. 丁文江先生法地質家馬球氏 (Mathieu) 及地質調查所採集如左。（葛利普先生鑑定）

Stereoplasmoceras pseudoseptatum Grabau

Stereoplasmoceras machiakouense Grabau

Actinoceras richthofeni Frech

Actinoceras tani Grabau

Actinoceras coulingi Grabau

Actinoceras suanpanoides Grabau

Actinoceras curvatum Grabau

Cyrtactinoceras frechi Grabau

Gonioceras shantungense Grabau

4. 河南

涉縣馬家溝石灰岩、產有珠角石一種。

Actinoceras coulingi Grabau

Cameroceras styliforme Grabau
Chihlioceras nathani Grabau
Chihlioceras chingwangtaoense Grabau
Piloceras platyventrum Grabau
Suecoceras yehliense Grabau
Suecoceras attenuatum Grabau

b. 黃汲清先生在北平西山奧陶紀層中、採有下列各種。

(a) 馬家溝石灰岩

Stereoplasmoceras pseudoseptatum Grabau
Actinoceras coulingi Grabau
Actinoceras suanpanoides Grabau

(b) 白林子石灰岩

Proterocameroceras minor Grabau
Proterocameroceras mathieui Grabau
Piloceras platyventrum Grabau
Chihlioceras nathani Grabau
Chihlioceras sp.

3. 山東 本省奧陶紀頭足類化石、數經採集、有如左列。

a. 高林氏 (Couling) 在膠州得有頭足類二種、由克理格氏 (Crick) 鑑定之、葛利普先生謂仍屬馬家溝石灰岩時期、並修正該化石之種名。(附於原名右方括弧內)

Actinoceras (Ormoceras) aff. teniufilum Hall (=A. coulingi Grabau)
Gonioceras sp. . . . . (cf. G. shantungense Grabau)

Actinoceras murakamii Kobayashi
Cyrtactinoceras mitsuishii Kobayashi
Discoactinoceras multiplexum Kobayashi
Cyrtoceras (Meloceras) aff. asiaticum Yabe

2. 河北

a. 北平地質調查所及其他學者、於河北省各處之下奧陶紀及馬家溝石灰岩中、採集極多頭足類化石、經葛利普先生鑑定、其種類如下。

(**a**) 馬家溝石灰岩

Vaginoceras tsinanense Grabau
Cycloceras ? peitoutzeense Grabau
Steroplasmoceras pseudoseptatum Grabau
Stereoplasmoceras machiakouense Grabau
Stereoplasmoceras actinoceriforme Grabau
Actinoceras richthofeni Frech
Actinoceras tani Grabau
Actinoceras coulingi Grabau
Actinoceras submarginale Grabau
Actinoceras nanum Grabau
Cyrtactinoceras frechi Grabau

(**b**) 下奧陶紀石灰岩

Proterocameroceras mathieui Grabau

a. 德地質家李希霍芬氏、於遼寧太子河畔之小市 (Hsiau-sörr) 得有下列頭足類化石一種、經佛萊希氏 (Frech) 之鑑定、謂屬上奧陶紀。現葛利普先生認爲與河北馬家溝石灰岩之時期相當。

Actinoceras richthofeni Frech

b. 一九二八年經日本 Kobayashi 鑑定之頭足類化石、有如下列、均採自遼寧之豆房溝牛心臺等處、時代與馬家溝石灰岩同。

Cycloceras (?) peitoutzense Grabau
Stereoplasmoceras pseudoseptatum Grabau
Stereoplasmoceras submarginale Kobayashi
Stereoplasmoceras subcentrale Kobayashi
Tofangoceras paucïannulatum Kobayashi
Tofangoceras irregulare Kobayashi
Actinoceras richthofeni Frech
Actinoceras tani Grabau
Actinoceras coulingi Grabau
Actinoceras manchurense Kobayashi
Actinoceras submarginale Grabau
Actinoceras nanum Grabau
Actinoceras harioi Kobayashi
Actinoceras suanpanoides Grabau
Actinoceras curvatum Grabau

Illaenus nanchangensis Sun

Bathyurus minor Sun

Bronteus sp.

四，宜昌石灰岩及艾家山層之地史時期

昔李仲揆教授於鄂西宜昌石灰岩中所得之化石數種，均來自該層頂部，經葛利普先生之鑑定，知屬下奧陶紀。惟該層下部，含有古珊瑚化石，其時期則論者不一，日本古生物家矢部長克根據化石上之性質，謝家榮先生根據地層上之關係，均以為應屬寒武紀，但葛利普先生仍疑為下奧陶紀。舒文博先生及著者往鄂北調查時，於本層下部，亦復未獲其他之標準化石，是此問題之解決，仍須待諸異日。

艾家山系之時期，多謂為中奧陶紀或上奧陶紀之下部。余等在鄂北調查，至南漳縣西三里之太紅山，除於本系上部採集極多之頭足類化石外，更自下部發現極多之三叶虫筆石腕足等類化石。筆石標本，保存完善，纖維可見，為前人在鄂調查所未發現者。其種名 *Didymograptus murchisoni* Beck 與英國藍特羅 (Llandielo) 之冒氏叉筆石層 (*D. murchisoni* zone) 為同時之停積。至於上部之時期，由所產之頭足類化石証之，與瑞典之直角石石灰岩及俄波羅的海省之鞘角石石灰岩正復相同。

五，湖北奧陶紀頭足類動物之來源

奧陶紀頭足類化石，我國北部及西南部均有之。在中部所見本類動物化石，來自北部乎，抑源出西南部乎。欲知其究竟，請先舉前人在我國各地奧陶紀中所採頭足類化石之種屬如次。

1. 東三省

量最多之 Triplecia (Yangtzella) poloi Martelli、此方則未一見、殆搜尋未力、抑另有他故歟。本層所採化石列後。

a. 艾家山層上部之化石

Endoceras grabaui Yü
Vaginoceras (Endoceras) wahlenbergi Foord
Vaginoceras chientzekouense Yü
Orthoceras chinense Foord var. kuangchiaoense Yü
Orthoceras chinense Foord var. equiseptatum Yü
Orthoceras cf. politum M'coy
Orthoceras remotum Yü
Orthoceras densum Yü
Orthoceras sp.
Cycloceras sp.

b. 艾家山層下部之化石

Didymograptus murchisoni Beck
Orthis calligramma Dalm.
Dalmanella sp.
Leperditia sp.
Asaphus hupehensis Sun
Taihungshania shui Sun

Vaginoceras peiyangense Yü
Vaginoceras shui Yü
Vaginoceras neichianense Yü
Vaginoceras uniforme Yü
Vaginoceras giganteum Yü
Vaginoceras sp.
Orthoceras chinense Foord var. eccentrica Yü
Orthoceras chinense Foord var. equiseptatum Yü
Orthoceras rudum Yü
Orthoceras suni Yü
Orthoceras elongatum Yü
Orthoceras sp.
Lituites lii Yü

4. 鄂北

鄂北奧陶紀地層、與鄂西大致相同。下爲厚逾一〇〇〇米之宜昌石灰岩、上爲艾家山層。後者層薄、厚約八〇米、更分二部、下部爲黃綠色頁岩、上爲淡綠色泥質石灰岩。本層分佈極廣、如南漳宜城鍾祥京山及襄陽之南境、莫不有其踪跡。其上部含頭足類化石之多、正不減鄂西之產量。中外學者、見鄂產直角石狀之頭足類化石、輙以寶塔石呼之、而名爲 Orthoceras chinense Foord、實則內含全角石類及直角石類、種屬紛歧、固未可以一概百也。下部頁岩中、亦產有多量之三葉虫腕足筆石等類化石。惟鄂西產

2. 鄂東　日本野田勢次郎 (Noda) 曾至東南一帶調査、文載支那地學調査報告第二卷。一九二三年秋、謝劉兩先生至陽新等縣察看地質、方悉野田氏昔日調査之失精確。査陽新等處奧陶紀之停積、爲灰色石灰岩。因初見於陽新大阪村、遂以村名名之爲大阪石灰岩。其頂部有紫色灰質頁岩一層、厚二〇米、內產頭足類腕足類及三叶虫等化石。視化石性質此層之地質時代、殆與鄂西艾家山系上部相當。化石有下列各種。

Vaginoceras belemnitiforme Holm
Vaginoceras endocylindricum Yü
Vaginoceras uniforme Yü
Orthoceras chinense Foord

3. 鄂東南部　李捷先生調査蒲圻崇陽等縣地質、謂奧陶紀停積物出露於地面者、殆全爲石灰岩所組成。由岩石性質言之、可分爲二部。下爲深灰色之厚層石灰岩、約五〇〇米。上部則爲紅色薄層狀石灰岩與灰質頁岩之互層、厚一四〇米、其底另有一層三〇米厚之黃灰色薄層石灰岩。頭足類化石、出自上部之底層者特多。按此處上部岩石之性質、雖與鄂西艾家山系有別、但由化石之種屬觀之、與艾家山層及大阪石灰岩頂部所產相同者、尙屬不少、然則此上部岩層之時期、殆亦與艾家山系相當歟。各種化石、有如左列。

Endoceras leei Yü
Vaginoceras wahlenbergi Foord var. cylindrica Yü

李仲揆教授、採得頭足類化石、原存北大地質標本室、現僅餘數種、合謝趙兩先生所採獲者、其類別如下。

a. 宜昌石灰岩

Cameroceras cf. styliforme Grabau

b. 艾家山系（上部）

Cameroceras tenuiseptum Hall var. ellipticum Yü
Cameroceras hsiehi Yü
Cameroceras subtile Yü
Cameroceras sp.
Vaginoceras neichianense Yü
Vaginoceras reedi Yü
Vaginoceras multiplectoseptatum Yü
Orthoceras chinense Foord
Orthoceras regulare Schlotheim
Orthoceras squamatulum Barrande
Orthoceras thyrsus? Barrande
Orthoceras yangtzeense Yü
Orthoceras? wongi Yü
Protocycloceras deprati Reed
Discoceras eurasiaticum Frech
Meloceras asiaticum Yabe

寧河畔雞心嶺、及鄂西宜昌上之南沱等處、見有極厚層石灰岩直覆於南沱冰磧層之上、其在南沱者、厚達一千二百米、名曰雞心嶺石灰岩、歸之於寒武奧陶紀。本層之頂部、另有一綠色灰質頁岩與結核狀石灰岩相間之岩層、厚約六十餘米、再上則爲志留紀之新灘系。一九二四年春、李仲揆教授曾赴長江三峽一帶、作精密之調查、發現威理士氏等所稱之雞心嶺石灰岩、不僅代表寒武及奧陶兩時期之岩層、更有葛利普氏所稱震旦紀之停積、亦且包括其中。於是廢雞心嶺石灰岩之舊名、而另名寒武奧陶兩紀岩層爲牛肝系、以示與下部之震旦紀有別。復於牛肝系下部、尋有寒武紀三葉虫化石、乃再將本系所含寒武及奧陶兩紀岩層實行劃開。下者曰石牌頁岩、厚二一〇〇米、化石有 Redlichia chinensis Walcott, Obolus sp. 屬下寒武紀。上部曰宜昌石灰岩及艾家山系、屬奧陶紀、與石牌頁岩爲不連續。宜昌石灰岩、厚約一一五〇米至一六八〇米、內有下奧陶紀化石、如 Callograptus cf salteri Hall, Proterocameroceras mathieui Grabau, Eccyliopterus sp, Asaphus sp, Archaeocyathus chihliensis Grabau, Girvanella sinensis Yabe 等類。艾家山系厚度爲一一〇米、可分兩部、下部爲綠色灰質頁岩及棕黃或淡灰色石灰岩之互層、如 Triplecia (Yangtzella) poloi Martelli, Clitambonites giraldii Martelli 爲其中最特別之化石。上部爲灰色石灰岩、含頭足化石極夥。由本系中所得化石、計有 Triplecia (Yangtzella) poloi Martelli, Clitambonites giraldii Martelli, Orthis calligramma Dalm., Eccyliopterus sinensis Frech, Vaginoceras duplex Wahlenberg, Discoceras eurasiaticum Frech, Endoceras sp, Cycloceras sp., Cyrtoceras sp., Asaphus cf expansus Dalm. 等。一九二四年秋、謝趙兩先生再至鄂西調查、述及奧陶紀岩層、與李仲揆教授所見者相同。

葛氏新創名稱		其他學者習用名稱
外殼	Ectoconch.	Shell (Exclusive of siphuncle)
內殼	Endoconch.	Siphuncle
外壁	Ectotheca.	Shell wall
內壁	Endotheca.	Endosipholining (often absent)
外梯板	Ectosepta.	Septa
內梯板	Endosepta.	Endosiphosheaths
壁襟	Tubus (pl. Tubi)	Septal funnels
內體管	Endosiphuncle.	Endosiphuncle
內體房	Endocone.	Endosiphocone
內圓管	Endocylinder.	Endosiphocylinder

三，湖北各處奧陶紀岩層之比較

湖北西境及東南之地質、業經李仲揆教授及謝家榮劉季辰趙亞曾諸先生先後測勘。十七年、李捷舒文博兩先生及著者復分赴崇陽蒲圻及鄂北諸縣調查。關於產生頭足類鸚鵡螺類化石之奧陶紀停積物、在西北者似與東南畧有不同之點。茲將各處奧陶紀岩層、（註一）簡述於次、以資比較。

1. 鄂西　一九〇三年、美人威理士 (willis) 及布賴克韋塔、(Blackwelder) 來我國調查地質、經過川境大

註一。一九二五春，謝劉兩先生至湖北西南部調查。一九二八秋，孟憲民先生至遠安當陽等縣調查。所述奧陶紀岩層，大致與鄂西相同，以未採集多量頭足類化石，故從略。

復不少、所受侵蝕程度、殊較崇陽及鄂北採得者爲深。李仲揆教授採集之標本、存北京大學地質標本室。謝趙兩先生所採集者、則儲地質調查所古生物研究室中。承吾師葛利普博士之命、將是項材料、併取而研究之。北京大學教授葛利普博士對著者之研究、指導良多、中央地質研究所所長李仲揆教授亦復多所指示、中國地質調查所所長翁詠霓博士與著者以研究上之種種便利、中國古生物誌編輯丁在君博士孫鐵仙博士亦嘗有所關注、許光熙計榮森二先生任攝影之勞、均識於此、藉表謝忱。

二，頭足類鸚鵡螺類化石構造名稱

本類化石、具外殼。其形不一、或爲直角石狀、或爲弓角石狀、有爲環角石狀、平面螺旋、螺環互相離開、有爲鸚鵡螺狀、螺環接觸、其後者且抱圍前者。殼之成於胚胎時者、曰始原殼。迨漸長而內具梯板者、曰體殼。體殼內含梯板若干、橫分全殼爲若干氣房。最後較大者曰體房、爲動物生活時收納肉體之處。有管狀小孔、穿過各梯板、是爲體管、其位置則視種類而異。梯板沿體管周圍、突向後曲折伸張、作漏斗狀、是爲壁襟。直角石類之壁襟甚短、全角石類之壁襟則甚長。

全角石類、體管較大、內部充以圓錐形之石灰質薄板、另有一更小管狀孔、直貫其中。本類中有名壁角石者、其體管周圍、更有一層覆被物、遮蔽於壁襟裏面。葛利普先生最近主張、謂全角石類之體管、可相當於直角石類之體殼、前者體管周圍之覆被物及圓錐形之石灰質薄板、各相當於後者之殼（註一）及梯板。遂另立新名、以名全角石類動物化石之各部。本篇關於全角石類化石、採用名詞、即葛氏所新創者。茲將新名臚列於左、附之以其他學者所習用之原名、以便讀者得有所比較焉。

註一。 此殼係狹義的，專指殼之外壁 (Shell wall) 而言。

中國中部奧陶紀頭足類化石

俞建章 著

一，引言

十七年五月、湖北建設廳石衡青先生電請地質研究所派員赴鄂調查地質礦產。李捷舒文博兩先生先至蒲圻嘉魚一帶測勘煤田、余因事後往、約會咸寧、至則李舒二先生方留崇陽調查、余乃趁暇在余家山一帶採集志留紀之三葉虫等類化石。時李舒二先生亦於崇陽採集多量之頭足類鸚鵡螺類化石、其長者約達一公尺、余以標本美麗可觀、遂先取而研究焉。

是年十月、舒文博先生與余再應約至鄂北調查。爲時不及三月、計經六縣、南漳宜城襄陽荊門鍾祥京山等是。在本區域內各地史時代均有相當之停積物。(鄂北一帶泥盆紀石英岩上多覆以含 Tetrapora, Schwagerina 之石灰岩、當時以其性質頗與南京棲霞系相似、遂歸之於上石炭紀。現葛利普博士謂棲霞系應屬下二疊紀、然則石炭紀岩層在鄂北等處、殆已全部缺失歟、) 所採化石以中奧陶紀下志留紀下二疊紀諸時期爲最豐富。其分佈最廣、產量最多、星羅碁布、觸目皆是者、厥爲艾家山系上部 (中奧陶紀) 之頭足類鸚鵡螺類化石。惟因行程匆促、未遑多事採集、至今思之、猶有餘憾。

初、謝家榮劉季辰兩先生、曾於陽新縣大阪石灰岩頂部、採有頭足類化石數種。十三年春、李仲揆教授率北大同學赴長江上游宜昌秭歸間考察地質、於艾家山系上部、復得有甚多之頭足類標本。是年秋、謝趙兩先生再至宜昌巴東一帶調查、所得頭足類化石更夥、惟標本保存不甚完整、僅存內殼者 (Endoconch) 有之、全爲內模型者 (Internal mould) 亦有之。其表面略具外殼之形態、而內部則爲凝結之泥土、原有構造、蕩然無存者、亦

古生物誌乙種第一號
第二冊

兪建章 著

中國中部奧陶紀頭足類化石

（學術研究與國立中央研究院合作）
農鑛部直轄地質調查所
國立北平研究院地質學研究所 印行

中華民國十九年七月

古生物誌乙種第一號

第二册

兪建章 著

中國中部奧陶紀頭足類化石

中華[redacted]國十九年七月

（學術研究與國立中央研究院合作）

農鑛部直轄地質調查所
國立北平研究院地質學研究所印行

THE GEOLOGICAL SURVEY OF CHINA

IN COOPERATION WITH
THE NATIONAL RESEARCH INSTITUTE OF GEOLOGY OF THE
ACADEMIA SINICA,
THE SECTION OF GEOLOGY OF THE NATIONAL ACADEMY OF PEIPING,
THE GEOLOGICAL DEPARTMENT OF THE NATIONAL
UNIVERSITY OF PEKING,
THE GEOLOGICAL SURVEY OF KWANGTUNG AND KWANGSI, AND
THE GEOLOGICAL SURVEY OF HUNAN.

Palæontologia Sinica

Series B, Volume I,

Fascicle 3.

BRACHIOPODA FROM THE ORTHIS BED OF THE NEICHIA FORMATION OF CENTRAL CHINA.

By

M. S. CHANG M. A.

WITH II PLATES AND 3 TEXT-FIGURES.

Published by the Geological Survey of China

古生物誌

地質調查所

PEIPING (PEKING) 1934

For Sale at the Following Offices:

Peiping: Geol. Surv. Library, 9 Ping Ma Sze. West City; French Bookstore, Grand Hotel de Pékin; **Shanghai:** Kelly & Walsh, Ltd., 12 Nanking Road; **London:** Edward Goldston, 25 Museum St. (W. C. 1); **New York:** A. G. Seiler & Co., 1224 Amsterdam Ave; G. E. Stechert & Co, 31-33 East 10th Street; **Leipzig:** Max Weg, Königstrasse 3: Buchhandlung Gustav Fock, Postschliessfach 100 **Tokyo:** Maruzen Company.

Series B. Vol. I, Fascicle 3

PALÆONTOLOGIA SINICA

Brachiopoda from the Orthis Bed of the Neichia Formation of Central China.

By M. S. Chang M. A.

With 2 Plates and

3 Text-Figures

古生物誌

地質調查所

Published by the Geological Survey

Peiping, 1934.

Printed by The Yu Lien Press,
253, Hatamen St., Peiping

CONTENTS

BRACHIODODA FROM THE ORTHIS BED OF THE NEICHIA FORMATION OF CENTRAL CHINA*

By M. S. Chang

INTRODUCTION

The material described in this paper was collected by Mr. C. C. Yü, geologist to the Institute of Geology, National Research Institute, at Taihungshan, Nanchang Hsien, Hupeh (湖北南漳縣太紅山) in 1928. When the writer joined the Geological Survey last February it was kindly put into his hands for study at the suggestion of Professor Grabau. To Mr. Yü he, therefore, wishes to express his sincere thanks. To Professor Grabau under whose sympathetic and inspiring guidance the study was made, he is also greatly indebted.

Stratigraphy of the Neichia Formation.

In his illuminating study of the geology of the Yangtze Gorges Professor J. S. Lee first established the Neichiashan Series, now designated the Neichia Formation. It was subdivided into two parts, an upper, the Pagoda Limestone and a lower, the Triplecia Beds (New Yangtzeella Beds). The Pagoda Limestone is a dense gray rock, only a few meters thick and characterized by the gigantic *Orthoceras chinense* Foord. The Triplecia (Yangtzeella) Beds, on the other hand, consist of an alternation of a dirty green, calcareous shale and slabby brownish-yellow or light grey limestones of a rather earthy composition with a thin-bedded grey limestone at the base. The slabby limestones are everywhere crowded with *Triplecia (Yangtzeella) poloi* and *Clitambonites giraldii*. In the list of fossils Professor Lee gave the following species:

Triplecia (Yangtzeella) poloi Martelli	(very abundant)
Clitambonites giraldii Martelli	(,, ,,)
Orthis calligramma Dalman	(not rare)
Eccyliopteris sinensis Frech	(abundant)
Vaginoceras duplex Wahlenb.	(,,)

* Received for publication in 1931.

Discoceras eurasiaticum Frech	(Common)
Endoceras sp.	(abundant)
Cycloceras sp.	(very abundant)
Cytroceras sp.	(rare)
Asaphus cf. expansus Dalman	(rare)

In agreement with Frech, Grabau, Hayasaka, Weller and others, Professor Lee concluded that the Neichia Series undoubtedly represents Middle Ordovician or the lowest part of the Upper Ordovician, being approximately equivalent to the Vaginoceras limestone of the Baltic Provinces of Russia.

In Nanchang Hsien of northern Hupeh Mr. C. C. Yü found the Neichia formation resting conformably on the Ichang limestone. Here as in western Hupeh, the Neichia is composed of two parts, a lower yellowish-green shale and an upper yellowish-green limestone. The fossils from each were preliminarily determined by Mr. Yü as follows:

(a) Fossils found in the lower shale

Graptozoa:	Didymograptus murchisoni
	Didymograptus sp. (several species)
Brachiopoda:	Orthis sp. (several species)
	Orthis calligramma Dalm.
	Dalmanella sp.
	Dinorthis sp.
Ostracoda:	Leperditia sp.
Trilobita:	Asaphus sp.
	Asaphus hupehensis Sun and Yü
	Taihungshania shui Sun and Yü
	Illaenus nanchangensis Sun and Yü
	Bronteus sp.
	Bathyurus minor Sun and Yü

(b) Fossils found in the upper limestone

Cephalopoda:	Cycloceras sp.
	Orthoceras sp. (several species)
	Orthoceras chinense Foord
	Vaginoceras chientzekouense Yü

The lower shale unquestionably represents the Triplecia Beds while the upper limestone is the Pagoda Limestone. Because of the presence of the Characteristic graptolite *Didymograptus murchisoni* Mr. Yü correlated the former with the Llandeilo of Great Britain and the latter with the Orthoceras limestone of Sweden and the Vaginoceras limestone of the Baltic Province of Russia.

From the above lists of fossils it seems evident that in the Gorge District, *Yangtzeella poloi* is the dominant fossil in the lower shale, but at Taihungshan, Nanchang Hsien its place is taken by *Orthis* and others. In spite of careful search Mr. Yü failed to discover a single specimen of *Yangtzeella*. The name "Triplecia or Yangtzeella Beds" is then not applicable in this case and the new term "Orthis Bed" is, therefore, introduced.

Most of the specimens in this lot are impressions of the interior or the exterior part of the shell. In order to reproduce the true nature of the fossils the making of molds is necessary. Unless otherwise stated, the following descriptions are based on the characters of the molds, rather than on those of the specimens themselves.

DESCRIPTION OF SPECIES

Genus **LINGULA** Bruguiere

1. Lingula sp.

Pl. I, Fig. 1a & b.

This species is represented by a pedicle valve, the anterior portion of which has been broken off. It is oval or ovate in cutline, with the broadest part across or below the middle. The beak is not shown, though the posterior region suggests slight tapering. The valve is moderately and evenly convex. The surface is so weathered that it does not show any concentric lines of growth or markings of any other kind.

REMARKS: The state of preservation of this species renders a precise determination impossible.

HORIZON AND LOCALITY: From the Orthis bed of the Neichiashan Formation, Taihungshan, Nanchang Hsien, Hupeh. Coll. C. C. Yü (Ser. No. X 249; Cat. No. 3363).

Genus **ORTHIS** Dalman

2. Orthis calligramma Dalman, var. sinensis Chang (var. nov.)

Pl. I, Fig. 2a & b.

cf. 1869. *Orthis calligramma* Dalman. Davidson, British Fossil Brachiopoda, Pt. VII, No. III, p. 240, pl. XXXV, figs. 1-17, varieties, figs. 18-24, (with literature references).

This species is represented by one internal mold of the pedicle valve. It is subquadrate to subsemicircular, wider than high and broadest at the hinge line.

The pedicle valve is convex, more so in the beak region. The beak is broken but a rostral cone is shown resting on the inner surface of the hinge area of the pedicle valve. The cone is somewhat triangular in shape, little extended and separated from the hinge line by two triangular depressions one on each side. The surface is covered by about twenty-one simple, rounded and radiating plications with the wider interspaces occupied by four or five fine longitudinal striæ. Where the weathering has not been complete concentric growth lines can be also seen.

Measurements:

Greatest width	= 17 mm
Hinge line	= 17 mm
Height	= 13 mm

Proportion of height to width* = 1.31

Davidson's *Orthis calligramma* gives the following measurements:

Fig. 8, Pl. XXXV,	Greatest width	= 34 mm
	Hinge line	= 29 mm
	Height	= 29 mm
Proportion of height to width		= 1.17
Fig. 1a, Pl. XXXV,	Greatest width	= 21 mm
	Hinge line	= 18 mm
	Height	= 18 mm
Proportion of height to width		= 1.17

REMARKS: This species preserves the essential characters of *Orthis calligramma* Dalman but differs in details as shown in the measurements given above. Its form suggests *Orthis carausii* but the plications of our shell are less rounded and with the interspaces occupied by fine longitudinal striæ.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. No. X203; Cat. No. 3364).

---

3. **Orthis calligramma** Dalman, var. **hupehensis** Chang (var. nov.)

Pl. I, Figs. 3a-d and 4a-d.

The holotype (Ser. No. X202, Pl. I, Fig. 3a) is an external impression of a pedicle valve. It is transversely subcircular and wider than high. The hinge line is a little shorter than the greatest width which lies about the middle part of the shell. The pedicle valve is convex, the central region, extending from the beak

* The height is taken as 1.

to the anterior part, being more pronounced, thus suggesting the presence of a slight fold. The beak is small and shows little incurvature. The surface ornamentation consists of twenty-four simple and round plications, the middle six being more strongly developed. Near the beak the interspaces between the plications are very narrow or nearly absent, but they expand very quickly, till at the anterior part of the shell they measure one mm. or a little more. They are also occupied by two or three fine longitudinal striæ.

Measurements:

Greatest width = 13 mm
Hinge line = 12 mm
Height = 11 mm
Proportion of height to width = 1.18

Another specimen of the same species (Ser. No. X232, Pl. I, Fig. 4a) has part of the right side of the shell broken away. It is smaller and a little more convex, but in other respects agrees with the holotype.

REMARKS: This species resembles Davidson's *Orthis calligramma* more than *Orthis calligramma* var. *sinensis* does. It differs only in its smaller size and more numerous plications.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X 202, X 232; Cat. Nos. 3365, 3366).

---

4. **Orthis carausii** Salter, var. **nanchanghsiensis** Chang (var. nov.)

Pl. I, Fig. 5a-d.

cf. 1869. *Orthis carausii* Salter, MS. Davidson, British Fossil Brachiopoda, Pt. VII, No. III, p. 229, pl. XXXIII, figs. 1-7.

This species is represented by a broken exterior impression of the brachial valve. It is subsemicircular, considerably wider than high, and has the hinge line equal to the greatest width. The valve is almost flat, with a gentle sinus covering about seven plications along the middle. The surface is marked by about thirty-two round plications which show branchings and bifurcations here and there. The plications in the central part are stronger than those on the sides, thus giving the shell a three-zoned appearance. The interspaces are wider and contain fine longitudinal as well as faint transverse lamellose striæ.

Measurements:

Greatest width = 18 mm
Hinge line = 18 mm
Height = 11 mm
Proportion of height to width = 1.64

Davidson's *Orthis carausii* as represented in fig. 1, Pl. XXXIII, gives the following results:

Greatest width = 18 mm
Hinge line = 16 mm
Height = 11.5 mm
Proportion of height to width = 1.57

REMARKS: This species resembles *Orthis carausii* in its form as shown in the above measurements, but it differs in the following respects: (1) greatest width at the hinge line instead of a little below; (2) more numerous and complicated plications; and (3) longitudinal and transverse striæ in the interspaces of the plications. Had there been more specimens at hand, it might have been even better to create a new species.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. No. X230; Cat. No. 3367).

---

5. **Orthis carausii** Salter, MS.

Pl. I, Fig. 6a-f.

1869. *Orthis carausii* Salter, MS. Davidson, British Fossil Brachiopoda, Pt. VII, No. III, p. 229, pl. XXXIII, figs. 1-7.

This is represented by the interior mold of the pedicle valve (Ser. No. X204, Pl. I, Figs. 6a, 6b) and the impression of an exterior (Ser. No. X205, Pl. I, Figs. 6c-6f). The former is semicircular and wider than high. The hinge line is at the greatest width and a little prolonged, so as to give the suggestion of the presence of ears at the cardinal extremities, which are acute. The valve is moderately convex in the central region, the sides being comparatively depressed. The beak is unknown, but a rostral cone is present, which is slightly incurved and bounded on the sides by two crescentic grooves. The surface is ornamented by about twenty-five simple, rather angular plications with wider interspaces between.

Measurements:

Greatest width = 9 mm
Hinge line = 9 ,,
Height = 6 ,,
Proportion of height to width = 1.50

Davidson's fig. 3, Pl. XXXIII measures thus:

Greatest width	=	14 mm
Hinge line	=	14 ,,
Height	=	10 ,,
Proportion of height to width	=	1.40

An exterior impression of another pedicle valve (Ser. No. X205) is less perfect than No. X204. Its greatest width is 6 mm. and the height, 4.5 mm, giving a proportion of height to width of 1.33. Its cardinal extremities are less extended and its convexity is not so strong. Its plications are also not so numerous, but they show branchings in one or two places.

REMARKS: Except for its smaller size and more numerous plications this species agrees well with *Orthis carausii* Salter, as figured by Davidson.

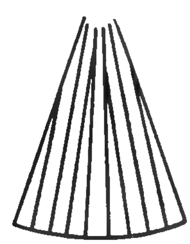
HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X 204, X 205; Cat. Nos. 3368, 3369).

---

6. **Orthis neichiaensis** Chang (sp. nov.)

Pl. I, Figs. 7a-d, 8a-d, 9a-d, 10a-b, & 11a-d, and Text-figs. 1-3.

The exterior impression of a typical brachial valve (Ser. No. X 218, Pl. I, Fig. 7a) is subquadrate and wider than high. The hinge line is shorter than the greatest width which lies about the middle of the shell. The valve is moderately flat with a sinal depression along the central portion. The surface is ornamented by about thirty-three simple and rounded plications with slightly wider interspaces which are occupied by very fine longitudinal and transverse lamellose striæ. The sinus is bounded by two plications which bifurcate about two mm. below the beak. In its center are found four plications which are a little stronger than the others. The arrangement of the sinal plications is shown in Text-Figure 1.



Text-Fig. 1. Arrangement of the sinal plication in specimen No. X 218.

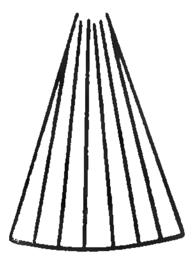
Measurements:

Greatest width	=	13 mm
Hinge line	=	10 ,,
Height	=	9 ,,
Proportion of height to width	=	1.44

A second exterior impression of a Brachial valve (Ser. No. X 216 Pl. I, Fig. 8a) is of a smaller specimen as compared with No. X 218. Its measurements are as follows:

Greatest width	=	8 mm
Hinge line	=	7 ,,
Height	=	5 ,,
Proportion of height to width	=	1.60

The sinal depression is very clear and the arrangement of the sinal plications is shown in Text-Figure 2.



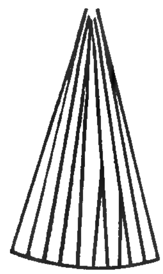
Text-Fig. 2. Arrangement of the sinal plications in specimen No. X 216.

The sinal plications have increased to six instead of four. Bifurcations and branchings of plications are in general more numerous than in the case of No. X 218.

A third exterior impression of the brachial valve (Ser. No. X 220, Pl. I, Fig. 9a) has the following measurements:

Greatest width	=	13 mm
Hinge line	=	6 mm?
Height	=	9 mm
Proportion of height to width	=	1.44

Part of the hinge line is broken away, so its extent is in doubt. No. X 220 differs from No. X 218 in (1) the lesser prominence of the sinus, (2) more bifurcation and branching of the plications, thus increasing the number to nearly forty, and (3) seven plications in the sinus instead of four, with arrangement as shown in Text-Figure 3.



Text-Fig 3. Arrangement of the sinal plications in specimen No. X 220.

An internal mold of the pedicle valve is shown by No. X 215, Pl. I, Fig. 10a. It is convex, with the beak region slightly incurved. The fold is not prominent. The surface ornamentation consists of more than forty plications which show more bifurcations and intercalations along the fold than in any other place.

An impression of the exterior of the pedicle valve (No. X 219 Pl. I, Fig. 11a) is a little larger and has a slight fold (representing the sinus). Its plications are much more numerous because of their profuse intercalations and bifurcations.

REMARKS. This species is characterized by a distinct though ill-defined fold in the pedicle valve and a well-developed sinus in the brachial valve. It resembles *Orthis calligramma* only in having striæ in the interspaces of the plications. In the order described the plications increase in number and grow more complicated. Whether this represents a state of progressive evolution is difficult to say, because the specimens at hand are too few to offer a definite explanation.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X 215, X 216, X 218, X 219, X 220; Cat. Nos. 3373, 3371, 3370, 3374, 3372).

---

7. **Orthis ellipsoides** Chang (sp. nov.)

Pl. I, Fig. 12a-d.

Specimens Nos. X 209 (Pl. I, Figs. 12b, 12a) and X 201 (Pl. I, Figs. 12c, 12d) represent the interior mold and the exterior impression of the pedicle valve respectively, which, when put together, fit into each other exactly. The species is of subelliptical outline, much wider than high. The hinge line is not well preserved, the shoulders sloping gently from the beak to the cardinal extremities which apparently mark the greatest width. The interior mold shows the rostral cone separated from the plicated part by a U-shape groove. The surface is covered by about twenty angular and rather simple plications with wider interspaces and intercalations and branchings here and there.

Measurements:

Greatest width = 6 mm
Height = 4 ,,
Proportion of height to width = 1.50

On the same slab is another specimen of the same species. The valve is a little more convex than No. X 201. The rostral cone shown in the interior mold is larger and is separated from the plications by two more or less parallel grooves which do not meet anteriorly and thus become U-shaped as in the case of No. X 209. The grooves become less and less deep as they recede from the beak, till in the anterior part of the cone there remains only a trace of them.

Remarks: This species is very much like *Orthis calligramma* Dalman, var? Reed (figs. 16-19, pl. V, the Ordovician and Silurian Brachiopoda of the Girvan District). It differs in not having fine longitudinal lines within the interspaces of the plications and faint transverse lamellose striæ. Owing to Reed's uncertainty with regard to his specimen a new specific name is here proposed. As noted by him this may be simply the young of *Orthis calligramma* Dalman, but for the present we will leave it under a distinctive designation.

Horizon and Locality: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X 201, X 209; Cat. Nos. 3375, 3376).

---

8. **Orthis calligramma** Dalman. var. **intercalare** Chang (var. nov.)

Pl. II, Figs. 1a-b, 2a-b, 3a-b, & 4a-b.

This species is represented by a number of molds of both the pedicle and the brachial valves. It is wider than high and has a hinge line which is a little less than the greatest width and the frontal margin regularly curved. The pedicle valve is gently convex, the beak being slightly incurved. The rostral cone is pear-shaped and marked off from the plicated portion by two crescentic grooves which become gradually less deep as they pass farther from the beak. On the surface of the cone are found seven longitudinal raised lines, the middle one being stronger than the rest and seemingly continuous with the median plication. The brachial valve is flat. A triangular rostral cone with a groove occupied by a tongue-shaped projection which does not reach the top, extends beyond the hinge line. It is surrounded on both sides by a deep depression into which short spines are pointing from the edge of the mold. In two other specimens a slight sinus is also shown. The surface is covered by about thirty rounded plications with wider interspaces and numerous intercalations, especially in the central part of the shell.

Measurements:

Greatest width = 13 mm
Hinge line = 12.5 mm
Height = 11 mm
Proportion of height to width = 1.18

REMARKS: This species is made a new variety because it differs from *Orthis calligramma* in having intercalations in its plications. The plications of *Orthis calligramma* always remain simple.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X 224, X 225, X 227; Cat. Nos. 3377, 3378, 3379).

---

9. **Orthis** cf. **unguis** Sowerby

Pl. II, fig. 5a-d.

cf. 1869. *Orthis unguis* Sow. Davidson, British Fossil Brachiopoda, Pt. VII, No. III, p. 257, pl. XXXVII, figs. 16-22.

Two specimens representing the interior mold and the exterior impression of the pedicle valve are known. They are very imperfect and a discriminate determination is impossible. They are referred to *Orthis* cf. *unguis* Sow. because their plications are very angular, a fact not known in the case of *Orthis calligramma*.

The shell is rather small, having a length of four mm. and a width of about six mm. It is almost flat and is ornamented by about fourteen simple and angular plications which when viewed from the front simulate the cross section of a roof.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X210, X211; Cat. Nos. 3381, 3382).

---

10. **Orthis** cf. **calligramma** Dalman, var. **subplicata** Reed.

Pl. II, Fig. 6a-d.

cf. 1917. *Orthis calligramma* Dalman, var. *subplicata* Reed. The Ordovician and Silurian Brachiopoda of the Girvan District, p. 828. pl. V, figs. 10-15.

Only interior molds of the pedicle valve of this species are known. The specimens are rather imperfect and an exact identification is, therefore, difficult.

The shell is subquadrate and wider than high, the hinge line being slightly less than the greatest width and the front regularly rounded. The pedicle valve is strongly convex and a little swollen. The beak is high and a little incurved. The rostral cone is highly developed and divided into one median and two lateral lobes by two deep and well-marked parallel grooves. The surface is mostly smooth, only marked by plications on the anterior two or three mm. of the mold[1]. The number of plications is not known on account of the broken nature of the specimen, but that there are intercalations and bifurcations seems to be certain.

Measurements:

Greatest width = 15 mm
Hinge line = 14 ,,
Height = 11 ,,
Length on curvature = 15 mm
Proportion of height to width = 1.36
Shell index = 0.93

Another specimen (No. X 206 Pl. II, Figs. 6, 6a) shows some difference from the above. It is less convex and the hinge line seems to be equal to the greatest width. The plications are simple and have no intercalations. A high triangular cardinal area is also suggested.

Remarks: This species agrees well with the descriptions by Reed. It differs from *Orthis calligramma* in being more convex and having plications of a more complicated character.

Horizon and Locality: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X 208, X 206; Cat. Nos. 3383, 3384).

Genus **PLECTORTHIS** Hall and Clarke

11. **Plectorthis** sp. 1.

Pl. II, Fig. 7a-d.

cf. 1917. *Orthis (Plectorthis) ardmillanensis* Reed. The Ordovician and Silurian Brachiopoda of the Girvan district, p. 831, pl. V, figs. 33-39.

This species is represented by the exterior impression of the pedicle valve. It is transversely elongated or Spirifer-like in form, the width being more than twice the height. The hinge line is equal to the greatest width and part of the hinge

1. Reed figures a similar mold (pl. V. fig. 13), but his other figures show that the exterior is well plicated.

area with a smooth surface is also shown. The shell is convex, the convexity being more pronounced in the posterior two-thirds of the central region, while the anterior third is abruptly deflected downwards, with a rather strong geniculation. The sides of the delthyrium are supported by delicate subparallel dental plates which in the impression of the exterior, suggest a rectangular rostral cone with sides about one mm. in length. The surface is covered by about forty rounded plications, many of them showing intercalations. Concentric lamellose striæ are also present.

REMARKS: The plications and shape of this species suggests *Plectorthis ardmillanensis* Reed, but its transverse elongation and the absence of longitudinal striæ within the interspaces of the plications at once separates them.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. No. X 212; Cat. No. 3385).

---

12. **Plectorthis** sp. 2

Pl. II, Fig. 8a-d.

cf. 1869. *Orthis elegantula* Dalman: Davidson, British Fossil Brachiopoda, Pt. VII, No. III, p. 211, pl. XXVII, figs. 1-9, (with literature references).

This species is also represented by an exterior impression of the pedicle valve. It is cardiform or has the shape of an inverted isosceles triangle. It is a little wider than high and has the greatest width at the hinge line. The beak region is filled by the broken rostral cone, margined by the delicate subparallel dental plates. The shell is convex, being most pronounced along the central region thus giving a steeply crescentiform section. The surface is ornamented by round and bifurcating plications, the number of which is indeterminable on account of the broken conditions of the shell. In the center of the anterior portion there are about five plicæ in two mm. The measurements are six mm. for height and seven mm. for width.

REMARKS: The specimen is too poor for specific identification.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü (Ser. No. X 214; Cat. N. 3386).

Genus **DALMANELLA** Hall and Clarke

13. **Dalmanella** cf. **elegantula** (Dalman)

Pl. II, Figs. 9a-d & 10a-d.

cf. 1869. *Orthis elegantula* Dalman: Davidson, British Fossil Brachiopoda, Pt. VII, No. III, p. 211, pl. XXVII, figs. 1-9, (with literature references).

cf. 1892. *Orthis elegantula* Dalman. Hall and Clarke, Palæontology of New York, Vol. VIII, Pt. I, pl. Vc. figs. 15-19.

This species is longitudinally ovate, much higher than wide. The hinge line is a little shorter than the greatest width which lies just below the median line of the shell. The pedicle valve is uniformly convex and rather strongly arched. The beak is moderately protuberant and a little incurved. The surface ornamentation consists of round plications which bifurcate into smaller and secondary plications at varying distances from the beak. Because of this feature the interspaces are very narrow. There are on the average eight plicæ in five mm. at the front.

REMARKS: This species agrees well with Davidson's description of *Orthis elegantula*. It differs from *Orthis testudinaria* Dalman in being higher than wide, while in the case of the latter the reverse is usually true.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X 213, X 236; Cat. Nos. 3387, 3388).

Genus **RAFINESQUINA** Hall and Clarke

14. Rafinesquina cf. muthensis Reed

Pl. II, Figs. 11a-b. 12a-b. & 13a-b.

cf. 1912. *Rafinesquina muthensis* Reed. Ordovician and Silurian Fossils from the Central Himalayas. Palæontologia Indica, Series XV, Vol. VII, Mem. No. 2, p. 43, pl. VIII, figs. 13-15.

This species is represented by a number of specimens, most of them being imperfect. Our best preserved pedicle valve (x 245, Pl. II, Fig. 12a) is semicircular in outline. The hinge line is slightly shorter than the greatest width which lies about the central part of the shell. The pedicle valve is moderately convex, more or less strongly arched in front. The beak is small and pointed; the hinge area smooth and narrow. The surface is covered by radiating and rather fine plications of unequal strength, which bifurcate and intercalate at various distances from the beak. In the space of three mm. at the front there are about six plications.

Measurements:

Greatest width = 19 mm
Hinge line = 18 mm
Height = 13 mm
Length on curvature = 17 mm
Proportion of height to width = 1.46
Shell index = 1.06

Reed's fig. 15, Pl. VII, gives:

Greatest width = 10 mm

Hinge line = 10 mm

Height = 7 mm

Proportion of height to width = 1.43

REMARKS: Owing to the imperfect nature of the specimen the true status of this species is not definitely known. It is referred to *Rafinesquina muthensis* Reed, because their characters are apparently in close affinity. They have, however, this difference; the greatest width of *Rafinesquina muthensis* Reed is at the hinge line while that of our species lies about the middle part of the shell. There are two other specimens (X 244 and X 246 Pl. II, Figs. 11a and 13a) which come from the same slab but show a slightly different form. They are more or less conical instead of elliptical in shape. For the present they are classified together with X 245, but that they may prove to be different is not entirely impossible.

HORIZON AND LOCALITY: Occurs with the preceding. Coll. C. C. Yü. (Ser. Nos. X244, X 245, X 246; Cat. Nos. 3389, 3390, 3391).

CONCLUSION.

The brachiopod fauna of the Yangtzeella Beds of the Gorge district is not yet fully known. Several years ago Miss Kolarova made a study but her results have not yet been published. Judging from the preliminary fossil lists of Professor Lee and Mr. Yü and comparing Miss Kolarova's material with the one described in this paper it at once becomes evident that *Yangtzeella* and *Clitambonites* are the dominant brachiopods in western Hupeh while *Orthis* takes their place in northern Hupeh as alreadly pointed out in the introduction. A difference of faunal facies like this can lead to but one conclusion; namely, the existence of a different horizon in the northern district. Whether or not the fact is such and what is the exact relation of the horizon to the Yangtzeella Beds in the Gorge District if it does exist, remain to be substantiated by further and more detailed stratigraphical work.

BIBLIOGRAPHY

Barrande, Joachim: Système Silurien du Centre de la Bohême, Vol. V, 1879.

Davidson, Thomas: The Silurian Brachiopoda, a Monograph of the British Fossil Brachiopoda. Palæontographical Society, 1865-1883.

Hall, James: Palæontology of New York, Vol. VIII, Pt. I, 1892.

Hayasaka, I.: Palæozoic Brachiopoda from Japan, Korea and China, Pt. I, Middle and Southern China. The Science Reports of the Tôhoku Imperial University, Sendai, Japan, Second Series, Vol. VI, No. 1, 1922.

Kayser, E.: Mittel-und Obersilurische Versteinerungen aus dem Gebirgsland von Tshau-Tien (China). Richthofen, China, Vol. IV, 1883.

Lee, J. S.: Geology of the Gorge District of the Yangtze. Bull. Geol. Soc. China, Vol. III, No. 3-4, 1924.

Mansuy, H.: Etude géologique du yunnan oriental, IIe partie, Paléontologie. Mém. Serv. Géol. de l'Indochine, 1912.

Reed, F. R. Cowper: The Lower Palæozoic fossils of the Northern Shan States, Burma. Palæontologia Indica, New Series, Vol. II, Mem. 3, 1906.

Reed, F. R. Cowper: Ordovician and Silurian fossils from the Central Himalaya. Palæontologia Indica, Series XV, Vol. VII, Mem. 2, 1912.

Reed, F. R. Cowper: Supplementary Memoir on New Ordovician and Silurian fossils from the Northern Shan States. Palæontologia Indica, New Series, Vol. VI, Mem. 1, 1915.

Reed, F. R. Cowper: Ordovician and Silurian fossils from Yunnan. Palæontologia Indica, New Series, Vol. VI, Mem. 3, 1917.

Reed, F. R. Cowper: The Ordovician and Silurian Brachiopoda of the Girvan District. Transactions of the Royal Society of Edinburgh, Vol. LI, Pt. IV, No. 26, 1917.

Schuchert, Charles and Le Vene, Clara M.: Fossilium Catalogus, 1: Animalia, Pars. 42: Brachiopoda. 1929.

Weller, Stuart: A Report on Ordovician Fossils collected in Eastern Asia in 1903-4. Research in China, Vol. III, the Carnegie Institution of Washington, 1913.

Yabe, H. and Hayasaka, I.: Palæontology of Southern China, Geographical Research in China 1911-1916. Tokyo Geographical Society, 1920.

Yü, C. C. and Shu, W. P.: Geology of Siangyang, Nanchang, Ichang, Chingmen, Chunghsiang and Chingshan districts, North Hupeh. Mem. the Institute of Geology, National Research Institute of China, No. VIII, 1929.

Yü, C. C.: The Ordovician Cephalopoda of Central China. Palæontologia Sinica, Series B, Vol. I, Fasc. 2, 1930.

EXPLANATION OF
PLATE I.

EXPLANATION OF PLATE I.

Fig. 1. *Lingula* sp. .... P. 7

1a Pedicle valve. Nat. size.

1b Same valve × 4.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3363).

Fig. 2. *Orthis calligramma* Dalman, var. *sinensis* Chang .... P 7

2a Internal mold of the pedicle valve. Nat. size.

2b Same mold × 2.

Loc: —Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3364).

Fig. 3 *Orthis calligramma* Dalman, var. *hupehensis* Chang .... P. 8

3a External impression of the pedicle valve of the holotype. Nat. size.

3b Gutta percha mold of same valve.

3c = 3a × 2.

3d = 3b × 2.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3365a, 3365b).

Fig. 4. *Orthis calligramma* Dalman, var. *hupehensis* Chang .... P. 8

4a External impression of another pedicle valve. Nat. size.

4b Gutta percha mold of same valve.

4c = 4a × 3.

4d = 4b × 3.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh

(G. S. C. Cat. Nos. 3366a, 3366b).

Fig. 5. *Orthis carausii* Salter, var. *nanchanghsiensis* Chang .... P. 9

5a Exterior impression of the brachial valve. Nat. size.

5b Gutta percha mold of same valve.

5c = 5a × 2.

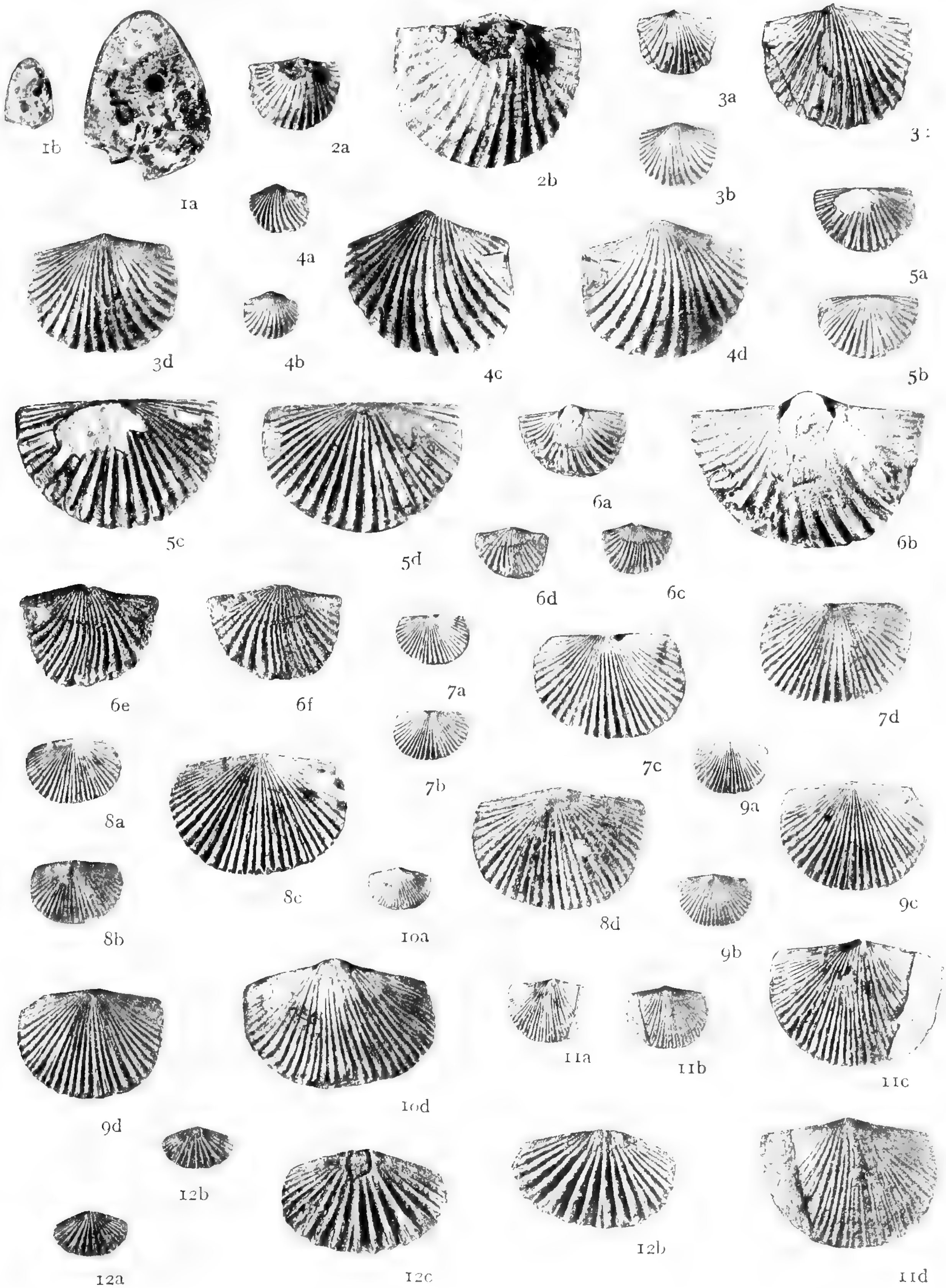
5d = 5b × 2.

Loc: -Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3367a, 3367b).

M. S. Chang:—Neichiashan Brachiopoda

Plate I



EXPLANATION OF PLATE I.—(Continued)

Fig. 6. *Orthis carausii* Salter. .... P. 10

6a Interior mold of the pedicle valve. × 2.

6b Same mold × 4.

6c Exterior impression of another pedicle valve × 2.

6d Gutta percha mold of same valve × 2.

6e = 6c × 4.

6f = 6d × 4.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3368, 3369a, 3369b).

Fig. 7. *Orthis neichiaensis* Chang .... P. 11

7a Exterior impression of the brachial valve, Nat. size.

7b Gutta percha mold of same valve.

7c = 7a × 2.

7d = 7b × 2.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3370a, 3370b).

Fig. 8. *Orthis neichiaensis* Chang .... P. 11

8a Exterior impression of another brachial valve × 2.

8b Gutta percha mold of same valve × 2.

8c = 8a × 4.

8d = 8b × 4.

Loc:.—Taihungshan, NanchangHsien, N. Hupeh.

(G. S. C. Cat. Nos. 3371a, 3371b).

Fig. 9. *Orthis neichiaensis* Chang .... P. 11

9a Exterior impression of a third brachial valve. Nat. size.

9b Gutta percha mold of same valve.

9c = 9a × 2.

9d = 9b × 2.

Loc:.—Taihungshan, NanchangHsien, N. Hupeh.

(G. S. C. Cat. Nos. 3372a, 3372b).

EXPLANATION OF PLATE I.—(Continued)

Fig. 10. *Orthis neichiaensis* Chang .... P. 11

10a Interior mold of the pedicle valve. Nat. size.

10b Same valve × 3.

Loc:.—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3373).

Fig. 11. *Orthis neichiaensis* Chang .... P. 11

11a Exterior impression of another pedicle valve. Nat. size.

11b Gutta percha mold of same valve.

11c = 11a × 2.

11d = 11b × 2.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3374a, 3374b).

Fig. 12. *Orthis ellipsoides* Chang .... P. 13

12a Exterior impression of the Pedicle valve × 2.

12b Interior mold of the pedicle valve × 2.

12c Interior mold × 4.

12d Exterior impression × 4.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3375, 3376).

EXPLANATION OF
PLATE II.

EXPLANATION OF PLATE II.

Fig. 1. *Orthis calligramma* Dalman, var. *intercalare* Chang .... P. 14

1a Interior mold of the pedicle valve. Nat. size.

1b Same mold × 3.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3377).

Fig. 2. *Orthis calligramma* Dalman, var. *intercalare* Chang .... P. 14

2a Interior mold of the brachial valve. Nat. size.

2b Same mold × 3.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3378).

Fig. 3. *Orthis calligramma* Dalman, var. *intercalare* Chang .... P. 14

3a Interior mold of another brachial valve × 2.

3b Same mold × 4.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3380).

Fig. 4. *Orthis calligramma* Dalman, var. *intercalare* Chang .... P. 14

4a Interior mold of a third brachial valve. Nat. size.

4b Same mold × 3.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3379).

Fig. 5. *Orthis* cf. *unguis* Sowerby .... P. 15

5a Interior mold of the pedicle valve × 2.

5b Same mold × 4.

5c Exterior impression of the pedicle valve × 2.

5d Same impression × 4.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3381, 3382).

M. S. Chang:—Neichiashan Brachiopoda

Plate II

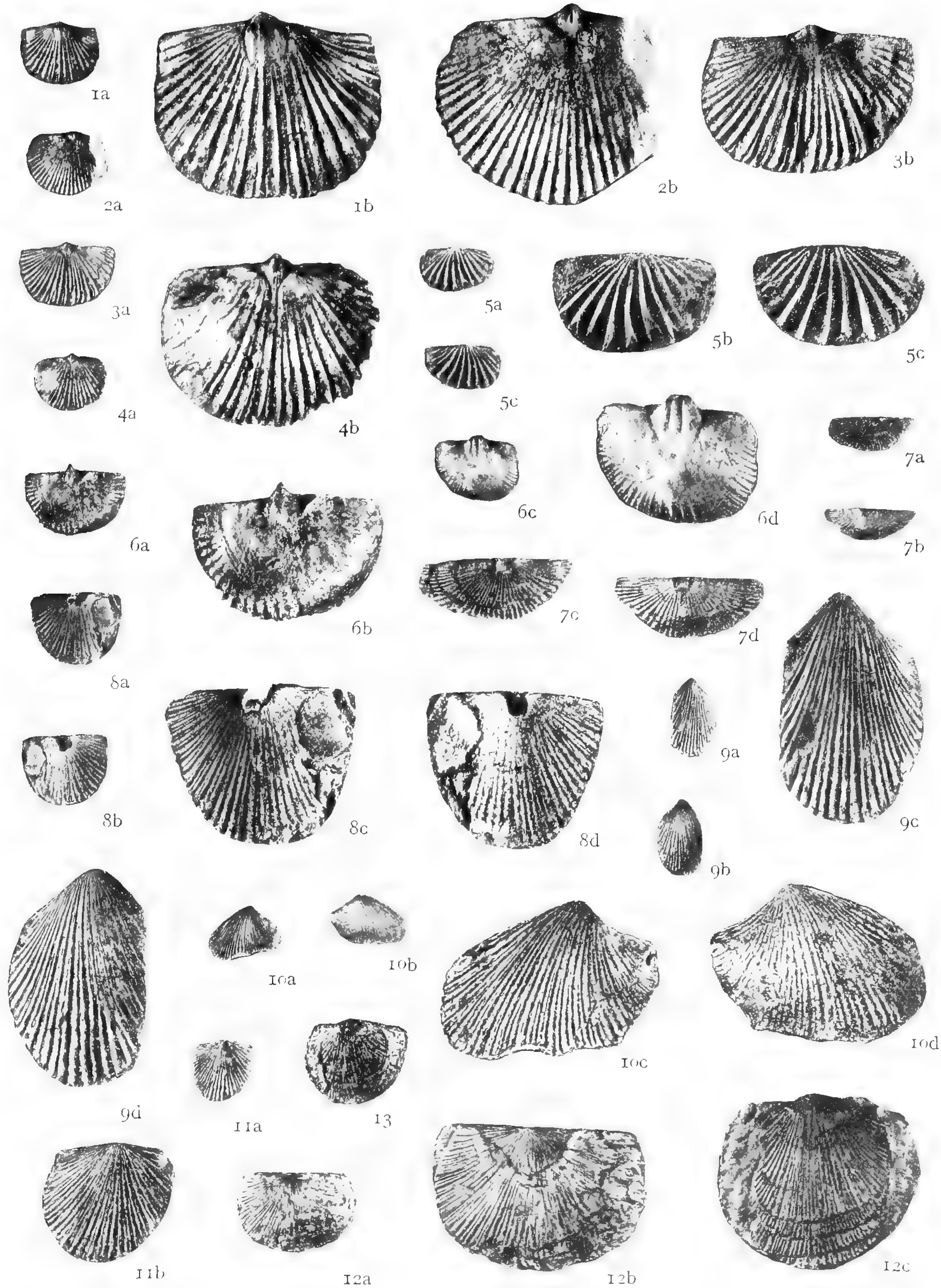


Fig. 6. *Orthis* cf. *calligramma* Dalman, var. *subplicata* Reed .... P. 15

6a Interior mold of the pedicle valve. Nat. size.

6b Same mold × 2.

6c Interior mold of another pedicle valve. Nat. size.

6d Same mold × 2.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3383, 3384).

Fig. 7. *Plectorthis* sp. 1 .... P. 16

7a Exterior impression of the pedicle valve. Nat. size.

7b Gutta Percha mold of same valve.

7c = 7a × 2.

7d = 7b × 2.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3385a, 3385b).

Fig. 8. *Plectorthis* sp. 2 .... P. 17

8a Exterior impression of the pedicle valve × 2.

8b Gutta percha mold of same valve × 2.

8c = 8a × 4.

8d = 8b × 4.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3386a, 3386b).

Fig. 9. *Dalmanella* cf. *elegantula* Dalman .... P. 17

9a Exterior impression of the pedicle valve. Nat. size.

9b Gutta percha mold of same valve.

9c = 9a × 3.

9d = 9b × 3.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3387a, 3387b).

Fig. 10. *Dalmanella* cf. *elegantula* Dalman .... P. 17

10a Exterior impression of another pedicle valve. Nat. size.

10b Gutta percha mold of same valve.

10c = 10a × 3.

10d = 10b × 3.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. Nos. 3388a, 3388b).

Fig. 11. *Rafinesquina* cf. *muthensis* Reed .... P. 18

11a Pedicle valve. Nat. size.

11b Same valve × 2.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3389).

Fig. 12. *Rafinesquina* cf. *muthensis* Reed .... P. 18

12a Another pedicle valve. Nat. size.

12b Same valve × 2.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3390).

Fig. 13. *Rafinesquina* cf. *muthensis* Reed .... P. 18

13a A third Pedicle valve. Nat. size.

13b Same valve × 2.

Loc:—Taihungshan, Nanchang Hsien, N. Hupeh.

(G. S. C. Cat. No. 3391).

8. *Orthis calligramma* Dalman, var. *intercalare* Chang (var. nov.)

9. *Orthis* cf. *unguis* Sowerby

10. *Orthis* cf. *calligramma* Dalman, var. *subplicata* Reed

11. *plectorthis* sp. 1.

12. *plectorthis* sp. 2.

13. *Dalmanella* cf. *elegantula* Dalman

14. *Rafinesquina* cf. *muthensis* Reed

在湖北南漳縣俞先生曾見艾家層覆於宜昌石灰岩之上，成整合關係。此處艾家層亦可分爲上下兩部：(一)下部黃綠色頁岩中含筆石數種(*Didymograptus murchisoni*, *Didymograptus* sp.)，腕足類數種(*Orthis* sp., *Orthis calligramma*, *Dalmanella* sp., *Diorthis* sp.)，豆形介類1種(*Leperditia* sp.)，三葉虫六種(*Asaphus* sp., *Asaphus hupehensis*, *Taihungshania shui*, *Illaenus nanchangensis*, *Bronteus* sp., *Bathyurus minor*)。(二)上部黃綠色石灰岩含頭足類數種(*Cycloceras* sp., *Orthoceras* sp., *Orthoceras chinense*, *Vaginoceras chientzekouense*)。

下部頁岩與揚子貝層相當，上部灰岩與寶塔石灰岩相當，似無問題。前者含 *Didymograptus murchisoni*，故俞先生以爲與英國之 Llandeilo 層同時，後者與瑞典之直角石灰岩及歐俄之 *Vaginoceras* 石灰岩相等。

南漳太紅山之下部頁岩中產正宜貝甚多，而在長江峽谷常見之揚子貝雖經搜求，毫無踪跡，故不能用揚子貝層一名，而創正宜貝層之名以別之。

本篇共述十四種及變種，其名如下：

1. *Lingula* sp.
2. *Orthis calligramma* Dalman, var. *sinensis* Chang (var. nov.)
3. *Orthis calligramma* Dalman, var. *hupehensis* Chang (var. nov)
4. *Orthis carausii* Salter, var. *nanchanghsiensis* Chang (var. nov.)
5. *Orthis carausii* Salter. MS.
6. *Orthis neichiaensis* Chang (sp. ncv.)
7. *Orthis ellipsoides* Chang (sp. nov.)

中國中部艾家層下部之腕足類化石

張鳴韶 著

本篇所述化石為民國十七年俞建章先生在湖北南漳縣太紅山所採。由葛利普教授之提議交著者研究，葛先生又任指導之責，著者對葛俞兩先生盛意，特誌謝忱。

李四光教授研究長江峽谷地質，首創艾家山系之名，其上部為寶塔石灰岩，下部為揚子貝層。據李四光教授揚子貝層中之化石如下：

Triplecia (Yangtzeella) poloi Martelli	(very abundant)
Clitambonites giraldii Martelli	(,, ,,)
Orthis calligramma Dalman	(not rare)
Eccyliopteris sinensis Frech	(abundant)
Vaginoceras duplex Wahlenb.	(,,)
Discoceras eurasiaticum Frech	(common)
Endoceras sp.	(abundant)
Cycloceras sp.	(very abundant)
Cytroceras sp.	(rare)
Asaphus cf. *expansus* Dalman	(rare)

李先生以為艾家系應屬中奧陶紀或上奧陶紀之最底部，此說與多數古生物學者之意見相同。據此則艾家系約當歐俄西部之 *Vaginoceras* 石灰岩。

中國古生物誌乙種第一號

第三期

張鳴韶著

中國中部艾家層下部之腕足類化石

中華民國二十三年五月

實業部地質調查所
國立北平研究院地質學研究所 印行
(學術研究與國立中央研究院國立北京大學兩廣地質調查所湖南地質調查所合作)

中國古生物誌乙種第一號

第三期

中國中部艾家層下部之腕足類化石

張鳴韶著

實業部地質調查所
國立北平研究院地質學研究所 印行
(學術研究與國立中央研究院國立北京大學兩廣地質調查所湖南地質調查所合作)

中華民國二十三年五月

GEOLOGICAL SURVEY OF CHINA

V. K. TING AND W. H. WONG DIRECTORS

Palæontologia Sinica

EDITORS:

V. K. TING AND W. H. WONG

Series B. Volume 1

Fascicle 4.

CONTRIBUTIONS TO THE CAMBRIAN FAUNAS OF NORTH CHINA

BY

Y. C. SUN

Palæontologist to the Geological Survey and Professor of Palæontology in the National Normal University, Peking.

PLATES I-V, 1 TEXT FIGURE

古生物誌

地質調查所

PEKING 1924.

Palæontologia Sinica.

中 國 古 生 物 誌

Published by the Geological Survey of China.

SERIES A. FOSSIL PLANTS OF CHINA.

Vol. I.

Fascicle 1. *R. Florin:* Zur Alttertiären Flora der südlichen Mandschurei, published Aug. 1922............Price $3.00 Mex.

Fascicle 2. *T. G. Halle:* Fossil plants from South-western China collected by Dr. K. V. Ting (in press)

Fascicle 3. *R. Florin:* Tertiare Pflanzenreste aus Nordchina (in preparation).

Vol. II.

Palæozoic Plants of China.

Fascicle 1. *T. G. Halle:* Palæozoic plants from Shansi (in press).

SERIES B. FOSSIL INVERTEBRATES OF CHINA.

Vol. I.

Fascicle 1. *A. W. Grabau:* Ordovician Fossils from North China. Published April, 1922............Price $5.00 Mex.

Fascicle 2. *A. W. Grabau:* Ordovician Fossils of North China, pt. 2. (In preparation).

Fascicle 3. *A. W. Grabau:* Ordovician Fossils of South China (In preparation).

Fascicle 4. *Y. C. Sun:* Contribution to the Cambrian faunas of North China.........Price $ 4.00

Fascicle 5. *A. W. Grabau and Y. C. Sun:* Graptolites of China (in preparation)

Vol. II.

Palæozoic Corals of China, Part I. The Tetraseptata.

Fascicle 1. *A. W. Grabau:* Introduction; Petraiidæ, Streptelasmaidæ and Cyathaxonidæ Published Sept. 1922............Price $3.00 Mex.

Fascicle 2. *A W. Grabau:* Zaphrentidae and Cyathophyllidæ. (In preparation).

Vol. III.

Palæozoic fauna of Yunnan 雲南古生界化石

Fascicle 1. *Y. C. Sun:* Cambrian fauna of Yunnan (In preparation.)

Fascicle 2. *A. W. Grabau:* Silurian Faunas of Yunnan (Ready for publication)

Fascicle 3. *A. W. Grabau:* Devonian Brachiopoda of Yunnan and neighbouring provinces (Nearing completion)

SERIES C. FOSSIL VERTEBRATES OF CHINA.

Vol. I.

Fascicle 1. *Max Schlosser:* Tertiary Vertebrates from Mongolia (119 pages and 6 plates)............Price $4.50

Fascicle 2. *Max Schlosser:* Fossil Primates from China (13 pages & 1 plate).........Price $1.00

Fascicle 3. *P. Teilhard:* Hipparion fauna of east Kansu etc. (In preparation)

Fascicle 4. *T. J. Ringström:* Nashörner der Hipparion-Fauna Nord-Chinas 156 pp. 12 pls.

Vol. II.

Fascicle 1. *O. Zdansky:* Jungtertiäre Carnivoren Chinas (in press).
The other fascicles will contain memoirs on Giraffidæ by Bohlin, Equidæ by Sefve etc.

Vol. III.

Fascicle 1. *Stensiö:* Fossil Fishes of Shantung (ready for publication).

Fascicle 2. *A. W. Grabau:* The Genus Lycoptera in North China and Mongolia (ready for publication.)

SERIES D. ANCIENT MAN IN CHINA.

Vol. I.

Fascicle 1. *J. G. Andersson:* The Cave-deposit at Sha Kou T'un in Fengtien. Price $3.50 Mex.

Fascicle 2. *Arne:* Painted Chinese Pottery from the Stone Age (in press)

Fascicle 3. *Davidson Black:* Human Skeletal Remains of Sha Kuo Tun, Fengtien, and Yang Shao, Honan (In press).

Series B. *Vol. I. Fascicle IV.*

PALÆONTOLOGIA SINICA

Editors:

V. K. Ting and W. H. Wong

Contributions to the Cambrian Faunas of North China

BY

Y. C. SUN

Palæontologist to the Geological Survey and Professor of Palæontology in the National Normal University, Peking.

Plates I - V, 1 text figure

古生物誌

地質調查所

Published by the Geological Survey of China

Peking 1924.

PUBLISHED DECEMBER 1, 1924.

Printed by

THE COMMERCIAL PRESS,

PEKING.

CONTENTS:

NOTE TO THE TRILOBITA

Throughout this paper the shorter dimension of the lobes of the glabella, the occipital ring and marginal rim, as well as of the axial rings and pleuræ of the thorax and pygidium is spoken of as their width. This seems desirable, since in comparing them with the separating furrows we speak of their shorter demensions as the width of the furrow. Thus the combined width of the glabellar lobes and furrows constitute the length of the glabella, while the combined width of the axial rings and furrows constitute the length of the axis of the thorax, etc. The length of the lobes consititutes the width of the glabella or thorax as the case may be. It is thus the measurement along the longitudinal axis of the entire animal, which constitutes the width of the lobes or rings of either cephalon or body. An exception to this is desirable in the case of the anterior lobe of the glabella the longitudinal measurement of which may be greater than the transverse. In such cases, to avoid misunderstanding—the measurement is further designated by the term antero-posterior or longitudinal this referring to the longitudinal axis of the animal as a whole. A few deviations from this rule have crept in, these being noted in the errata.

CONTRIBUTIONS TO THE CAMBRIAN FAUNAS OF NORTH CHINA

BY

Y. C. SUN.

INTRODUCTION.

Since the important and extensive studies of Walcott on the Cambrian Faunas of China, no work was done in the field until the systematic collection of Chinese fossils, in connection with the detailed exploration and mapping, was undertaken by the Geological Survey. In 1919 Mr. H. C. T'an of the Survey made a collection of Cambrian fossils from the northern rim of the Kaiping Basin which proved of such interest on preliminary study by Prof. Grabau, that it was decided to make a more detailed examination of the Cambrian as well as other formations of this locality. Accordingly the Survey sent an expedition to the Kaiping Basin, in charge of Prof. Grabau, and of this I was a member. On our return, the Cambrian material was placed in my hands for study and description.

In the same year, Dr. J. G. Andersson studied the Sha-Kuo-Tun 沙鍋屯 deposits in west Fengtien, and brought back a collection of Upper Cambrian fossils from this region, where the Upper Cambrian rests disconformably upon the Sinian rocks.

In the spring of 1923, the National University Expedition, in charge of the author, went to Shantung to study the Cambrian stratigraphy of that province. I was accompanied by several college students (C. C. Yang, S. T. Chang, C. C. Tien, Y. T. Chao, K. M. Wang, P. Tsai) who assisted me in measuring sections and making collections of fossils.

In the upper part of the Chaumitien limestone of Chau-Mi-Tien, we found a new horizon containing many species of *Orthoceras* and other cephalopods. Associated with these are *Ptychaspis*, *Eoorthis* and the new genus *Changia* of the family *Dikelocephalinæ*. The cephalopods probably represent an invasion of an early Ordovician type of fauna into the region where the Upper Cambrian fauna still persisted. These beds are probably to be regarded as still Cambrian rather than the Lower Ordovician. Nevertheless, this zone should be separated from the Chaumitien limestone.

In the Tai-An 泰安 district, we discovered four horizons in Kao-Li-Shan, 高里山 2 li from the city. Several new genera and species were found in this formation. The fauna is closely related to the *Ceratopyge* beds of Sweden, but it is quite distinct from the Chaumitien fauna. All fossils were obtained from the high beds and belong to the uppermost part of the Upper Cambrian, while the lower part is unfossiliferous, probably representing a part of the Chaumitien limestone.

A large number of well preserved specimens of *Drepanura* and *Damesella* were obtained from Ta-Wen-Kou, 大汶口, 50 li S. of Tai-An.

In the autumn of 1923, the author revisited the Kaiping Basin with two classes of the Geological Institute of the National University; and we made an extensive collection of Middle and Lower Cambrian fossils.

Dr. F. F. Mathieu, geologist of the Kailan Mining Administration, kindly sent me the Cambrian material which he had collected at Lei-Chuang 雷莊 and also joined us in the field at Chao-Kou-Chuang 趙各莊.

More recently Messrs. Y. T. Chao and C. C. Tien, graduates in Palæontology from the National University, and now members of the Survey staff, obtained a large number of well preserved specimens of Cambrian fossils from the Kushan beds in Lincheng 臨城 in southern Chihli, and they recognized also the Manto shale and Changhia limestone in that region, but did not find any fossil in it. The horizon found by them is the *Blackwelderia* zone whjch is essentially of Kushan age, and lies disconformably below the Lower Ordovician. They also found a new genus of the order *Proparia* characterized by having long genal spines on the fixed cheeks.

The present contribution covers the material so far obtained from North China, but it does not exhaust the field. A second contribution will be issued after further extensive collections have been made.

Eight new Genera and subgenera, and forty one new species are described in this paper.

In conclusion, I wish to express my thanks to Mr. K. C. Liu for making the drawings; to Dean C. Ho for his kindness in arranging the university excursions, and to Drs. W. H. Wong and H. T. Chang for suggestions and criticisms. Finally I am under great obligations to Prof. Grabau who has put the material in my hands for study, and given many suggestions and directions.

STRATIGRAPHIC SUMMARY

The Cambrian is known at present from Chihli, Shantung, Shansi and Manchuria. The lithologic character of each formation varies according to the condition of the deposition. Generally the southern regions (Shantung etc.) are characterized by limestones in the Upper Cambrian (Chaumitien), while this formation is represented by shales interbedded with Wurmkalke in Chihli. Farther north-east (Manchuria), a part of the Changhia limestone is replaced by the red shale.

The subdivisions of the Cambrian as now recognized in North China are as follows:

SUPER-FORMATION

Lower Ordovician

Probably a disconformity in all cases; (ascertained in many).

CAMBRIAN

Upper Cambrian

Fêngshan series

Chaumitien formation

Middle Cambrian

Kushan formation

Changhia formation

Lower Cambrian

Manto formation

CHIHLI PROVINCE

A. Kaiping Basin. The Cambrian strata are well developed in the Kaiping Basin and the subdivisions are as follows:

ORDOVICIAN

Yehli limestone

disconformity

Upper Cambrian

5	Fêngshan series	200-300 ft.
4	Changshan series	150-200 ft.

Middle Cambrian

3	Kushan formation (a part)	0-50 ft.
2	Changhia limestone	300-400 ft.

Lower Cambrian

1 Manto shale 400-500 ft.

disconformity

SINIAN

Black limestone

MANTO FORMATION—This is the oldest known Cambrian division of North China. It consists mostly of red, purple and green shales, sometimes interbedded with sandy limestones. It occurs in Chao-Kou-Chuang, 趙各莊 Lei-Chuang 雷莊 and especially in Chêng-Shan, 稱山 where the section was made. The following species are found in this formation:

Brachiopoda

1 Acrothele cheni Sun
2 Lingulella manchuriensis? Walcott
3 Obolus sp.

Trilobita

4 Conokephalina gerardi Sun
5 Conokephalina kaipingensis Sun
6 Ptychoparia (Emmrichella) chêngshanensis Sun
7 Ptychoparia sp.
8 Ptychoparia yohi Sun
9 Ptychoparia fongi Sun

CHANGHIA LIMESTONE—This consists of oolitic limestone and various shades of massive limestone. It is found in the northern slope of Chêng-shan and is usually called cliff limestone. It contains the following species:

Brachiopoda

1 Nissusia hayasakai Sun

Trilobita

2 Solenopleura nodosa Sun
3 Anomocare flava Walcott
4 Lisania rectangularis Sun
5 Lisania? hsuchiachuangensis Sun
6 Damesella blackwelderi var. minor Sun
7 Dorypyge richthofeni Dames
8 Dolinometopus deois Walcott
9 Crepicephalus sp.

KUSHAN SHALE—A part of this formation may be present, but so far no fossils have been found.

CHANGSHAN SERIES—This series consists of red or purple shales with seven or eight intraformational (edgewise) limestone conglomerates (wurmkalke). The red shale is richly fossiliferous and is found in Jên-Chuang, 任莊 2 li N. of Chao-Kuo-Chuang, and Chêngshan. The lithological charater of this red or purple shale is not unlike that of the Manto shale, but it can be distinguished by the series of wurmkalk beds interbedded with it. The detail section is given in the bulletin* of the Geological Society of China (Vol. II No. 1-2). p. 94-15. It contains the following species.

Brachiopoda

1 Obolus mollisonensis? Walcott

2 Eoorthis sp.

Trilobita

3 Changshania conica Sun

4 Changshania? truncata Sun

5 Agnostus hoi Sun

Obolus mollisonensis? Walcott is an American species from the Upper Cambrian of North American. *Eoorthis* is one of the Upper Cambrian genera. The other genera and species are new. Lithologically the red fossiliferous shales are interbedded with intraformational conglomerates (Wurmkalke) which are characteristic of the Upper Cambrian. This series corresponds to the lower part of the Chaumitien limestone of Shantung.

FÊNGSHAN SERIES—This series is composed of shales and thin-bedded limestone (calcilutite); and represents the uppermost part of the Upper Cambrian. It is very well developed at Fêng-Shan 鳳山 in the Yeh-li 冶里 region where the disconformable contact between the Fêngshan limestone and the overlying Ordovician limestone was discovered. The Fêngshan limestone is also found in Lei-Chuang, Chihli. The most common species are as follows:

Brachiopoda

1 Obolus luanhsiensis Grabau (Mss.)

2 Lingulella kayseri Grabau (Mss.)

Trilobita

3 Ptychaspis subglobosa Grabau (Mss.)

4 Ptychaspis suni Grabau (Mss.)

5 Mansuyia orientalis (Grabau) Sun

6 Illænurus sp.

7 Anomocare sp.

---

* The Upper Cambrian of Kaiping Basin by the author.

This is a new fauna and entirely distinct, and may be called the Asiatic Ceratopyge fauna. The most common specis is *Mansuyia orientalis* (Grabau) Sun which is also abundantly found in the Kaolishan formation. *Ptychaspis* and *Illænurus* are not uncommon. The formation is certainly of uppermost Cambrian age.

Ptychaspis subglobosa Grabau also occurs in the Kaolishan formation of Shantung, with which formation this Fêngshan series is to be correlated. The limestone conglomerate in this formation is unlike the wurmkalk (intraformational conglomerate) which is characteristic of the Chaumitien limestone or the Changshan series.

B. Lincheng. In Lin-Cheng, 臨城 S. Chihli, a complete section was studied by Y. T. Chao and C. C. Tien. A large number of well preserved specimens were obtained from the Kushan formation of that region, none being found in the older formations (Manto and Changhia)

The subdivisions are as follows:

Super-formation: Lower Ordovician

(disconformity)

Middle Cambrian	
Kushan formation	50-100 ft.
Changhia limestone	700-800 ft.
Lower Cambrian	
Manto shale	200-300 ft.

(disconformity)

Subformation: Sinian

The Kushan formation furnishes the following species:

Brachiopoda

1. Obolus linchengensis Sun

Trilobita

2. Wongia triangulata Sun
3. Blackwelderia tieni Sun
4. Stephanocare richthofeni Monke
5. Blackwelderia sinensis var. linchengensis Sun
6. Tienistion subconica Sun

Stephanocare richthofeni Monke and *Blackwelderia sinensis* Walcott are present in this formation, and it is essentially the Kushan shale horizon of Shantung. One new species of *Blackwelderia* and one new species of *Teinistion* are also found in this formation. The most unique form is the new genus *Wongia* of the order proparia. This genus, *Wongia*, is quite distinct from any known type of foreign countries, and is certainly one of the most characteristic genera of the Middle Cambrian of China.

SHANTUNG PROVINCE

A. Kao Li Shan. This a low hill, 2 li west of Tai An, is composed of limestone conglomerate, limestone and shale. The lower part consists of unfossiliferous beds occationally with wurmkalk, and probably represents a part of the Chaumitien formation. The upper part is mostly of shale, limestone and limestone conglomerate which is unlike the wurmkalk (intraformational conglomerate) of the Chaumitien formation. The following section was made by the class of 1923 of the Geological Institute of the National University under the direction of the author.

		Feet	Inches
25	conglomerate limestone (partly covered) F 4	30	0
24	thin-bedded limestone		6
23	fine oolitic limestone	3	5
22	shale	2	6
21	conglomerate limestone F 3	1	2
20	Shale	2	6
19	conglomerate limestone	1	0
18	shale	3	7
17	Obolus limestone F 2	1	0
16	oolitic limestone	2	6
15	thin-bedded limestone		9
14	conglomerate limestone		4
13	thin-bedded limestone		9
12	oolitic limestone		4
11	thin-bedded limestone	1	2
10	compact and dark gray limestone F 1	1	0
9	thin bedded limestone	11	0
8	ochery limestone	2	3
7	thin-bedded limestone	2	8
6	ochery limestone	2	8
5	thin-bedded limestone	2	8
4	intraformational limestone	11	0
3	ochery limestone	4	4
2	thin-bedded ochery limestone	7	0
1	intraformational conglomerate	20	0

The following species are found in the University collection:

Graptozoa

1. Clonograptus? cambria Sun

Brachipoda

2. Obolus taianensis Sun F_2
3. Syntrophia orthia Walcott F_1
4. Agnostus cyclopygeformis Sun F_1
5. Ptychaspis subglobosa Grabau F_3
6. Ptychaspis angulata var. chinensis Sun F_1
7. Quadraticephalus walcotti Sun F_4
8. Kaolishania pustulosa Sun F_1
9. Mansuyia orientalis (Grabau) Sun F_1
10. Taianocephalus grabaui Sun F_1
11. Chuangia batia walcott F_1
12. Illænurus ceres Walcott F_3
13. Illænurus Pagoda Sun

Dr. Walcott has correlated this formation with the Chaumitien limestone of the Chang-hia region and referred it to the lower part of that formation, but with our present faunal evidence this formation is recognized as younger than the Chaumitien limestone and should be given a separate name.

Ptychaspis subglobosa Grabau also occurs in the same character of limestone (limestone conglomerate) of the Fêngshan formation. *Mansuyia orientalis* (Grabau) Sun is also the most common species in that formation. The succession of the strata and the palæontology clearly indicates that this formation is the equivalent of Fêngshan limestone of Chihli, and certainly belongs to the upper part of the Upper Cambrian.

Agnostus cyclopygeformis Sun is very closely related to the European form *A. cyclopyge* of Sweden. This indicates that the Upper Cambrian sea of China had a close connection with that of Europe. That is why many Chinese and European forms appear to be identical.

Ptychaspis angulata Mansuy is found abundantly in the Upper part of the Upper Cambrian of Tonking, it is also present in this formation. Hence this formation is equivalent to *Ptychaspis angulata* zone of Indo-China.

The discovery of the new genus *Quadraticephalus* of the family Dikelocephalinæ which comprises the characteristic form of the Upper Cambrian of North America is of considerable interest and significance.

The presence of *Clonograptus* and the *Cyrtoceras* figured by Walcott is of significance, because both are more typical of the Ordovician and must at least be regarded as transition types of the Cambro-Ordovician strata. The graptolite was found several years ago by Mr. K. W. Hsu during an excursion to the locality in charge of Dr. H. W. Wong.

I agree with Dr. Walcott in putting this formation in the Upper Cambrian, but I regret that I cannot follow him in including this formation in the Chaumitien limestone. I am disposed to separate this formation under a new name, the Kaolishan (Kaoli) formation, and to refer it to the uppermost part of the Upper Cambrian.

b. Chaumitien. 炒米店 This is the type locality for the Chaumitien limestone which was named by Willis and Blackwelder. Near the top of that limestone, we found a new horizon characterized by a transition fauna. The name of Chaumitien limestone, I think, should be restricted to the lower part of that formation, while the upper beds characterized by the Ordovician types should be given a separate name.

The following species are found in the upper zone:

Brachiopoda

1. Billingsella sp.

Cephalopoda

2. Loxoceras cambria Sun*
3. Orthoceras nanshanensis Sun*

Trilobita

4. Changia chinensis Sun
5. Ptychaspis acamus var. punctata Sun
6. Ptychaspis tani Sun

Ptychaspis and Billingsella are the characteristic fossils of Upper Cambrian while Loxoceras and Orthoceras are apparently Ordovician forms.

Because the presence of Ptychaspis acamus Walcott I am constrained to put this horizon in very late Cambrian rather than basal Ordovician, and consider that the cephalopod element is a new invasion.

It is evident that this formation, characterized by the mixed fauna, should not be included in the Chaumitien limestone which is now restricted to those lower beds characterized by Wurmkalke (intraformational conglomerates). This upper horizon, however, may be the equivalent of the Fêngshan series of Chihli.

---

* These will be described in a reparate paper by the Author.

c. TAWENKOU. 大汶口 This place, 50 li south of Tai-An, is well known for Stone-swallows. This formation is very fossiliferous and of Kushan age. The lower part furnishes a large number of Drepanuras while the upper contains some Blackwelderias and Damesellas.

The following species were found in this formation:

1. Drepanura premesnili Bergeron
2. Drepanura ketteleri Monke
3. Agnostus douvillii Bergeron
4. Liostracina krausii Monke
5. Shantungia spinifera Walcott
6. Agnostus kushanensis Walcott
7. Stephanocare richthofeni Monke
8. Damesella sp.
9. Blackwelderia sp.

FENGTIEN PROVINCE

Only the Upper Cambrian is known from Sha-kuo-T'un, Chin-Hsi-Hsien, 錦西縣 west Fengtien. The fossils were collected by. J. G. Andersson, mining adviser to the Chinese Government. The section is given in the Bulletin of the Geological Society of China (Vol. II No. 1-2 p. 101.).

The following species are found in this limestone:

Trilobita

1. Ptychaspis walcotti Mansuy
2. Ptychaspis acamus Walcott
3. Ptychaspis chinhsihsiensis Sun
4. Ptychaspis (Anderssonia) fêngtienensis Sun
5. Agnostus sp.

Brachiopoda

6. Eoorthis shakuotunensis Sun

This formation is characterized by two new species of *Ptychaspis* and certainly belongs to the Upper part of the Cambrian. The Lower and the Middle Cambrian are absent in this region and the Shakuotun limestone lies disconformably upon the pre-Cambrian (Sinian) rocks.

The subdivisions of the Cambrian of N. China are as follows:

	SHANTUNG		CHIHLI	FÊNGTIEN
	TAIAN REGION	CHANGHIA REGION (Kiulung Group)	KAIPING BASIN (Changshan Group)	CHINHSIHSIEN
U. Є.	Kaolishan limestone Chaumitien limestone?	Orthoceras Zone	Fêngshan limestone	Shakuotun limestone
		Chaumitien limestone	Changshan series	
M. Є.	Kushan formation	Kushan formation	Kushan shale	
	....	Changhia limestone	Changhia limestone	
L. Є.	Manto shale	Manto shale	Manto shale	

From the lithological, and stratigraphic relations, and the Palæontology, it is clear that the early Middle Cambrian sea, must have been free from mechanical sediments to permit the formation of oolitic limestone and then become gradually shallow in the late Middle Cambrian and the Upper Cambrian time permitting the formation of shales and intraformational conglomerates.

The Lower Cambrian sea of China had no connection with the Atlantic or the Boreal province; but the Middle Cambrian was to some extent confluent with the Boreal and west American Provinces, and more particularly was this the case in Upper Cambrian time.

A number of American genera, and even species are found in this country, though, on the whole the faunas are quite distinct.

DESCRIPTION OF SPECIES

Class **GRAPTOZOA** Grabau

Genus **CLONOGRAPTUS** Hall

Clonograptus? Cambria Sun (sp. nov.)

Plate I. Fig. 1.

This species is only represented by one stipe slightly curved.

Stipe somewhat rigid and slender. Thecæ fifteen to sixteen in 10 mm., slender tubes inclined 30° or more. Apertural margins concave oblique, conspicuously mucronate. Each theca averages 1.5 mm. in length and 0.5 mm. in width. Maximum width of stipe about 1 mm.

In form this species resembles *Clonograptus tenellus* from the Dictyonema shale of Sweden and England; but it differs in that it has 15 or 16 thecæ in 10 mm. while in *C. tenellus* only 10 thecæ are found in 10 mm. As the generic determination is mainly based on the number of stipes, and only one stipe of this species is known, the generic determination of this specimen is still somewhat doubtful.

This species occurs in a thin slab of gray limestone which was collected several years ago by Mr. K. W. Hsu (徐偉曼) of National South Eastern University.

Horizon and locality: Upper Cambrian; Kaolishan limestone of Tai-An, Shantung.

Class **ANNELIDA**

Cenns **CLIMACTICHNITES** Logan

Climactichnites mathieui Sun (sp. nov.)

Plate I. **Fig. 2.**

One specimen from Luanchou contains the trails of an annelid, which apparently belongs to *Climactichnites*. The trails of *Climactichnites* were also found in the Upper Cambrian of New York and Wisconsin, N. America.

Woodworth suggests that the animals which made these trails were mollusks capaple of crawling up from the water at low tide, while Walcott thinks the trails were certainly made by annelids.

I agree with Dr. Walcott, because many annelids have been found in the Cambrian strata.

The Chinese form is represented by an impression of the trails on the under side of the rock, which clearly shows the character in relief.

It is small, being only 3.5 mm. in width having 8 grooves in 1 cm, indicating that it was the trail of an annelid of ordinary size.

This species is quite distinct from any known foreign species. I take pleasure in naming it in honor of Dr. F. F. Mathieu, geologist of the Kailan Mining Administration.

Measurements:—

Average width of groove with very narrow ridges separating it ....1 mm.

Average length of the groove..2 mm.

Horizon and locality: Lower Cambrian, Manto shale of Luanchou; collected by Dr. F. F. Mathieu.

Class **BRACHIOPODA** Duméril

Genus **OBOLUS** Eichwald

Obolus (Westonia) leei Sun (sp. nov.)

Plate I. Fig. 3a-3c.

Shell of medium size, depressed convex; general form broadly ovate, almost subquadrate, with the pedicle valve obtusely acuminate. The frontal margin nearly straight, both sides are nearly parallel, regularly and gently rounded; posterior margins straight on both sides of the beak, meeting at the latter at an angle of about 125°. Shell little longer than the wide.

Surface marked by coarse concentric lines of growth and the characteristic ornamentation. This appears to be formed of a very fine network of oblique depressed lines which divide it into minute diamond-shaped spots, a surface which resembles, under a strong lens, the texture of finely woven cloth.

This species is represented by only one valve of the shell; the measurements are as follows:

Length.. 9.0 mm.
Width .... 8.5 mm.

Horizon and Locality:—Cambrian: from purple shale of Luan-Chou. Collected by Dr. F. F. Mathieu, geologist to the Kailan Mining Administration of Tang-Shan.

This species is named after Prof. J. S. Lee 李四光 of the National University.

The surface-ornamentation of this species is not unlike that of *Obolus* (*Westonia*) *stoneanus* (Whitfield) from the Upper Cambrian sandstone of Sauk county Wisconsin (U. S. A.) but it differs in the broad form of the shell, and also in size.

This species is characterized by its subquadrate form and reticulated structure of the surface, which is a feature quite distinct from that of any known Chinese species.

Obolus mollisonensis? Walcott

Plate I. Figs. 4a, 4b.

1912 *Obolus mollisonensis* Walcott, Cambrian Geology and Pal. (Smiths. Miscell. coll. Vol. 57) Vol. II No. 7; p. 231, pl. 35, figs. 10-12.

1938 *Obolus mollisonensis* Walcott, Sun. Bull. Geol. Soc. of China. Vol. II No. 1-2 p. 94 (listed).

Shell small, of subovate outline; moderately convex, length and width subequal. Posterior border nearly straight meeting at the beak and forming an obtuse angle (110°). Anterior lateral borders rounded, frontal margin more gently rounded. Convexity most pronounced near the umbonal region, the shell becoming flattened towards the front.

Surface uneven, marked by fine irregular, concentric line of growth, and a few coarse concentric wrinkles.

This shell shows almost exactly the characters of the species described under *Obolus mollisonensis* by Walcott from the Lower Ordovician of Mount Mollison British Columbia, and although the interior characters are not known, I tentatively refer it to that species because of the agreement in form.

This shell also resembles *Obolus* (*Bröggeria*) *salteri* (Holl) of the Upper Cambrian and Lower Ordovician of north western Europe, but the surface features of *Obolus* (*Bröggeria*) *salteri* are absent in our specimens; and the agreement is closer with the Mount Mollison specimen. Only two specimens of this species have been found in China, one of which is poorly preserved.

A comparison of the measurement of our best specimen (Fig. 4 a) and of W. American and European forms give as follows:

	Chinese specimen fig. 4 a	Walcott type	O. (Bröggeria) salteri
Length	5.6 mm.	5.3 mm.	6.0 mm.
Width	6.0 mm.	5.6 mm.	6.8 mm.

Horizon and Locality:—Early Upper Cambrian: from purple shale of Changshan formation of Chao-kou-chuang, Luan-Hsien, Chihli: collected by Survey Expedition.

Obolus linyuensis Sun (sp. nov.)

Plate I. Fig. 5.

Shell small, oval; moderately convex, length slightly greater than the greatest width. Posterior borders nearly straight meeting at the beak approximately in an angle of 80°. Antero-lateral borders rounded.

Surface marked by lines of growth which are regular, giving a smooth and glistering appearance, but becoming more coarse in the anterior part.

This species is represented by only one specimen and characterized by its small glistening shell with concentric lines of growth regularly arranged.

Measurements:—

Length ....4.0 mm.

Width ....3.8 mm.

This species resembles *Obolus willisi* Walcott from the Upper Cambrian and Middle Cambrian of Alabama, in form, but differs in the absence of the punctate character of the surface and also in the character of the umbo and in size.

HORIZON AND LOCALITY:—Cambrian: from limestone inter-bedded in Manto shale of Hung-shan-T'ou, 紅山頭 Lin-Yu Hsien: collected by University excursion in 1923 under the direction of the author.

Obolus taianensis Sun (sp. nov.)

Plate I, Fig. 6 a, 6 b.

Shell small, ovate in form, pedicle valve obtusely rounded; valves moderately convex, the convexity increasing gradually from the margins to the umbonal portion of the shell.

Surface marked by concentric lines: when the outer layer of the shell is exfoliated, numerous radiating striæ will appear on the surface. The shell is formed of lamellose layers, which make a strong thick shell.

Measurements:—

Length ....5.9 mm.

Width ....6.4 mm.

The shell figured by Walcott on Plate II fig. 2, from Kaolishan and provisionally referred to *O. matinalis* Hall may belong to this species, agreeing with it in general form and size, though the length of Walcott's specimen is slightly greater than the width.

This species is distinguished by its oval shape, moderate convexity of the shell and the lamellose character of the shell surface. It is represented by many individuals which occur abundantly in that zone.

HORIZON AND LOCALITY:—Upper Cambrian: associated with *Ptychaspis subglobosa* Grabau in the upper beds of Kaolishan limestone (Coll. Y. C. Sun).

Obolus luanhsiensis Grabau (mss.) (sp. nov.)

Plate I, Figs. 7 a-7 c.

1883 *Lingulella* sp. Kayser in Richthofen China, Vol. pl. 111, fig. 2.

1919 *Obolus?* sp. indet. Walcott, Cambrian Brachiopoda p. 62.

1922 *Obolus luanhsiense* Grabau (mss.)

1923 Obolus luanhsiense Grabau, Sun. Bull. Geol. Soc. China, Vol. II, p. 98 (listed).

"Shell moderately large of subtriangular outline and moderate to strong convexity; length slightly less than the greatest width which is in the anterior third of the shell. Posterior borders nearly straight meeting at the beak approximately in a right angle. Antero-lateral borders rounded, front straight or more rarely faintly sinuate. Convexity most pronounced in the umbonal region, the shell becoming flattened towards the front.

"Surface marked by lines of growth which are fine and regular in the young shell giving the surface a smooth appearance, but become coarser and more of the nature of faint concentric wrinkles in the adult portion, where the shell is also sometimes characterized by a few faint radiating wrinkles. Exceedingly fine radiating lines are shown under a high power lens on the young shell.

"*Dimensions.* Three individuals measure respectively: length 7.6 mm., 5.6 mm., 6.4 mm., width 8. mm., 5.1 mm., 6.5 mm.

Horizon and Locality:—Associated with *Lingulella kayseri* Grabau in the thin-bedded limestone layers of the Fêngshan formation of Upper Cambrian age at Yeh-li, Luan-Hsien, Chihli; collected by H. C. T'an.

"This species is not unlike *Lingula petalose* Hicks from the Arenig of Whitesand Bay (Davidson: Silurian Brachiopoda, pl. XLIX, fig. 30, p. 337). That species is described as broadest in the middle, but some of the specimens figured by Davidson show the greatest width in the anterior third. In this respect, as well as in general shape and in size, they agree fairly well with our species." (Grabau).

Genus **LINGULELLA** Salter

Lingulella dimorpha Sun (sp. nov.)

Plate I, Fig. 8a-8b.

Shell of medium size, and subrectangular form; length and width approximately as six to five. Sides of shell nearly parallel, but gently curved, frontal margin rounded at the sides, straight in the center; posterior margins straight on either side of the beak, meeting at the latter at an angle of about 150°.

Surface marked by two stages of growth lines. The young stage is characterized by its undulating growth-lines, while the adult stage is marked by ordinary growth-lines crossed by very fine radiating striæ. A triangular median depression is slightly marked, and outlined by two slightly elevated broad and low ridges which are only seen on the perfect specimen of the shell.

This species resembles *Lingulella kayseri* Grabau in form, but differs in the character of the growth-lines, in the more obtuse beak and also in size.

This species is characterized by two different stages of growth lines, subrectangular form, and the obtuse angle of the beak of the shell.

	1	2
Measurements:—	Luanchou	Yehli
Length	12.00	18.5
Width	10.50	12.8

Horizon and Localities:—Upper Cambrian: from thin-bedded clayey limestone of Luan-chou. Collected by Dr. F. F. Mathieu. Also in lower part of Fêngshan formation near Yeh-li. Coll. by Y. C. Sun.

Lingulella liui Sun (sp. nov.)

Plate I, Figs. 9a-9c.

Shell small, elongate egg-shaped with both posterior and anterior end obtusely rounded: depressed-convex, the frontal margin obtusely rounded; width gradually increases from the frontal margin to the middle of the shell. Beak obtuse with an angle of 110°; greatest width is in the middle of the shell.

The outer surface usually has a glistening appearance and is marked by regular fine but sharp concentric striæ and coarser lines of growth at frequent intervals. When the outer shell is exfoliated, it is distinctly marked by many elongated pustules, and the frontal margin by very fine radiating striæ.

This species is represented by three specimens all apparently ventral valves. It presents quite distinct a form from any known Chinese species.

This species resembles *Lingulella ferruginea* Salter in general appearance, but differs in the character of the shell, in the more elongated form, and in the absence of the distinct radiating striæ. Three specimen measure respectively; length 5.5 mm. 4.9, 5.5, width 3.5, 3.3, 3.4.

Horizon and Locality:—from the Cambrian purple shale of Luan-Chou: collected by Dr. F. F. Mathieu. The specific name is given in honor of Mr. C. P. Liu, 劉基盤 dean of the Geological Department of the National Normal College of Peking.

Lingulella kayseri Grabau (mss.) (sp. nov.)

Plate I, Figs. 10 a-10c

1883 Lingulella sp. Kayser, in Richthofen. Vol. IV, p. 35, pl. III, fig. 3.

1919 Lingulella davisii Walcott (non McKoy) Cambrian Brachiopoda p. 489, pl. XXX, figs. 2, 2 a; pl. XXXI, figs. 6, 6a-h.

1922 Lingulella kayseri Grabau (mss.)

1923 Lingulella kayseri Grabau, Sun. Bull. Geol. Soc. China, Vol. II. p. 98. (listed)

"Shell of medium size and subrectangular form; length and width approximately as five to four. Sides of shell nearly parallel and only gently curved, frontal margin rounded at the sides, straight in the center; posterior margins straight on either side of the beak, meeting at the latter at an angle of about 125°.

"Surface marked by growth lines and at intervals by faint concentric wrinkles. Crossing these are radiating striæ which on the posterior lateral margins, where they are most strongly marked, have an obliquely outward and backward direction, giving a pronounced ornamentation to the surface.

"*Dimensions*. The following dimensions show the rate of variation in the length and width of the shell in millimeters.

	1	2	3	Richthofen's, specimens	
Length	10.0	10.2	11.3	17.0	13.0
Width	8.2	8.5	9.0	13.5	10.5

"This species appears to be the same as the specimens noted and figured as *Lingulella* cfr. *nathorsti* Linnarson by Kayser, and which were obtained by von Richthofen in a greenish-gray thin-bedded or somewhat slaty limestone from Sai-ma-ki 寨馬集 Liau-tung, Manchuria. There that species is associated with another shorter and rounder form (*Obolus*) which appears to be identical with the smaller form associated with our species. The associated trilobites in the Liau-Tung region comprise *Conocephalites frequens, Anomocare latelimbatum, Agnostus chinensis*. The last two species are referred by Walcott to the Middle Cambrian whereas our specimens are associated with Upper Cambrian trilobites. It is not impossible that the specimens described by Kayser belong to distinct species. They are larger than our specimens and apparently without their ornamentation but agree closely with them in form and proportions.

"Horizon and Locality:—In the Upper Cambrian Fêngshan formation of Yeh-li: collected by Mr. H. C. T'an" (Grabau).

Dr. Walcott referred the specimen figured by Kayser to *Lingulella davisii* (McCoy), from which however our species is quite different. McCoy's species is characterized by relatively greater width, by a more nearly rectangular umbonal region, and by the lack of the characteristic ornamentation found in our species, though this may also be absent in the specimens figured by Kayser.

Genus **ACROTHELE** Linnarson

Acrothele cheni Sun (sp, nov.)

Plate I, Figs. 11a-11b.

All the specimens representing this species are flattened by compression on the argillaceous shale, and are also more or less distorted.

General form subcircular except for the straight posterior margin. Pedicle valve flat due to compression with the apex 2.5 mm. from the posterior margin. A triangular false area extends from the apex to the margin; it is defined by a slight depression and a low ridge at the outer edges; surface marked by numerous more or less regular lines of growth, but not marked by radiating lines.

Nothing is known of the interior characters.

This species is characterized by its subcircular form, numerous concentric growth striæ and the position of the apex.

A shell 10.5 mm. in width has a length of 9.5 mm. while another measures 9 mm. in length and 9.3 in width.

Horizon and Locality:—Middle Cambrian: from Changshan shale of Chao-kuo-chuang, Luan-Hsien, Chihli. Collected by S. Chen 陳 旭 of class 1925 of the Geological Institute of the National University.

Genus **NISSUSIA** Walcott

Nissusia hayasakai Sun (sp. nov.)

Plate I, Fig. 12.

Shell semioval with the hinge line a little shorter than the greatest width of the shell; surface of shell marked by radiating ribs and also by a few concentric lines.

Pedicle valve convex, ribs become more pronounced in the frontal part of the shell. Ribs increase by bifurcation and with nodes on their crests; they are broad, the interspaces being narrower than the ribs. A median sinus moderately distinct extends from the umbo to the frontal margin of the shell.

The plications of the shell and the form suggest *Huenella*; but the nodes on the crests of the ribs serve to distinguish it. All species of *Huenella* except *etheridgii* are from the Upper Cambrian.

Nothing is known of the interior of the shell.

This species is characterized by its transverse form, broad radiating ribs with nodes on their crests and the less pronounced median sinus.

Measurements:—

Length...6 mm.
Width..9 mm.

HORIZON AND LOCALITY:—Middle Cambrian: from Changhia limestone of Chêng-shan, 2 li from Luan-Hsien, Chihli (Coll. K. S. Hsu 徐光熙).

This species is named after the Japanese Palæontologist Dr. I. Hayasaka. It is represented by several crushed valves. It is associated with *Damesella blackwelderi* var *minor*, *Dorypyge richthofeni* etc.

Genus **EOORTHIS** Walcott

Eoorthis shakuotunensis Sun (sp. nov.)

Plate I, Figs. 13a-13b.

This species is represented by a number of the pedicle valves and one interior of the pedicle valve.

Shell moderately convex, subquadrate in outline with angular cardinal extremities. Hinge line usually forming the greatest width of the shell. Posterior margin on both sides of beak straight, forming an angle of 160 degrees. Median fold faint on the ventral valve.

Surface marked by a few rounded radiating ribs, which where farthest apart measure 3 in 2 mm; there are 4 or 5 fine striæ between each pair of larger ones. The ribs increase in number by interpolation and may appear at any distance from the beak, usually becoming coarser near the frontal margin.

The associated interior of a pedicle valve (Fig. 13 b.) shows the cardinal area, muscular impression and the fracturing and the deflection of the striations along the margin of the interior of the valve.

This species is characterized by a long hinge line, a subquadrate form, and the rounded ribs with 4 or 5 fine ones between.

Measurements:—

	Pedicle valve	Interior of the pedicle valve
Length	13.5 mm.	13.0 mm.
Width	14.5 mm.	14.5 mm.

HORIZON AND LOCALITY:—Upper Cambrian: from the Shaokuot'un limestone of Chin-Hsi-Hsien, Fêngtien; collected by Dr. J. G. Andersson.

Eoorthis sp. indt.

Of this species only a broken specimen was found in the purple shale of the Chang-shan group. It is marked by transverse form, distinct round ribs with broad interspaces, four ribs occupying a space of 2.5 mm. near the frontal margin.

HORIZON AND LOCALITY:—Early Upper Cambrian from purple shale of Chang-shan group of the Kaiping Basin. Associated with this are *Changshania conica*, and *Changshania? truncata:* Collected by Dr. F. F. Mathieu and Y. C. Sun.

Genus **SYNTROPHIA** Hall and Clarke

Syntrophia orthia Walcott

Plate 1, Figs. 14a-14b.

1913 *Syntrophia orthia* Walcott, Research in China. Vol. III. p. 85, pl. 5, figs. 1, 1a, 1b.

Dr. Walcott described and figured the external shell of both valves of this species. His full description is as follows:—

"General form irregularly oval with the ventral view obtusely angular toward the apex; rounded, biconvex, with a deep mesial sinus on the ventral and a strong median fold on the anterior half of the dorsal valves.

"Surface smooth, with the exception of a few concentric striæ and lines of growth.

"The ventral valve has a strong median sinus that occupies about one-third of the width of the valve at the anterior margin and projects forward to fit into the fold in the front of the margin of the dorsal valves; the sides of the median sinus are elevated and, with the downward curving lateral slopes, form a strong rounded ridge on each side of the sinus; none of the specimens in the collection show the area, but from the profile of the valve it must have been of moderate height, with a rather short apex curving over it.

"Dorsal valve with a minute apex from which a narrow, slightly developed median fold extends out to about the center of the shell, where it becomes elevated and projects forward to the front margin; the remaining portions of the surface are uniformly convex, sloping away from the median fold to the margin of the valves" (Walcott 1923).

In our collection, an internal mold of the ventral valve was discovered. I add to the original description the following:

Othoid form, moderately convex, with a strong median sinus which occupies about one third the width of the valve at the anterior margin; the sides of the median sinus are elevated, and with the downward sloping lateral slopes form a strong, rounded ridge on each side of the sinus.

Spondylium free not supported by median septum and marked by subparallel ridges, merging into the median sinus. Hinge line long forming about the greatest width of the shell; postero-cardinal angles angular.

Surface anteriorly marked by a few indistinct strong lines of growth and especially characterized by radiating striæ on both lateral slopes.

Measurements:	Ventral valve	Interior of ventral valve
Length	4.0 mm.	6.5 mm.
Width	5.3 mm.	7.6 mm.

HORIZON AND LOCALITY:—From the Kaolishan limestone of Tai-An-Fu. (Coll. Y. C. Sun).

---

class **TRILOBITA** Walcott

Genus **AGNOSTUS,** Brongniart

Agnostus cyclopygeformis Sun (sp. nov.)

Plate II, Figs. 1a-h.

Cephalic shield moderately convex, width and length subequal, semicircular in outline and slightly contracted at the postero-lateral angles; rim narrow with uniform width; dorsal furrow shallow and distinct; frontal groove shallow and distinct connecting the frontal rim and the glabella.

Glabella cylindrical, about one-third the width of the cephalon, contracted at the middle by slight incurving of the sides. It is divided by two slightly impressed backwards curving furrow into three lobes. The second lobe is distinctly marked by an elongated tubercle; frontal groove shallow and distinct; two small triangular lobes at the postero-lateral margin of the glabella.

Thorax unknown.

Caudal shield moderately convex, little wider than long, with uniformly elevated rim. Axial lobe short, about one third the total length, pentagonal in outline bounded laterally by two strong oblique furrows and posteriorly by two slightly impressed curving furrows which meet at an obtuse reêntrant angle. A large, distinct and elongated tubercle is situated at the middle of the margin of the axial lobe. Limb moderately convex, marked by a median groove from the median tubercle of the axis near to the posterior margin. On either side of the median tubercle and the caudal groove is a row of nine foramina in the form of an elongated elliptical ring. This feature is beautifully shown.

This species is very closely related to *Agnostus cyclopyge* Tullberg of Europe. The cephalic groove of the head, short pentagonal shaped axial lobe suggest *A. cyclopyge;* but it differs in the absence of the distinct lateral spines and the presence of the elliptical ring of foramina of the pygidium.

This is the first species of *Agnostus* found in the Upper Cambrian of China, and it is significant that it is very closely related to *A. cyclopyge* Tullberg, an index fossil of the Upper Cambrian of Europe.

Measurements:	No. 501	No. 502	No. 503	No. 504
Cephalon				
Length	4.0	4.4	4.8	2.5
Width	4.0	4.4	4.8	2.5
Length of the glabella	3.1	3.1	3.51	0.75
Length of the first lobe	1.0	1.0	1.0	0.5
Length of the second lobe	0.8	0.8	0.9	0.5
Length of the third lobe	1.3	1.3	1.6	0.75
Width of the glabella at base.	2.0	2.5	2.5	1.5

Pygidium	No. 507	No. 508	No. 509	No. 510
Length	5.0	3.1	3.0	3.0
Width	5.2	3.4	3.2	3.2
Length of the axial lobe	1.5	1.0	1.2	1.4
Frontal width of the axial lobe	2.3	1.6	1.5	1.5
Posterior width of the axial lobe	1.75	1.2	1.1	1.1

LOCALITY AND HORIZON:—Upper Cambrian: lowar part of the Kaoli limestone of Tai-An-Fu, Shantung. (Y. C. Sun Coll.)

Agnostus hoi Sun (sp. nov.)

Plate II, Figs. 2 a-d.

1923 *Agnostus hoi* Sun, Upper Cambrian of Kaiping Basin, Bulletin of the Geological Society of China. Vol. II, No. 1-2, p. 98. (listed)

Head shield round, gently convex forming about two-thirds of a circle; slightly contracted at base. Glabella conical gently convex, with two small transverse triangular lobes forming the postero-lateral portion of the glabella on each side.

A shallow glabellar furrow curves backwards and separates the small anterior lobe and a large posterior lobe; and immediately in front of this furrow, is situated a small but distinct median tubercle. Dorsal furrow deep and distinct converging toward the front.

Limb of the cephalon moderately convex, sloping down regularly on all sides to the margin and marked by a slightly impressed frontal groove in the front of the glabella. Border of head shield narrow, rounded, and separated by the strong marginal groove.

Thorax unknown.

Pygidium semicircular usually wider than long, moderately convex.

Axis broad and long, about two thirds the width of the pygidium, laterally circumscribed on each side by one strong deep furrow. It is divided by one nearly transverse furrow into two lobes; the anterior lobe is distinctly marked by the median elongated tubercle, especially pronounced near the posterior margin of the lobe; one pair of broad transverse furrows opposite the median tubercle outlines four tubercle-like portions one on each corner of the lobe.

The posterior or second lobe, moderately convex in the anterior portion and sloping down near to the broad groove; and also marked by one pair of oblique crescentic short, broad and slightly impressed furrows.

Limb very narrow, separated from the axis by a very strong deep furrow, broad in the middle part just opposite the transverse furrow which separates the anterior lobe from the posterior lobe.

Pygidium bordered by a very broad groove and very narrow rim with a pair of very short, backwardly projecting spines on the postero-lateral margins.

Measurements:—

	No. 513	No. 514
Cephalon		
Length	2.4 mm.	2.0 mm.
Width	2.3 mm.	1.9 mm.
Length of glabella	1.6 mm.	1.5 mm.
Width of glabella at base	1.3 mm.	1.2 mm.
Pygidium		
	No. 515	No. 516
Length	2.5 mm.	2.0 mm.
Width	2.9 mm.	2.6 mm.
Length of axial lobe	2.0 mm.	1.7 mm.
Width of axial lobe	1.5 mm.	1.4 mm.

The general appearance of the cephalon, and the large axis of the pygidium suggest *A. chinensis* Dames, but it differs from this in the more conical glabella and the detailed character of the axis of the pygidium. Our species, however, is very closely related to that species as figured by Walcott, (Research in China, Vol. III, pl. 7, fig. 5 a) but is nevertheless distinct.

I take pleasure in naming this new species in honor of prof. C. Ho, 何杰 dean of the Geological Department of the National University.

Horizon and Locality:—Early Upper or late Middle Cambrian; abundantly found in the purple shale of the Changshan formation. Collected by Prof. A. W. Grabau and Dr. F. F. Mathieu.

Genus **Dorypyge** Dames

Dorypyge richthofeni Dames

Plate II, Figs. 3a, d.

1883 *Dorypyge richthofeni* Dames, China, Richthofen, Vol. IV. p. 24, plate 1, fig. 1-6.

1913 *Dorypyge richthofeni* Dames, Walcott, Research in China, Vol. III, p. 108-109 pl. 8 fig. 31 a-f.

Doctor Dames gives a detailed description of this species. This species is most common, being found everywhere in the Changhia limestone of North China.

Doctor Walcott points out the following differences between *Olenoides* and *Dorypyge:*

(a) The glabella of *Olenoides* expands toward the front, while that of *Dorypyge* contracts in front of the pits in the dorsal furrow.

(b) The pleural lobes of the pygidium of *Olenoides* have broad, shallow furrows with sharp, narrow ridges separating them, while those of *Dorypyge* have narrow furrows with broad, rounded ridges between them. The type of *Olenoides*, *O. nevadensis*, has a finely granulated surface, and the type of *Dorypyge* a coarsely granulated surface.

This species is characterized by a high arched glabella, narrow uptuned frontal border, presence of a large distinct occipital node, pustulose character of the surface; and a pygidium with spinose margin and with two large strong outward and backward pointing spines of the postero-lateral margin.

Measurements:—

Cranidium

	No. 517	No. 519
Length of cranidium	10.0 mm.	13.0 mm.
Anterior width of cranidium	—	12.0 mm.
Posterior width of cranidium	15.2 mm.	20.0 mm.
Length of glabella	7.5 mm.	10.0 mm.
Width of occipital ring	2.0 mm.	2.2 mm.

Pygidium

	No. 518	No. 520
Length	7.5 mm.	10.0 mm.
Anterior width (exclusive of spines)	13.0 mm.	15.5 mm.
Posterior width (exclusive of spines)	8.0 mm.	10.5 mm.
Length of axial lobe	6.5 mm.	8.5 mm.

Horizon and Locality:—Middle Cambrian: from Changhia limestone of Chêng-shan, 8 li from Chao-Kou-Chuang. Collected by University excursion in 1923 under the direction of the author.

Genus TEINISTION Monke

Teinistion subconica Sun (sp. nov.)

Plate II, Figs. 4.

cfr. 1903 *Teinistion lansi* Monke. Jahrb. Königl. Preuss. Geol. Landesanstalt und Bergakademie Vol. XXIII, Pl. 1, p. 117, pl. 4, figs. 1-17; plate 9, fig. 3.

cfr. 1913 *Teinistion lansi* Monke Walcott, Research in China, Vol. 3, p. 110, pl. 9, fig. 3.

This species is only represented by a fragmentary cranidium and an associated pygidium. Cranidium moderately convex; glabella strongly elevated, contracted in the upper part, with the sides curving inward, very broad at the base nearly twice the width of the frontal portion, frontal portion regularly rounded; it is not marked by glabellar furrows, but pustuled by scattered granules; occipital furrow very shallow slightly impressed.

Fixed cheeks very broad behind nearly the basal width of the glabella, nearly flat, scarcely rising from the dorsal furrow; palpebral ridge well marked, extending inward and forward from the palpebral lobe to the front of the glabella. Palpebral lobe not well shown in our specimen; frontal border narrow, slightly contracting backward in the front of the glabella. Facial suture cutting the anterior border at a point in front of the anterior base of the palpebral lobe, thence forming a signoid curve to the eye lobe; arching about the palpebral lobe they extend outward and nearly parallel to the posterior margin, then abruptly backward cutting the posterior rim. Dorsal furrows deep and distinct; occipital ring wide separated from the glabella by a very slightly indicated forward-arching occipital furrow; the center of occipital ring broader than the sides.

Associated pygidium referred to this species transversely semicircular, marginal border spinose with the anterior pair of spines very strong and long, gently curved backwards.

This species resembles *Teinistion lansi* Monke in form, but the subconical glabella, the narrow frontal border, the proportionally broader fixed cheeks and the pustulose character of the surface serve to distinguish it from Monke's species.

Measurements:—(Cat. 521)

Length of cranidium	2.8 mm.
Length of glabella and occipital ring	2.5 mm.
Width of the glabella at the base	2.0 mm.

HORIZON AND LOCALITY:—Middle Cambrian: from Kushan formation of Lincheng, Chihli. Collected by Y. T. Chao and C. C. Tien.

Genus STEPHANOCARE Monke

Stephanocare richthofeni Monke

Plate II, Figs. 5a-c.

1903 *Stephanocare richthofeni* Monke, Jahrb. Königl. Preuss. Geol. Landesanstalt und Bergakademie, Vol. XXIII, pt. 1, p. 136, plate 7, fig. 1-17, plate 8 fig. 1-11. (Species described and discussed as a new species and the genotype).

1905 *Damesella chione* Walcott, Proc. U. S. Nat. Mus., Vol. XXIX, p. 40. (species described and referred to Damesella).

1913 *Stephanocare richthofeni* Monke Walcott, Research in China, Vol. 3, p. 114, Pl. 7, fig. 17, 17a-f.

Drs. Monke and Walcott described this species very fully. From the Lincheng material only one large cranidium, one hypostoma and a small pygidium probably of this species are known.

Cephalon transversely semicircular, moderately convex. Glabella convex, truncato-conical, slightly rounded in the front, the length is slightly greater than the width at the base; a posterior pair of glabellar furrows strong and deep extending obliquely inward and backward; a second pair of glabellar furrows very slighly impressed and short; the space between the second pair of furrows and the posterior furrows is a little wider than that between the first pair and the second pair. A third pair is faintly indicated. Occipital furrow narrow, transverse, clearly defined; occipital ring not well shown owing to the strongly weathered character of the specimen; dorsal furrow narrow and distinct.

Fixed cheeks less than one half the width of the glabella at the base, and moderately convex; they round up from the dorsal furrow to the palpebral lobe; back of the line of which they slope gently to the furrow of the postero-lateral limb, and to the front furrow within the frontal margin. Palpebral lobe not shown. Postero-lateral limb narrow and extending over a considerable distance to a rather blunt, rounded end; frontal rim in the form of a straight strongly scalloped ridge, with broadly rounded concave scallops pointing forward and separated by spine-like ridges which project at right angle to the frontal margin and are usually seven in number on the cranidium; frontal margin separated from the glabella and fixed cheeks by a narrow furrow which is scalloped forward in conformity with the scallops of the frontal rim. In front of the palpebral lobe the facial suture extends forward and slightly outward to the frontal margin. Postero-lateral furrows broad and distinct. Posterior rim scarcely scalloped.

An associated hypostoma referred to this species is very marked. Central portion subovate and convex; bordered by a narrow ridge on the side and the posterior portion, frontal rim flat and marked by short spines. The posterior third seems to be defined by broad shallow slightly arched backward converging transverse depressions.

Associated pygidium transversely semicircular, with a spinose margin and strongly convex axis narrowing backwards at a moderate rate, and devided by shallow but sharp transverse furrow into four rings and a broader terminal lobe. Only part of the first anterior ring is shown, and the other rings are not well defined.

Limb almost flat except for abruptly decending marginal portion, the furrows crossing the axis prolonged on the limb deviding it into a corresponding number of segments, each of which terminated in the marginal spine, those of the last pair being shorter than the preceeding ones.

Surface of cranidium, hypostoma and pygidium marked by numerous depressed pustules.

Associated with this species are *Blackwelderia tieni*, *Blackwelderia cilix* var. *linchengensis*, *Wongia triangulata*, and *Teinistion subconica* etc.

Measurements:—

Cranidium (cat. 522 a)

Length of glabella .... 6.3 mm.
Frontal width of glabella .... 3.5 mm.
Basal width of glabella .... 6.0 mm.
Width of frontal border .... 1.3 mm.
Distance between two spines of the frontal margins .... 1.0 mm.

Hypostoma (associated) (cat. 522 b)

Length .... 3.7 mm.
Width .... 3.0 mm.

Pygidium (associated) (cat. 522 c)

Length .... 3.3 mm.
Anterior width .... 5.0 mm.

Genus BLACKWELDERIA Walcott

Blackwelderia sinensis var linchengensis Sun (var. nov.)

Plate II, Figs. 6a-d.

cfr. 1913 *Blackwelderia sinensis* Walcott, Research in China Vol. 3, p. 121-123, pl. 9 figs. 5, 5a-g.

This species is represented by several cranidia, separated free cheeks, one segment of the thorax and an associated pygidium.

Cephalon transversely semicircular, moderately convex, strongly elevated near the palpebral lobes, frontal margin straight.

Glabella large, truncato-conical in outline, moderately convex, marked by three pairs of glabellar furrows; the posterior pair of furrows very broad extending obliquely inward; the second pair short and slightly impressed; the anterior pair usually not shown on the specimens. Occipital furrow transverse slightly arching forward near the center, broad in the center and slightly impressed at both sides. Dorsal furrow clearly defined extending from the frontal rim to the postero-lateral furrows.

Fixed cheeks nearly two-thirds the width of the glabella opposite the palpebral lobe. They rise from the dorsal furrow to the palpebral lobes and slope with a gentle curvature downward both to the frontal limb, and somewhat more abruptly to the posterior margin. Palpebral lobe strongly elevated, its length nearly equal to the frontal width of the glabella; postero-lateral limbs wider than the width of the glabella at its base; occipital ring transverse with uniform width throughout. The frontal border turn-up into a narrow elevated rim without line of demarkation from the frontal limb.

Facial suture decends to the anterior part of the palpebral lobe directly backward but slightly inward; then, curving around the latter, passes obliquely outward, and backward, cutting the border of the cephalon a little back of the postero-lateral angle.

Associated free cheek about the same width of fixed cheeks opposite the palpebral lobe with a strong backward extending spine; the body of the cheek rises with a gentle covexity to the base of the eye-lobe.

The associated thoracic segment has a convex axis about the width of the flat surfaces of the pleural lobe on either side, the outer half of the pleural lobe is abruptly bent downwards forming an angle of about 120 degrees with the inner portion; surface of pleuræ marked by a broad and deep pleural groove which is wider on the flat part than on the depressed part.

Associated pygidium semicircular in outline, with a spinose margin; axial lobe strongly convex, subconical, with a narrow and round posterior end; it is divided by transverse furrows into four rings and a wider terminal portion, which has a faint fifth depression, indicating a fifth ring; the posterior portion of the axis slopes rather rapidly down to the margin; dorsal furrows distinct. Pleural lobes very gently convex for the inner half, the outer portion descending down abruptly. Surface marked by three relatively deep and broad furrows on either side, and one short shallow furrow slightly impressed in the posterior part; the segments defined by the furrows are broader than the furrows, strongly convex at the center and flattened at the margin.

The border is practically a continuation of the slope of the segments and furrows of the pleural lobes; it is marked opposite the segments by short, backward-pointing flat, broad spines not clearly defined, due to the strong weathering of the specimens, and diagonally opposite the lateral angle of the axis by two long, strong, backward-extending and little outward diverging thick and round spines.

All the cranidia, and the associated free cheek are strongly marked by pustules throughout.

The associated pygidium referred to this species was also strongly pustulose, but because of the weathered character of the surface, the pustules are only found in a few places. The cranidium of this variety is rather similar to that of *B. sinensis* in form, but it differs from the latter in its conical glabella, in the narrower fixed cheeks, in the strongly pustulose character of the whole surface, in the narrow elevated frontal rim and in the character of the pygidium.

The main difference is that in the postero-lateral angle of the glabella the dorsal furrows separate the fixed cheeks from the glabella whereas that of *Blackwelderia sinensis* is replaced by a low ridge which connects the fixed cheeks and the glabella in the form of a small triangular lobe.

The associated pygidium of this species resembles more closely that of *B. cilix;* but it differs entirely from the latter in the strongly pustulose character of the surface, number of axial rings, in the narrow rounded terminal ring and in having the long spines close together at the margin and diverging outward instead of being parallel.

This variety is characterized by its proportionally narrow fixed cheeks, strongly pustulose character of the surface, well defined dorsal furrows, and the postero-lateral angle of the glabella.

Measurements:—

Cranidium	No. 523 a-b	No. 524	No. 525
Length of cranidium	9.0 mm.	8.3 mm.	8.0 mm.
Width of cranidium at the palpebral lobe	12.5 mm.	10.0 mm.	10.5 mm.
Width of fixed cheeks at palpebral lobe	3.5 mm.	3.0 mm.	3.2 mm.
Length of Glabella	6.8 mm.	6.0 mm.	6.0 mm.
Width of glabella at the base	6.0 mm.	5.2 mm.	5.2 mm.

Width of occipital ring	1.5 mm.	1.0 mm.	1.0 mm.
Width of frontal rim	1.0 mm.	0.8 mm.	0.8 mm.
Pygidium (associated)			
Length	6.2 mm.		
Width	11.0 mm.		

HORIZON AND LOCALITY:—Late Middle Cambrian: from thin-bedded limestone in Kushan shale of Lin-Cheng, collected by Y. T. Chao and C. C. Tien.

BLACKWELDERIA TIENI Sun (sp. nov.)

Plate II, Figs. 7 a–c.

cfr. 1905 *Olenoides* (?) cilix Walcott, Proc. U. S. Nat. Mus., Vol. XXIX, p. 27, (described and discussed as a new species).

cfr. 1906 *Blackwelderia cilix* (Walcott), *idem*, Vol. XXX p. 573, (description of species extended and more throughly discussed).

cfr. 1913 *Blackwelderia cilix* (Walcott), *idem*. Research in China, Vol. III p. 119.

This is the most common species of the Lincheng material. It is represented by many cranidia, separated free cheeks and the associated pygidia.

Cephalon transversely semicircular and rather strongly convex. Glabella truncato-conical in outline and marked by three pairs of furrows. Posterior furrow is strongly marked and broad, extending obliquely inward and backward. The second furrow is slightly indicated by short faint lateral impressions and the anterior furrow is sometimes shown only by very faint indications. Frontal limb broad and concave; frontal rim very narrow and sharply elevated; occipital furrow strongly marked broadly curving forward at the center; occipital ring broader than the furrow and convex, slightly arching forward at the center; dorsal furrows distinct.

Fixed cheeks narrow, their width being somewhat more than two thirds the width of glabella opposite the palpebral lobe, rising regularly from the dorsal furrow to the palpebral lobe; facial suture cuts the frontal border about at a right angle, extending straight back to the palpebral lobe; palpebral lobe small and elevated.

Associated free cheek subtriangular in outline and divided into an interior convex body and the border, a sharp long genal spine very marked; inside of which the margin of the cheeks forms a broad second spine with the facial suture.

Pygidium semicircular in outline moderately convex and with spinose margin; axial lobe conical with pointed terminal portion nearly reaching to the margin of the pygidium. Posterior margin with two backward pointing spines, next outer pair only slightly longer.

Surface pustulose under a strong lens.

This species differs from *B. cilix* Walcott in the comparatively narrow frontal limb, in the absence of distinct first and second glabellar furrows, in the pustulose character of the surface, in the absence of the longitudinal ridge and in the conical terminal portion and the comparatively uniform spinose character of the pygidium.

Moreover, the facial suture cuts the front of fixed cheeks nearly at right angles, being approximately parallel to the corresponding portion of the other suture, whereas the facial suture of *B. cilix* cuts the fixed cheeks obliquely toward the anterior palpebral lobe.

This species is named after Mr. C. C. Tien in recognization of the fine collections made by him.

Measurements:—	No. 526
Cranidium	
Length of cranidium	10.0 mm.
Width of cranidium at the palpebral lobe	10.0 mm.
Length of glabella	6.5 mm.
Length of frontal limb and rim	1.6 mm.
Width of occipital ring	1.6 mm.
Pygidium (Associated)	
Length	10.5 mm.
Anterior width of pygidium	18.0 mm.

Horizon and Locality:—Late Middle Cambrian: from thin-bedded limestone of Kushan horizon of Lin-Cheng, Chihli (Y. T. Chao and C. C. Tien Coll.).

Blackwelderia gigas Sun (sp. nov.)

Plate II, Figs. 8.

One pygidium was obtained by the University Excursion from the Kushan formation of Ku-Shan, Shantung. This is the largest pygidium of *Blackwelderia* so far found in China, and deserves to be designated by a separate name.

Semicircular in outline, moderately convex, and with a spinose margin; axis moderately convex, conical, tapering to its posterior end; it is divided by four clearly marked broad and arched transverse rounded furrows into four transverse rings and a long terminal portion which has a slight fifth depression, indicating a fifth ring; the posterior portion of the axis slopes gradually down to the margin.

Owing to strong weathering and abrasion of this specimen, the presence or absence of two long, strong, backward-extending spines can not be determined.

Dorsal furrow shallow and distinct. Pleural lobes flat for a short distance from the axis, and then curve gently downward to the border; they are separated by four shallow furrows which divided the limb into five corresponding segments. The spines of the border are practically continuations of the pleural lobes.

The most interesting fact is that this pygidium occurs in a bed of conglomeratic limestone from the uppermost part of the Kushan formation. Certainly it represents the latest type of the Middle Cambrian.

Measurements:—	No. 527
Length of pygidium	25 mm.
Anterior width or greatest width	40 mm.

Horizon and Locality:—Middle Cambrian: from conglomeratic limestone of Kushan formation of Kushan; 崮 山 collected by C. C. Tien and Y. T. Chao who were in my party during the University Excursion.

Genus **DAMESELLA** Walcott

Damesella blackwelderi Walcott var. **minor** Sun (var. nov.)

Plate II, Figs. 9 a-c.

cfr. 1905 *Damesella blackwelderi* Walcott Proc. U. S. Nat. Mus., Vol. XXIX, p. 35.

cfr. 1913 *Damesella blackwelderi* Walcott, Research in China, Vol. IV, p. 125-128, plate 10, fig. 1.

This variety is represented by several cranidia.

The type species is fully described by Dr. Walcott as below.

"Glabella large truncato-conical in outline, and marked by three pairs of short furrows, the posterior pair of furrows forms a rounded pit near the margin, and continues obliquely outward as a shallow furrow to the central third of the glabella, separating a short, rounded lobe on each side, the middle pair of furrows is short and very slightly impressed; the anterior pair of furrows is indicated by a short, smooth narrow space at the anterior fourth of the glabella; occipital furrow of medium width, rounded at the bottom, and rather deep; it curves backward slightly at the sides and then arches gently forward at the middle; occipital ring of medium width, curving slightly backward at the ends and forward at the center, rounded on top; dorsal furrow strongly marked all about the glabella and passing posteriorly into a narrow but well-defined furrow within the posterior margin of the postero-lateral limb; the front of the glabella almost overhangs a strong furrow within the frontal border, that separates the frontal border from the fixed cheeks; frontal border or rim strong, rounded, and arching slightly upward in front of the glabella.

"Fixed cheeks a little more than one half the width of the glabella; they slope gently back to the furrow on the postero-lateral limb and rather rapidly downward, in front of the palpebral lobe, to the furrow within the frontal border; a clearly defined, low, rounded palpebral ridge extends opposite the anterior fourth of the glabella to the palpebral lobe, into the rim of which it merges; postero-lateral limb about one and one-third times as long as the width of the glabella at its base, and back of the palpebral lobe about one third the length of the cephalon elevated at the outer rim, and rather narrow. The facial sutures cut through the rounded frontal margin of the cephalon obliquely and then extend around backward, passing almost directly to the anterior margin of the palpebral lobe; curving around the rather small eye lobe, they pass obliquely outward and backward, cutting the border of the head a little back of the postero-lateral angle".

This variety differs from the type species figured by Dr. Walcott in the shorter glabella, narrow fixed cheeks, less distinct palpebral ridge, the more convex glabella, comparatively broader frontal border, and also in the small size. This variety is particularly characterized by its small form with broad truncato-conical glabella.

Measurements:—	var. minor		B. blackwelderi
	No. 528	No. 529	No. 530
Length of cranidium	6.5 mm.	4.5 mm.	20.0 mm.
Width of cranidium at palpebral lobe	8.5 mm.	5.5 mm.	—
Length of glabella	4.5 mm.	3.2 mm.	14.0 mm.
Anterior width of the glabella	3.0 mm.	2.2 mm.	9.1 mm.
Width of glabella at its base	4.5 mm.	3.0 mm.	—
Width of frontal rim	1.0 mm.	0.8 mm.	3.0 mm.
Width of occipital ring	1.0 mm.	0.8 mm.	—
Width of fixed cheeks on each side at the palpebral lobe	2.5 mm.	1.5 mm.	—

Horizon and Locality:—Middle Cambrian: from massive Changhia limestone of Chao-Kou-Chuang, Luan-Hsien, Chihli. Collected by University Excursion under my direction (K. H. Hsü 徐光熙 Coll.).

Genus **PTYCHOPARIA** Corda

Ptychoparia fongi Sun (sp nov.)

Plate II, Figs. 10 a, b.

This species is represented by several dorsal shields and the cranidia associated with them.

Cranidium moderately convex; length and width are subequal. Glabella moderately convex, becoming narrower toward the front, the front part regularly rounded; it is marked by three pairs of distinct glabellar furrows; the anterior pair (first pair) short, broad and transverse, extending a very short distance from the dorso-lateral furrows; the second pair about the same length and nearly parallel to the first pair, but comparatively broad; the third pair (posterior pair) broad and oblique extending backwards and inwards.

The occipital furrow very deep and very pronounced, transverse and connecting the postero-lateral furrows at both sides. The occipital ring moderately convex, very broad at the center, becoming narrower toward both sides.

Fixed cheek broad about two-thirds the width of the glabella opposite the palpebral lobe; palpebral ridge distinct extending the anterior part of the palpebral lobe nearly to the antero-lateral angle of the glabella; dorso-lateral furrows rounded and distinct.

Frontal limb flat or slightly convex and separated from the frontal rim by a shallow transverse furrow; frontal rim elevated and upturned from the marginal furrow to the margin; its frontal edge very slightly round; its width about the same as the frontal limb.

The facial suture cuts the frontal rim and then turns directly backward and slightly inward toward the palpebral lobe, and curves around this lobe, and finally extends backward and outward to cut the free cheek from the postero-lateral limb which is distinctly marked by a pronounced postero-lateral groove.

The thorax of a small associated individual has thirteen or fourteen segments with a narrow axial lobe and wide pleural lobes. The pleural furrow starts on the inner front side of the pleural lobe of each segment and, widening nearly to the width of the segment, begins to narrow at the point of geniculation and terminates near the posterior margin at the somewhat abrupt falcate termination of the pleuræ.

Pygidium small with a broad axis and pleural lobes indistinctly segmented.

The form of the glabella and the character of the glabellar furrows suggest *P. granosa* Walcott from the Manto shale of Shantung, but the comparatively narrow frontal limb, the more conical glabella, and the character of the surface serve to distinguish it.

This differs also from *P. yohi* in the shorter and less conical glabella, presence of three distinct glabellar furrows and also in the upturned frontal rim.

This species is characterized by the subconical glabella distinctly marked by three pairs of furrows, comparatively narrow frontal limb and the wide fixed cheeks. It is named after Mr. K. L. Fong 馮景蘭, dean of the Geological Department of Chun-Chow University 中州大學, Honan.

Measurements: —	10 a	10 b
Length of cranidium	8.5 mm.	6.5 mm.
Frontal width of cranidium	8.0 mm.	6.2 mm.
Posterior width of cranidium	1.3 mm.	1.0 mm.
Length of glabella	5.0 mm.	3.8 mm.
Anterior width of glabella	3.2 mm.	2.5 mm.
Posterior width of glabella	4.5 mm.	3.5 mm.
Width of frontal rim	1.5 mm.	1.2 mm.
Width of frontal limb	1.0 mm.	0.9 mm.
Width of occipital ring	1.4 mm.	1.1 mm.

Horizon and Locality:—Lower Cambrian: from Manto shale of Chêngshan, 8 li east of Chao-Kou-Chuang, Chihli. (Coll. F. F. Mathieu and Y. C. Sun).

Ptychoparia leichuangensis Sun (sp. nov.)

Plate II, Figs. 11 a, b.

This species is represented by two small fragmentary cranidia.

Head-shield semicircular, usually much wider than long. Glabella short and broad, subconical, rounded in front, decreasing in width anteriorly, its length about one half the length of the head-shield: convex and marked with three pairs of short horizontal distinct glabellar furrows, occipital furrow transverse and distinct; occipital ring broad in the center, becoming narrow at both sides; dorsal furrows deep and well marked.

Fixed cheeks gently convex about two thirds the width of the glabella opposite the palpebral lobe; palpebral ridge distinct and horizontal, extending from the anterior furrow to the palpebral lobe. Frontal limb moderately convex, about one-third the length of the glabella, and separated from the frontal rim by a distinct marginal furrow. Frontal rim narrow and elevated about two-thirds the length of the frontal limb.

The facial suture, after cutting the frontal border, diverges slightly outward down to the palpebral lobe, curves around this lobe and finally cuts the fixed cheeks in an outward direction. Postero-lateral limb large and marked by a broad postero-lateral furrow.

This species is characterized by its small form, short very broad subconical glabella, convex frontal limb, and the comparatively narrow fixed cheeks.

Measurements:—	11 a	11 b
Length of cranidium	1.7	2.0
Greatest width of cranidium	2.8	3.2

HORIZON AND LOCALITY:—Late Lower Cambrian: from Manto shale of Lei-Chuang, 雷 莊 Luan-Chou; collected by Dr. F. F. Mathieu.

Ptychoparia yohi Sun (sp. nov.)

Plate II, Fig. 12.

This species is represented only by one crushed cranidium slightly broader than long.

Glabella moderately convex, subconical in outline, the front part regularly round; posterior width broad. It is marked by three pairs of very slightly impressed glabellar furrows. Occipital furrow transverse, shallow and very slightly impressed. Occipital ring very broad at the center and becoming narrower at both sides.

Fixed cheek about the same width of the glabella opposite the palpebral lobe; palpebral ridge distinct from the anterior part of the palpebral lobe near to the antero-lateral portion of the glabella. The facial suture cuts the frontal border to the anterior part of the palpebral lobe in a convex curve, bends around the latter and finally cuts the free cheeks from the postero-lateral limb, also with a convex curve.

Frontal limb flat, slightly broader than the frontal rim; frontal rim elevated and with regularly arched outline.

Surface apparently smooth.

The general form of the cranidium resembles that of *P. fongi* Sun, but the differences between them are mentioned after the description of that species.

This species is characterized by the smooth conical glabella with a broad base, comparatively broader fixed cheeks, and less distinctly defined occipital and glabellar furrows. This species is named after Mr. S. S. Yoh 樂森璕 who accompanied me in that region during the University Excursion.

Measurements:—

Length of cranidium	8.5
Width of cranidium opposite the palpebral lobe	10.0
Length of glabella	5.0
Anterior width of glabella	2.7
Posterior width of glabella	5.0
Width of fixed cheek at the palpebral lobe	2.8
Width of occipital ring	2.0
Width of frontal limb and frontal rim combined	2.4

HORIZON AND LOCALITY:—Lower Cambrian: from light micaceous purple shale of Chêng-Shan, 8 li from Chao-Kou-Chuang, Luan-Hsien, Chihli (Coll. Y. C. Sun).

Ptychoparia (Emmerichella) chengshanensis Sun (sp. nov.)

Plate III, Figs. 1 a, b.

This species is represented by several cranidia and associated pygidia probably of this species.

Cranidium usually broader than long, and apparently smooth.

Glabellar moderately convex, short and broad, slightly narraw toward the front; the anterior part regularly rounded. Occipital furrows shallow but distinct, merging into the postero-lateral furrow at both sides.

Occipital ring transverse and comparatively narrow, only slightly broader in the central portion.

Fixed cheek broad, about the same width as the glabella opposite the palpebral lobe; slightly convex near the palpebral lobe and becoming flat toward both the front and the postero-lateral furrow. Palpebral ridge very slightly indicated. The facial sutures first cut the frontal border directly backward to the anterior part of the palpebral lobe; curve around this and then cut the free cheek from the postero-lateral limb with a convex arc. Palpebral lobe of medium size.

Frontal limb flat and somewhat broader than the frontal rim from which it is separated by a shallow marginal furrow. Frontal rim slightly elevated, broader at the center, becoming narrower toward each side; the frontal margin gently rounded.

The associated pygidium is rather transverse; axial lobe very broad, cylindrical, divided by three indistinct furrows into four transverse rings and one terminal portion; pleural lobe also divided by four distinct furrows into five segments.

Surface apparently smooth.

This species is distinguished by its smooth character of the cranidium, short and broad glabella, narrow occipital ring, comparatively narrow frontal limb, and by its transverse form. It differs from *P. fongi* Sun in the absence of distinct glabellar furrows, in the shorter and broader glabella, and the more transverse form. It also differs from *Ptychoparia yohi* Sun in the more transverse form, the shorter and broader glabella and the absence of the glabellar furrows.

Measurements:—

Cephalon		
Length of cranidium	5.5	2.7
Frontal width of cranidium	5.5	2.7
Posterior width of cranidium	9.2	4.0
Length of glabella	3.2	1.6
Greatest width of glabella	3.2	1.7
Width of fixed cheek	2.0	1.0
Width of frontal rim	1.0	0.5
Width of frontal limb	0.5	0.35
Width of occipital ring	1.0	0.50

Horizon and Locality:—Lower Cambrian: from micaceous purple shale of Chêng-Shan, 8 li from Chao-Kou-Chuang, Chihli. (Y. C. Sun Coll.)

Genus **Changshania** Sun

1923 Changshania conica Sun and Chanshania truncata Sun, Bulletin of the Geological Society of China Vol. II, No. 1-2.

Cephalon semicircular in outline, exclusive of genal spine, gently convex. Frontal rim rather narrow about the same width as the postero-lateral limb. Glabella slender, truncato-conical or conical and smooth; occipital furrow straight and distinct; occipital ring nearly transverse and of uniformly width; dorsal furrows shallow and distinct.

Fixed cheeks narrow, the facial suture cuts the frontal border slightly inward and backward straight to the anterior part of the palpebral lobe curves around the latter; and then extends obliquely outward directly to the postero-lateral margin. Palpebral lobe long about two-third the length of the glabella, outlined by the intra-curving furrow, Frontal limb broad flat or gently concave, its margin slightly rounded. Postero-lateral limb very short and marked by the transverse postero-lateral furrow extending transversely to both extremities.

Free cheeks broad with uniformly narrow border extending into a slender curving genal spine; cheek body flat and broad. An associated hypostoma elongate ovate with a distinct posterior curving furrow.

Only the pleuræ of the thorax are known, these being flat and of uniform width, and separated from each other by parallel furrows.

Pygidium transverse, with uniform narrow border. Axial lobe conical marked by four transverse furrows into four transverse rings and one terminal section which is situated near to the posterior border of the pygidium. Pleural lobe also segmented. Antero-lateral angle extending into a round extension.

The truncato-conical glabella, broad frontal limb and the transverse form of the pygidium may suggest *Ptychoparia (Emmerichella)*, but the conical glabella, the ratio of the anterior width to the posterior width of the cranidium, comparatively narrow fixed cheeks and the antero-lateral extension of the pygidium serve to distinguish it.

Genotype—*Changshania conica* Sun.

Changshania conica Sun (sp. nov.)

Plate III, Figs. 2 a-k.

1923 *Changshania conica* Sun. Bulletin of the Geological Society of China Vol. II, No. 1—2 (listed).

The generic description of *Changshania* is based on this species.

This species is represented by several cranidia, separated free cheeks, an hypostoma, pleuræ of the thorax and by a number of pygidia.

This species is characterized by its subconical smooth glabella, narrow anterior width of the cranidium, long palpebral lobe, comparatively narrow fixed cheeks and the pygidium with round antero-lateral extensions.

Horizon and Locality:—Early Upper Cambrian: from Changshan shale of Chao-Kou-Chuang.

Measurements:—

Cranidium	A	B	C	D
Length	9.0 mm.	7.5 mm.	6.5 mm.	6.5 mm.
Anterior width	7.5 mm.	5.6 mm.	5.0 mm.	5.0 mm.
Posterior width	17.8 mm.	—	12.5 mm.	—

	2 a	2 b	2 c	2 d
Length of glabella	5.5 mm.	4.5 mm.	4.0 mm.	4.0 mm.
Basal width of glabella	4.5 mm.	3.5 mm.	3.0 mm.	3.0 mm.
Width of frontal rim	1.0 mm.	0.8 mm.	0.75 mm.	0.75 mm.
Width of frontal limb	1.9 mm.	1.5 mm.	1.0 mm.	1.1 mm.
Width of occipital ring	1.0 mm.	0.9 mm.	0.8 mm.	0.9 mm.
Hypostoma	2 e			
Length	6.5 mm.			
Width	4.0 mm.			
Pygidium	2 f	2 g	2 h	2 i
Length	5.0 mm.	4.2 mm.	5.0 mm.	4.5 mm.
Width at the union with thorax	12.8 mm.	10.0 mm.	12.5 mm.	—
Anterior width of the axis	3.5 mm.	2.6 mm.	3.2 mm.	3.5 mm.

Changshania? truncata Sun (sp. nov.)

Plate III, Figs. 3.

1923 *Changshania truncata* Sun. Bulletin of The Geological Society of China Vol. II, No. 1-2 (listed).

This species is represented by several cranidia, free cheeks and pygidia probably of this species.

Cephalon semicircular in outline, with genal angles (of free cheeks) prolonged into slender spines bending inward to the body. Glabella truncato-conical, apparently smooth; occipital furrow slightly curved and distinct; occipital ring of uniform width throughout.

Fixed cheeks very narrow, about one half the width of the glabella at the palpebral lobe. The facial suture cuts the frontal border slightly obliquely to the anterior part of the palpebral lobe, curves around the latter and then extends outward to the postero-lateral margin. Palpebral lobe long and marked by infracurving furrow; postero-lateral limb narrow and marked by a distinct postero-lateral furrow.

Free cheeks and pygidia apparently of the same type as in *Changshania conica* Sun.

This species is characterized by its broad truncato-conical glabella, narrow fixed cheeks and slightly curved occipital furrow and the transverse pygidium with conical axis and antero-lateral rounded extensions.

This species differs from *Changshania conica* Sun in the broad truncato-conical glabella, comparatively narrow fixed cheeks, and narrow postero-lateral limb. Its form lies between *Emmerichella* and *Changshania* and I provisionally place it under *Changshania*, because it has narrow fixed cheeks, large palpebral lobes, and the antero-lateral extension of the pygidium. The specific name is given in reference to its truncated glabella.

HORIZON AND LOCALITY:—Associated with the preceeding.

Measurements:—

Cranidium	
Length	8.0 mm.
Width at the palpebral lobe	8.2 mm.
Length of glabella	5.5 mm.
Anterior width of glabella	3.0 mm.
Posterior width of glabella	5.0 mm.
Width of frontal border	2.0 mm.
Length of palpebral lobe	2.8 mm.
Width of occipital ring	1.0 mm.
Width of fixed cheek at the palpebral lobe	2.0 mm.

Genus **CONOKEPHALINA** Brögger

Conokephalina kaipingensis Sun (sp. nov.)

Plate III, Fig. 4 a-b.

This species is represented by several fragmentary central portions of the cephala. Cephalon semicircular, moderately convex. Glabella subrectangular, becoming narrower anteriorly, front margin slightly rounded; antero-lateral angles also rounded. It is marked by three pairs of the glabellar furrows; the posterior pair distinct, obliquely extending backward and inward from the dorsal furrow; the second pair very short and horizontal opposite to the anterior edge of the palpebral lobe, the anterior pair slightly impressed rarely shown in the specimens. Occipital furrow distinct, bending slightly backward; occipital ring broad in the center, becoming narrow at both sides and also apparently marked by a node at its center.

Fixed cheeks very narrow, less than one half the width of the glabella at the palpebral lobe. The facial suture decends with a convex curve to the anterior edge of the palpebral lobe, curves around the latter and finally extends outward to outline the short postero-lateral limb. Palpebral lobe elongate, separated from the fixed cheek by a curving furrow, and situated opposite the posterior furrows; dorsal furrows rounded and distinctly marked; palpebral ridge indistinct extending obliquely from the anterior part of the palpebral lobe near to the frontal margin of the glabella. Frontal limb narrow and separated from the frontal rim by a shallow forward curving furrow, frontal rim about the width of the frontal limb, slightly elevated and with regularly rounded margin.

Only one segment of the thorax is known. Axial and pleural segments are both strongly marked by distinct grooves.

Surface marked by strong pustules.

In form this species is similar to *C. vesta* Walcott of Fang-Lan-chön, Shansi, but differs from the latter in the narrow occipital ring, distinct glabellar furrow, indistinct palpebral ridge and the pustulose character of the surface.

The pustulose character of the surface and the narrow fixed cheeks suggests *Conokephalina belus* Walcott from Tai-An, Shantung, but it differs from the latter in the narrow occipital ring and in having the palpebral lobe placed further back and opposite the posterior pair of glabellar furrows.

This species is characterized by the subrectangular glabella, distinct glabellar furrows, pustulose character of the surface and the palpebral lobe placed back of the center of the glabella.

Measurements:—

	4 a
Length of cranidium	8.5 mm.
Width of cranidium at the palpebral lobe	9.5 mm.
Length of glabella	5.5 mm.
Width of glabella	5.0 mm.
Width of frontal limb	1.0 mm.
Width of frontal rim	1.0 mm.
Width of occipital ring	1.3 mm.

Horizon and Locality:—Late Lower Cambrian: from Manto shale of Chao-Kou-Chuang, Luan-Hsien, Shantung. Collected by H. T. Yu (余新都).

Conokephalina gerardi Sun (sp. nov.)

Plate III, Figs. 5 a–c.

This species is represented by several fragmentary cranidia and associated pygidia probably referable to it.

Cranidium gently convex, subquadrilateral in outline, exclusive of free cheeks. Glabella subquadrilateral, slightly narrower in front, frontal part rounded, marked by a distinct longitudinal ridge; occipital furrow narrow shallow, slightly curved backward; occipital ring broad in the center, becoming narrow at both sides.

Fixed cheeks little wider than one half the width of the glabella opposite the glabella and nearly flat from the dorsal furrow to the palpebral lobe. Palpebral lobe large about one half the length of the cephalon and situated a little back of the central portion of the glabella; palpebral ridge strong and prominent merging into the anterior edge of the palpebral lobe from the dorsal furrow. Frontal limb flat, of medium width, and separated from the frontal rim by a shallow distinct furrow. Frontal rim about one half the width of the frontal limb and of uniform width throughout, slightly elevated.

The associated pygidium, probably of this species, is small with convex broad axial and segmented pleural lobes.

In form this species resembles *Conokephalina vesta* Walcott from the Middle Cambrian of Shansi, but the broad frontal limb, the absence of the distinct glabellar furrows and the more rounded frontal margin of the glabella serve to distinguish it.

This species is named in honor of Mr. Jacques Gerard engineer and geologist of the Chao-Kou-Chuang Mines.

This species is characterized by the acutely rounded frontal margin of the glabella, the smooth surface of the glabella, presence of the longitudinal median ridge, large and long palpebral lobe and the small pygidium with broad convex axial lobe and segmented pleural lobe.

Measurements:—	6 a	6 b	6 c
Length of cranidium	8.0	5.4	8.0
Width of cranidium at the palpebral lobe	8.0	6.2	—
Length of glabella	5.5	3.5	5.5
Width of glabella at base	5.0	3.0	4.5
Width of frontal limb and rim	1.5	1.1	1.7
Width of occipital ring	1.1	0.8	1.1

Horizon and Locality:—Manto-formation of Chêng-Shan, Chao-Kou-Chuang. Collected by University Excursion in 1923 (H. T. Yu 余新都 Coll.).

Genus **CREPICEPHALUS** Owen.

Crepicephalus sp. indt.

Plate III, Fig. 6.

This is only represented by one pygidium.

Quadrilateral in outline, exclusive of lateral spines. Axial lobe very convex, cylindrical, with three transverse rings and one terminal ring which is again divided into one transverse ring and one terminal portion, far apart from the posterior margin. The sides nearly parallel, contracting slightly at the middle, by incurving of the sides. Pleural lobe gently convex, also segmented by furrows. The postero-lateral and posterior margins flat and broad; lateral spines broad.

Width 5 mm. Length 4.4 mm.

HORIZON AND LOCALITY:—Middle Cambrian: from Changhia limestone of Chêngshan, 8 li from Choa-Kou-Chuang, Chihli. Collected by University Excursion.

Genus MANSUYIA Sun (gen. nov.)

This genus differs from *Crepicephalus* in having very narrow fixed cheeks, in the absence of the palpebral ridge, in having very deep distinct dorsal furrows and in the short oblong form of the glabella.

The general form of the cranidium suggest *Anomocare* and *Anomocarella*, but the pygidium of this genus serves to distinguish it.

The associated pygidia of this genus are of the type of *Ceratopyge*, but the present genus differs greatly from that one in the cranidium.

Genotype: *Mansuyia orientalis* (Grabau) Sun.

This genus is characterized by its short oblong glabella, narrow fixed cheeks, and absence of the palpebral ridge. The pygidium has two inward-curving slender lateral spines which spring out from the second segment of the pleural lobe of the pygidium.

Mansuyia orientalis (Grabau) Sun

Plate III, Figs. 7 a–j.

1922 *Ceratopyge orientalis* Grabau (Mss.).

1923 *Ceratopyge orientalis* Sun. Upper Cambrian of Kaiping Basin. Bulletin of the Geological Society of China Vol. II, No. 1-2, p. 98. (listed).

This species is represented by many cranidia and the associated pygidia.

Glabella moderately convex, oblong in form, the front part slightly rounded; marked by three pairs of shallow broad short pits slightly impressed; occipital furrow rounded, and distinct; occipital ring uniform in width throughout, dorsal furrows and frontal furrow in the front of the glabella deep and clearly defined; frontal limb narrow slightly convex and elevated, separated from frontal rim by a shallow broad groove; frontal limb narrow in the middle, becoming wider toward each ends, and sloping down anteriorly to the broad shallow groove in the front of the glabella; frontal rim moderately convex, broad in the middle, becoming narrower towards each sides.

Fixed cheeks very narrow; eye lobe of medium size, centrally placed.

The associated pygidium is of about the size of that of *Ceratopyge forficula*. It is broader than long with a well-defined convex median axis gently tapering backwards to within a short distance of the posterior margin of the pygidium where it is bluntly rounded. Median axis or axial lobe subconical and long with a very gentle rate of tapering, divided by seven transverse shallow distinct furrows into seven rings and one terminal portion which is again divided by shallow transverse furrows into two portions. The pleural lobes, in like manner, are also divided by five shallow slightly impressed furrows into six segments, the second being the broadest. Antero-lateral margins of limb rounded.

Lateral or side spines of pygidium slender long curved inward in the free part. The spine springs out from the broadest second segment of the pleural lobe which extends forward at an angle of about 45° with the median line, to about the position between the second and third ring of the axis.

In the majority of specimens from Chihli, this continuation of the spine and the segmentation of the axis and the pleuræ are not readily noted because of the worn or crushed character of the specimen.

Surface apparently smooth or slightly pustulated.

This species is characterized by its deep dorsal furrows and frontal furrow which separates the frontal limb and the glabella, short oblong glabella, narrow fixed cheeks, medium eye lobe and the strong lateral spines of the pygidium which spring out from the second segment. It is associated with *Kaolishania pustulosa*, etc.

Horizon and Locality:—Upper Cambrian: from Kaolishan limestone of Tai-An, Shantung (Y. C. Sun Coll.), also found in Fêngshan limestone of Luan-Hsien, Chihli by Mr. H. C. T'an of the Survey. More than thirty specimens examined.

Measurements:—

Cranidium	7 a	7 b	7 c	7 d	7 e
Length of cranidium	15.0 mm.	11.0 mm.	9.0 mm.	10.2 mm.	13.2 mm.
Width of cranidium at the palpebral lobe	13.5 mm.	10.5 mm.	8.1 mm.	10.0 mm.	—
Length of glabella	9.5 mm.	6.7 mm.	5.5 mm.	6.0 mm.	8.0 mm.
Width of glabella opposite the palpebral lobe	8.0 mm.	5.7 mm.	5.0 mm.	5.5 mm.	7.0 mm.
Width of frontal limb	2.3 mm.	1.8 mm.	1.5 mm.	1.8 mm.	2.5 mm.

Width of frontal rim	1.8 mm.	1.3 mm.	1.0 mm.	1.0 mm.	1.5 mm.
Width of occipital ring	2.0 mm.	1.7 mm.	1.4 mm.	1.5 mm.	2.0 mm.
Pygidium	7 f	7 g	7 h	7 i	7 j
Length	9.0 mm.	9.0 mm.	10.5 mm.	10.0 mm.	8.5 mm.
Width	14.5 mm.	14.2 mm.	15.5 mm.	12.5 mm.	13.0 mm.
Length of axial lobe	8.5 mm.	8.2 mm.	10.0 mm.	9.0 mm.	8.0 mm.
Average width of the transverse rings	1.1 mm.	1.1 mm.	1.2 mm.	—	—
Length of side spines (measured on curvature)	16.0 mm.	12.0 mm.	7.5 mm.	8.0 mm.	5.0 mm.

Genus **Kaolishania** Sun (gen. nov.)

General form subquadrangular, moderately convex; axial and pleural lobes strongly defined.

Cephalon wider than long, subsemicircular in outline; glabella truncato-conical, moderately convex and marked by three pairs of the lateral furrows, the posterior pair deep and broad, obliquely extending backward, the second pair deep and short, and slightly extending obliquely backward, and the anterior pair marked by a very slight trace; occipital furrows strong and distinct, occipital ring broad in the center, becoming narrow toward each side. A median longitudinal ridge extends from the front border of the glabella to the occipital furrow. The straight frontal part of the glabella and the fixed cheeks are separated from the frontal border by a strong and deep groove; frontal border narrow, slightly rounded in the front and turning up from the deep strong frontal groove to the frontal margin.

Fixed cheeks slightly convex and rising from the dorsal furrow, about one half the width of the glabella; palpebral ridge extending backward and outward from the dorsal furrow to the anterior part of the palpebral lobe; palpebral lobe of medium size.

Free cheeks moderately convex, elongate, broad at the anterior end where they join the fixed cheeks and the frontal border, and narrow at the posterior, ending in a slender rounded lateral spine; the cheek-body broad and moderately convex, separated from the slightly elevated narrow border by a distinct curving furrow.

The facial suture cuts the outer postero-lateral side of the genal angle, and passes almost directly inward to the base of the eye lobe, arching around the latter, it passes with a slight convex curve directly forward to the front margin.

Only one part of the fragmentary segment is known; the axial segment is moderately convex and marked by a strong groove; the pleural segment more or less flat and also marked by a broad distinct groove which gradually tapers to a point before the pleural segment reaches its end.

Pygidium large subquadrangular in outline; the axial lobe narrow and slender, divided by six distinct transverse furrows into five rings and one terminal section which is usually again divided by a shallow furrow into one ring and the terminal portion, and nearly reaches to the border; the pleural lobes broad, divided by five distinct furrows into six segments. The first two furrows descend with curving outline; while the other three extend obliquely backward to the border, usually short and slightly curved. The largest segment is the second segment from which the lateral spine springs out. The posterior border is narrow, separated from the pleural lobe by the posterior marginal groove, slightly convex and regularly rounded, and also slightly contracted at the posterior margin of the pygidium. Lateral spines about the same length as the pygidium, pointing directly backward but slightly outward.

Surface strongly marked by high pustules.

Genotype: *Kaolishania pustulosa* Sun.

This very remarkable trilobite resembles the genus *Blackwelderia* in the form of the glabella, but the strong side spines of the pygidium serve to distinguish it.

Kaolishania pustulosa Sun (sp. nov.)

Plate III, Figs. 8 a-h.

The description given of the genus *Kaolishania* includes what is known of the species.

This species is characterized by its truncato-conical glabella, narrow and concave frontal border, the distinct palpebral ridge, the short broad side-spine of the pygidium, the strongly pustulose character of the surface and the subquadrangular form of the pygidium.

This is the most common species in the collection from Tai-An. It is associated with *Mansuyia orientalis* (Grabau) Sun, *Chuangia batia* Walcott etc.

Measurements:—

Cranidium	8 a	8 b
Length of cranidium	11.0 mm.	12.5 mm.
Length of glabella	8.0 mm.	9.5 mm.

	8 a	8 b		
Width of cranidium at palpebral lobe	13.0	—		
Frontal width of glabella	4.5	5.0		
Basal width of glabella	7.5	8.5		
Width of frontal border	1.0	1.5		
Width of occipital ring	2.0	2.0		
Pygidium	8 e	8 f	8 g	8 h
Length	10.5	8.0	7.5	8.5
Width	17.0	14.0	12.5	14.0
Length of axial lobe	8.5	7.3	7.0	7.5
Anterior width of axial lobe	5.5	4.0	4.0	4.4

HORIZON AND LOCALITY:—Upper Cambrian: from massive gray limestone of Kaolishan from which the generic name is derived (Y. C. Sun Coll.).

Genus **LISANIA** Walcott

Lisania ? hsuchiachuangensis Sun (sp. nov.)

Plate IV, Fig. 1 a–b.

Cranidium subquadrilateral in outline, exclusive of the free cheeks. Glabella strongly convex subrectangular; antero-lateral angle rounded; apparently smooth; occipital furrow shallow but distinct; occipital ring narrow at both sides, becoming broader toward the center marked by a distinct central occipital node. Dorsal furrow narrow and clearly defined.

Fixed cheeks narrow, little more than one third the width of the glabella, sloping anteriorly to the frontal border and backward to the postero-lateral limbs; palpebral lobe about one-third the length of the cephalon; palpebral ridge distinct; frontal border slightly convex rounded in front very broad at the middle and separated from the glabella and the fixed cheeks by a narrow deep and distinct furrow. Postero-lateral limbs narrow about one half the width of the glabella and pronounced.

This species may be compared with *L. agonius* Walcott from the lower shale member of the Kiu-lung group of Yen-Chuang 顏 莊, Shantung, but differs from the latter in the more rectangular form, comparatively narrow occipital ring and in its shorter palpebral lobe.

HORIZON AND LOCALITY:—Middle Cambrian: from the Changhia limestone of Chêng-Shan, near Hsu-Chia-Chuang 徐家莊, Luan-Hsien, Chihli. (Coll. K.S. Hsu 徐光熙).

Measurements:—	1 a	1 b
Length of cranidium	6.5 mm.	4.0 mm.
Width of cranidium	6.0 mm.	4.0 mm.
Length of glabella	4.8 mm.	3.0 mm.
Width of frontal border	0.9 mm.	0.5 mm.
Width of occipital ring	1.0 mm.	0.5 mm.

Lisania rectangularis Sun (sp. nov.)

Plate IV, Fig. 2 a, b.

This species is represented by two broken central portions of the cephalon. Glabella moderately convex, subrectangular in outline; frontal margin rounded, apparently smooth; occipital furrow transverse and distinct; occipital ring broad at the center becoming narrow toward the sides.

Fixed cheeks narrow, less than one half the width of the glabella, the facial suture cut the frontal border slightly outward, backward to the anterior edge of the palpebral lobe; and thence curves around this lobe near to the occipital furrow; palpebral lobe large about one half the length of the cephalon, slightly convex.

Frontal border slightly convex with curving rounded margin, broad at the middle, becoming gradually narrow at the sides.

This species resemble *Lisania* cf *bura* (Walcott) from the Middle Cambrian of Changhia, Shantung, but differs in the subrectangular glabella, the large palpebral lobe and the course of the facial suture.

This species is characterized by its subrectangular glabella, narrow fixed cheeks, large palpebral lobe and the comparatively broader frontal border.

Horizon and Locality:—Middle Cambrian: from Changhia limestone of Chêng-Shan near Chao-Kou-Chuang, Chihli. Collected by Mr. K. S. Hsu 徐光熙, of Class 1925 of the Geological Institute of National University.

Measurements:—	2 a	2 b
Length of cranidium	3.5 mm.	3.3 mm.
Length of glabella	2.5 mm.	2.0 mm.
Width of glabella at palpebral lobe	1.7 mm.	1.5 mm.
Width of frontal limb	0.7 mm.	0.6 mm.
Width of occipital ring	0.5 mm.	0.6 mm.
Width of fixed cheek at the palpebral lobe	1.0 mm.	1.0 mm.

Genus SOLENOPLEURA Angelin

Solenopleura nodosa Sun (sp. nov.)

Plate IV. Figs. 3 a, b.

General form of cranidium transversely subrhomboidal, convex Glabella as long as the width at its base, the sides converging from the base towards the rounded front, so as to narrow the glabella about one fourth; anterior portion of the glabella very convex; three pairs of glabellar furrows, the posterior furrow distinct extending obliquely inward and backward and making an angle 45° with the dorsal furrow; the second and anterior pairs short and shallow in the form of pits; occipital furrow broad and well defined by the downward curvature of the posterior margin of the glabella and the rising of the surface of the occipital ring; occipital ring broad at the center, becoming gradually wider towards the sides, with a distinct median node at the posterior margin, dorsal furrow deep and well defined.

Fixed cheeks very convex at the center and sloping down toward the front groove and the postero-lateral groove, about one half the width of the glabella; palpebral lobe small and situated about in the middle of the glabella. Palpebral ridge moderately distinct, extending from the anterior part of the palpebral lobe, toward the dorsal furrow in front of the second furrow of the glabella. Postero-lateral limbs unknown; frontal limb very narrow and convex in front of the glabella and separated from the frontal rim by the broad and shallow frontal groove; frontal rim convex, rounded, about the width of the frontal limb and frontal groove combined, and of uniform width, with a straight frontal margin.

Surface marked by large pustules uniformly scattered.

This species is represented by two specimens of the cranidia.

This species is characterized by the presence of the small occipital node, palpebral ridge and also by the straight frontal margin of the frontal rim, and by the large uniformly scattered pustules.

Horizon and Locality: —Middle Cambrian; from the massive cliff-making limestone of Chao-Kou-Chuang, Luan-Hsien, collected by National University Excursion under my direction in September 1923.

Measurements:—

	3 a	3 b
Length of cranidium	12.5 mm.	6.6 mm.
Length of glabella	7.5 mm.	3.8 mm.
Width of glabella at base	7.2 mm.	3.5 mm.
Width of occipital ring at the center	2.0 mm.	1.1 mm.
Width of fixed cheeks at the palpebral lobe	4.0 mm.	2.0 mm.

Width of frontal limb	1.4 mm.	0.8 mm.
Width of frontal rim	1.4 mm.	0.9 mm.

In form this species resembles *Solenopleura beræ* Walcott from Yen-Chuang, Shantung; but it differs in the presence of the distinct occipital ring and also of the palpebral ridge.

The presence of the palpebral ridge and the distinct occipital node suggest *Solenopleura holometopa* Angelin, but the position of the palpebral lobe and the proportionally shorter glabella serve to distinguish it. In this species the length of the glabella and its width at the base are subequal, while in the Swedish species the glabella is usually longer than wide.

Moreover, the palpebral ridge of our species extends from the anterior part of the palpebral lobe to the dorsal furrow, just a little in front of the second furrow of the glabella, while in *S. holometopa* it is distinctly marked and extends to the dorsal furrow one sixth the length of the glabella from the frontal margin of the glabella.

Genus **CHUANGIA** Walcott

1911 *Chuangia* Walcott, Smithsonian Miss. Coll., Vol. 57, No. 4, pp. 83-84.

1913 *Chuangia* Walcott, Research in China, Vol. 3, pp. 170-172.

Original description: "This genus is proposed for a group of Upper Cambrian trilobites in which the cephalon has a truncato-conical or sub-quadrangular glabella; a narrow, concave frontal limb and so far as known, a smooth test.

"The associated pygidium is large, with a strong axis, broad pleural lobes, and few indications of segments". (Walcott 1913 pp. 170-172).

Doctor Walcott compared the genus with *Anomocare* and *Ptychoparia* on account of the likeness of the general form of the cranidium. He also states under the description of the genus, that the characteristic frontal limb of *Chuangia* serves to distinguish it from the other two genera; and the genus *Chuangia* is characterized by the concave frontal limb which meets with the rim to form an angle and the rim does not rise above the dupwar sloping surface of the frontal limb.

In the Tai-An material collected by the college excursion, the outer shell of this genus was discovered and the shell or test is strongly marked by fine pustules; when the outer shell is exfoliated, the cranidium appears smooth.

Genotype—*Chuangia batia* Walcott.

CHUANGIA BATIA Walcott

Plate IV, Figs. 4 a–e.

1905 *Ptychoparia? batia* walcott, Proc. U. S. Nat. Mus., Vol. XXIX, p. 75.

1911 *Chuangia batia* walcott, Smithsonian Misc. Coll., Vol. 57, No. 4, p. 84, pl. 15, figs. 3, 3 a. (Referred and figured as genotype of new genus Chuangia).

1913 *Chuangia batia* walcott, Research in China, Vol. III pp. 170-171, plate 17, figs. 20, 20 a-d.

Cephalon, exclusive of the free cheek, subrhomboidal, moderately convex. Glabella truncato-conical; marked by three pairs of glabellar furrows very faintly shown; the posterior pair shallow, broad and slightly impressed extending from the dorsal furrow backward and inward; only faint traces of the broad second and anterior pairs of glabellar furrows are shown; occipital furrow nearly straight, rounded and very shallow; occipital ring strong, very slightly convex and slightly wider at the center than at the ends and marked by a minute node at the center near the occipital furrow; median longitudinal ridge distinct from the frontal margin of the glabella to the occipital furrow, dorsal furrow distinct but not strongly marked.

Fixed cheeks slightly convex, about one half the width of the glabella at the palpebral lobe, and curved downward in front to the frontal rim and backward in the furrow within the posterior margin; palpebral ridges distinct from the anterior part of the palpebral lobe to the dorsal furrow opposite the first pair or anterior glabellar furrows. Palpebral lobe small, and situated a little back of a transverse line drawn through the center of the cephalon; anterior lateral angle of the cranidium regularly rounded.

The facial suture converges on both sides from the anterior margin down to the anterior part of the eye, curves around the lobe and finally decends obliquely outward to the posterior corner.

The frontal margin of the cranidium forms a regular low arc, and is strongly bent up forming a high rim. Postero-lateral limb large, and marked by a strong and broad furrow within the elevated posterior margin. The front of the glabella and of the fixed cheeks curves down into a shallow furrow, from which the frontal rim rises before curving over to form a thick frontal margin.

An associated hypostoma, 9 mm. wide and 11 mm. long, is probably of this species. Shell strongly marked by fine pustules.

Measurements:—	4 a	4 b	4 c	4 d
Length of cranidium	10.7 mm.	8.5 mm.	8.7 mm.	13.5 mm.
Anterior width of cranidium	9.7 mm.	8.0 mm.	8.0 mm.	12.5 mm.
Posterior width of cranidium	15.0 mm.	—	12.6 mm.	—
Length of glabella	6.8 mm.	5.5 mm.	6.0 mm.	9.0 mm.
Basal width of glabella	5.8 mm.	4.5 mm.	4.5 mm.	7.0 mm.

Width of occipital ring	1.3 mm.	1.0 mm.	1.0 mm.	1.5 mm.
Width of frontal border	2.7 mm.	2.3 mm.	2.3 mm.	3.0 mm.

HORIZON AND LOCALITY:—Upper Cambrian: from the lowest horizon of the Kaolishan limestone. Associated with this are *Mansuyia orientalis* (Grabau) Sun, *Kaolishania pustulosa* Sun, *Syntrophia orthia* Walcott etc. (Coll. Y. C. Sun).

This species is represented by many cranidia and associated pygidia; and is really one of the most common forms of Kao-Li-Shan.

The Kaolishan specimens differ from the type species in the presence of the median longitudinal ridge, in its distinct palpebral ridge and broader frontal border, longer glabella and comparatively narrow fixed cheeks. The course of the facial suture is also different from that in Walcott's specimens, converging slightly on both sides from the frontal margin to the eye, while in our material the facial suture converges rapidly on both sides from the frontal margin to the palpebral lobe.

This form is characterized by its concave frontal border, truncato-conical glabella, absence of the distinct glabellar furrows, distinct longitudinal median ridge, and palpebral ridge; and the finely pustulose character of the outer shell.

Genus **CHANGIA** Sun (Gen. nov.)

1923 *Changia* Sun, Bulletin of the Geological Society of China, Vol. II, No. 1-2 (listed).

General form elongate oval, moderately convex. Glabella of cylindrical form contracted in the middle by incurving of the sides opposite the palpebral lobe; marked by three pairs of short, slightly impressed furrows; occipital furrow distinct; occipital ring uniform in width throughout. Dorsal furrow deep broad and round; frontal furrow broad and deep.

Fixed cheeks very narrow; palpebral lobe of medium size and elevated; the facial suture cuts the frontal border with convex arc to the anterior part of the palpebra lobe, curves around the lobe and finally extends outward to the margin of the postero-lateral limb. Frontal border slightly convex, very broad, sloping down from the frontal groove in the front of the glabella to the rim of the border; antero-lateral angles rounded. The postero-lateral limb narrow, marked by a broad, shallow groove extending from the dorsal furrow to the extremities of the limb.

Free cheeks large ending into a strong genal spine which has about the same length as the cheek, body border narrow and depressed; cheek-body slightly convex, forming a triangular depressed area inside the posterior margin.

Thorax unknown.

Pygidium large with a strong central axis that terminates within a broad flattened border. Central axis divided by broad, deep and round furrows into six or more transverse rings; pleural lobes also marked by broad furrows opposite the transverse rings of the central axis, but much flattened.

Surface apparently smooth under the lens.

The incurving sides of the glabella, the broad and flat frontal border and narrow fixed cheeks suggest the genus *Saukia*, but our genus differs from the latter in its longer glabella, three pairs of short slightly impressed glabellar furrows, and also in the position and the comparatively small size of the palpebral lobe.

This genus is the most common one in the upper zone of the Upper Cambrian of Chau-Mi-Tien and belongs to the family *Dikelocephalinæ.*

This genus is characterized by its broad, slightly convex frontal border, subrectangular glabella with both sides contracting in the middle, narrow fixed cheeks, large free cheeks, comparatively small palpebral lobe which is centrally placed, and the large pygidium with flattened border.

The generic name is given in honor of Dr. H. T. Chang 章鴻釗, former president of the Geological Society of China.

Genotype:—*Changia chinensis* Sun.

CHANGIA CHINENSIS Sun (sp. nov.)

Plate IV, Figs. 5 a–g.

General form large elongate and oval, moderately convex, cephalon transversely semicircular with genal angles extended into a strong spine. Glabella moderately convex, elongate, subcylindrical, contracting opposite the palpebral lobes by incurving of the sides of the glabella; marked by three pairs of short glabellar furrows, the posterior pair broad and short extending obliquely backward; the second pair of furrows parallel to the posterior one but short and also slightly impressed, the anterior pair very short and very slightly impressed; occipital furrow broad and shallow arching forward in the middle, occipital ring moderately convex broad in the middle and arching forward.

Frontal limb very broad, slightly convex, separated from the glabella by a strong distinct groove in the front of the glabella, the frontal margin slightly curved and the antero-lateral angles rounded. Dorsal furrows deep and distinct.

Fixed cheeks very narrow, slightly convex; the facial suture cuts the frontal border slightly outward and than inward toward the anterior part of the palpebral lobe, curves around the latter and finally extends outward and backward, outlining the postero-lateral limb. Palpebral lobe of medium size and elevated. Postero-lateral limb narrow, triangular in outline; marked by a broad postero-lateral furrow extending outward but slightly backward to both extremities.

Free cheeks very large, subtriangular in outline, exclusive of genal spine, with a narrow depressed flat border; cheek-body slightly convex and broad, ending in a long genal spine.

Pygidium transverse, large and with a strong central axis that terminates within a broad flattened border. It is marked by clearly defined transverse rings that extend out in the pleural lobes to the border.

Surface smooth.

This species is characterized by the elongate cylindrical glabella, broad frontal border and also small palpebral lobe centrally placed. It is represented by several cranidia, free cheeks and pygidia.

HORIZON AND LOCALITY:—Upper Cambrian: Upper zone of the Upper Cambrian of Chau-Mi-Tien region, Shantung. Collected by university expedition.

Measurements:—

Cephalon			
Cranidium (a-c)	5 a	5 b	5 c
Length of cranidium	25.0	10.0	10.0
Front width of cranidium	18.0	7.0	7.5
Length of glabella	15.5	6.5	6.0
Width of glabella opposite the palpebral lobe	8.0	4.0	4.0
Width of frontal border	6.5	2.3	2.6
Width of occipital ring	3.5	2.0	2.0
Free cheeks (d-f)	5 d	5 e	5 f
Length of cheek	37.0	35.0	12.5
Width of cheek	15.0	15.0	6.2
Length of genal spine (preserved)	10.0	32.0	6.5
Pygidium (g)	5 g		
Length	30.0		
Width	50.0		

Genus **QUADRATICEPHALUS** Sun (gen. nov.)

General form elongate oval; moderately convex. Cephalon transversely semiovate with genal angles extended backward in a strong spine.

Cranidium subrectangular in outline, exclusive of postero-lateral limb. Glabella moderately convex, sub-cylindrical with both sides parallel, slightly rounded in the front. It is marked by three pairs of glabellar furrows; the posterior pair shallow, distinct, extending obliquely inward and backward and connecting in the middle; the second pair short and shallow, being parallel to the posterior pair; the first or anterior pair very short about one fifth the width of the glabella; a median longitudinal ridge very pronounced, extending from the frontal furrow to the occipital furrow. Occipital furrow broad and rounded, slightly narrow in the center; dorsal furrow broad deep and rounded; frontal groove or furrow rounded and distinct; occipital ring transverse and of nearly uniform width.

Fixed cheeks very narrow, about one fourth the width of the glabella at the palpebral lobe; palpebral lobe very small and situated opposite the second furrow of the glabella and a little in front of the center of the glabella. The facial suture curve slightly outward from the frontal margin, thence curves inward to the anterior angle of the palpebral lobe and around it, and finally extends obliquely outward to outline the free cheeks from the postero-lateral limbs.

Frontal border slightly convex or flat with antero-lateral angle rounded, very broad, of uniform width throughout, about one fourth the length of the cranidium, the middle part of the border very slightly impressed.

An associated free cheek probably of this species, is large and broad with flat broad border and ending in a strong genal spine.

Surface strongly punctate.

This genus is entirely distinct from any other known in the Upper Cambrian of China and evidently belongs to the family *Dikelocephalinæ*. *Quadraticephalus* differs from *Saukia* in the longer subrectangular glabella with subparallel sides and straight frontal margin, small eye lobe and the punctate character of the surface.

Quadraticephalus differs from *Dikelocephalus* in the position of the palpebral lobe situated in the front of the middle of the glabella, longer glabella and also in the glabellar furrows. Other differences may be found in future when more complete specimens are obtained.

This genus is similar to the genus *Chuangia* in form, but the presence of the median longitudinal ridge, subrectangular glabella with subparallel sides and punctate character of the surface serves to distinquish it from that genus which is found in the Chau-Mi-Tien region of Shantung. The subrectangular glabella, pronounced median longitudinal ridge, small eye lobe opposite the second pair of furrows, narrow fixed cheeks and the punctate character of its surface are characteristics of this genus.

Genotype:—*Quadraticephalus walcotti* Sun.

Quadraticephalus walcotti Sun (sp. nov.)

Plate IV, Figs. 6 a-d.

This species is represented by several cranidia and separated free cheeks associated with it.

The generic description of *Quadraticephalus* is based on this species, and therefore nothing need be added here.

The species is characterized by the broad, slightly convex frontal border of the cephalon, small eyelobe placed opposite the second pair of the glabellar furrow, subrectangular glabella with a pronounced median longitudinal ridge, the presence of a depression dividing the frontal limb on the median line of the glabella and the free cheeks with their very broad strong genal spines.

The specific name is given in honor of Dr. C. D. Walcott in recognition of the great work done by him on the Cambrian Faunas of China.

Horizon and Locality—Upper Cambrian: from Kaolishan limestone of Tai-An, just below the foot of the Pagoda, i.e. the highest bed in that region (Coll. Y. C. Sun).

Measurements:—	6 a	6 b	6 c
Length of cranidium	15.5 mm.	14.8 mm.	10.0 mm.
Frontal width of cranidium	11.0 mm.	11.0 mm.	—
Length of glabella	9.6 mm.	9.8 mm.	6.5 mm.
Width of glabella opposite the palpebral lobe	6.2 mm.	6.5 mm.	4.0 mm.
Width of frontal border	4.0 mm.	3.4 mm.	2.0 mm.
Width of occipital ring	2.2 mm.	2.0 mm.	1.3 mm.

Quadraticephalus? convexus Sun. (sp. nov.)

Plate IV, Fig. 7.

This species is represented by a broken central portion of the cephalon. Glabella quadrate in form very convex; it is distinctly marked by a longitudinal ridge extending from the furrow in the front of the glabella to the occipital furrow. It is also marked by two pairs of the glabellar furrows. The first or anterior pair faintly impressed and twisted;

the posterior pair shallow and slightly impressed extending from the dorsal furrow to the median ridge where they unite.

Occipital furrow shallow and broad, merging into the dorsal furrows on both sides.

Fixed cheek very narrow, about one fourth the width of the glabella. Frontal border convex and marked by the broad groove which separates the frontal border from the glabella.

Surface finely punctate.

I place this species under *Quadraticephalus* because of the quadratiform outline of the glabella, the presence of a distinct longitudinal median ridge, the narrow fixed cheek and the fine punctate character of the surface, although the frontal border is quite different. This species differs from *Q. walcotti* in the narrow frontal border, short and broad convex glabella and the glabellar furrows. When a perfect specimen is discovered, other differences may be found.

Measurements:—	7
Length of cranidium	14.5 mm.
Length of glabella	10.0 mm.
Width of fixed cheeks opposite the palpebral lobe	2.0 mm.
Width of frontal border	2.6 mm.

Horizon and Locality:—Upper Cambrian: from conglomerate limestone of of Kao-Li-Shan (Coll. Y. C. Sun).

Genus **PTYCHASPIS** Hall

Ptychaspis chinhsiensis Sun (sp. nov.)

Plate IV, Figs. 8 a-f.

1923 *Ptychaspis chinhsihsiensis* Sun, Upper Cambrian Fossils from Fêngtien. Bulletin of the Geological Society of China Vol. II, No. 1-2 p. 101 (listed).

This species is represented by several cranidia, separated fixed cheeks, and associated hypostoma and pygidia.

Dorsal shield elliptical in outline, moderately convex, with a large genal spine on each side.

Glabella moderately convex, the greatest convexity in the anterior lobe; it is divided by a broad distinct backwards arching transverse furrow into one long anterior lobe and one narrow transverse lobe. Anterior lobe very long, marked by two pairs of furrows, the posterior pair very short and broad and the anterior pair slightly impressed, rarely distinct; the second lobe rather transverse, narrow at the center, becoming wider at the sides; occipital furrow distinct and broad arching forward at the center; occipital ring moderately convex, broad at the center and narrow at both sides.

Fixed cheeks very narrow, about one half the width of the glabella at the palpebral lobe; convex near the palpebral lobe, becoming more gentle both in the front and at the back of the palpebral lobe. Palpebral lobe distinctly elevated and separated from the fixed cheeks by an outward bending palpebral furrow, which extends from the posterior furrow of the anterior lobe to the front of the occipital furrow; dorsal furrows rounded and distinct in confluence with the postero-lateral furrow; postero-lateral limb narrow, the outer ends bending slightly backward; postero-lateral furrows distinctly marked, very broad near the dorsal furrow, becoming narrower toward the end.

The facial sutures first cut the front border, then extend inward and backward to the anterior part of the palpebral lobe, curve around this lobe and finally extend backward and outward to cut the posterior border of the cephalon.

Frontal border gently convex, broad at the middle and becoming gradually narrow on both sides, separated from the glabella and the fixed cheeks by a shallow furrow.

Free cheeks exclusive of the genal spine, subtriangular in outline; the border is well defined and extends to the facial suture; the body of the cheek moderately convex; genal spine about the same length as the cheek, pointing backward and slightly outward; the body as well as glabella separated from the border by a distinct groove; the border of uniform width, marked by several irregular striations.

The associated hypostoma is subrectangular in outline, with obtusely rounded posterior border; the central portion or body strongly convex, marked by a pair of the posterior furrows which extends obliquely inward and backward and are nearly parallel to the margin of the central body. Posterior rim very narrow and elevated, separated from the central portion by a broad posterior groove.

Fragmentary segments of the thorax are known with the axis gently arched and marked by a distinct groove; pleuræ about the same width as the axis, flat and marked by grooves narrowing toward the sides before reaching the end.

Pygidium subsemicircular in outline and transverse; the central axial lobe very convex and conical near to the posterior margin of the pygidium, divided by five distinct furrows into five transverse rings and one long terminal ring; the pleural lobes broad marked by nine or more furrows into ten or more segments which extend up to the flat planulate margin of the pygidium.

Cranidia, free cheeks, hypostoma and pygidia appear granulated under a strong lens.

This species is characterized by its finely granulated character, rather short second lobe, broad flat frontal border, absence of pustules and the conical axial lobe of the pygidium.

The form of the glabella and its size suggest *P. acamus* Walcott, but it differs from the latter in the comparatively narrow second lobe, in the absence of a marked pustulose and punctate character and in the broad frontal border. When the entire specimen of *P. acamus* is found, other differences will be found.

The largest specimen (c) 17 mm. in width has a length of 16 mm.

Measurements:—

Cephalon	8 a	8 b
Length of cranidium	—	11.0 mm.
Width of cranidium of palpebral lobe	—	11.5 mm.
Length of glabella	5.5 mm.	7.5 mm.
Width of glabella at palpebral lobe	4.0 mm.	5.5 mm.
Width of anterior lobe	4.5 mm.	6.0 mm.
Width of second lobe	1.0 mm.	1.3 mm.
Width of occipital ring	1.1 mm.	2.0 mm.
Hypostoma	8 d	
Length	6.5 mm.	
Width	6.0 mm.	
Free cheeks	8 e	
Width of cheek body at palpebral lobe	3.5 mm.	
Width of border of free cheeks	2.0 mm.	
Pygidium	8 f	
Length	5.0 mm.	
Width	—	
Length of axis	4.5 mm.	
Anterior width of axial lobe	2.0 mm.	

Horizon and Locality:—Upper Cambrian: from thin bedded argillaceous limestone of Sha-Kuo-Tun, Chin-Hsi-Hsien (錦西縣) from which this species is named. Collected by Dr. J. G. Andersson.

Ptychaspis angulata Mansuy var. **chinensis** Sun

Plate V, Figs. 1 a, b.

1915 *Ptychaspis angulata* Mansuy. Faunes Cambriennes du Haut-Tonkin, p. 25 pl. III, fig. 2 a-v. Mém. Serv. Géol. de l'Indochine. Vol. IV, fasc. II.

1916 *Ptychaspis angulata* Mansuy. Faunes Cambriennes de L'Extrême-Orient Mériditional, pl. V, fig. 12 a-e. Pl. VI, fig. 1 a-d.

Mansuy described this species very fully, the translation of his description being as follows:

"The glabella is subrectangular, a little larger at the base than at the anterior extremity. The anterior lobe is roundly arched; the dorsal furrows, deep and narrow, are faintly sinuous. The first lateral furrows, well marked, very oblique behind, spread over two-thirds of the width of the glabella; they seem really to represent a second pair, the first pair of lateral furrows being frequently erased in species of this genus. The following furrows (transverse furrows) very deep, parallel to the preceding lateral ones, are continuous. Occipital furrow sinuous. The lower edge of the head, the occipital furrow, the lateral furrows and the anterior edge of the glabella are about equidistant in both varieties. In the middle of the occipital ring, a striking tubercle is noticeable in most samples; this tubercle, often broken at the top, gave rise to a spine more or less developed.

"Fixed cheeks very narrow, with a variable convexity, usually fairly well marked. Ocular lobes about semicircular, sinuous anteriorly, are contiguous to the glabella and join it in a very short ocular line. Frontal limb narrow, almost flat with a large arched tubercle in the middle; its width equal to that of the marginal rim, which is larger in the middle than laterally, and is separated from the limb by a large but not deep furrow. The anterior edge of the head is not curved but forms a very open obtuse angle. The sutures, very oblique in their posterior portion up to the ocular lobes, are sinuous; after having passed these occular lobes they become rectilinear and parallel to the axis of the glabella before reaching the anterior margin. The free cheeks though dissociated, are easily differentiable one from the other according to width. The surface is regularly convex, with the maximum convexity at the center. The marginal rim, large and elevated, with curved section, enlarges more and more until it reaches the genal angle. The posterior rim of the cheeks is much narrower. The genal spine, long, strong, acicular, with circular section, is nevertheless at its base much smaller than the peripheric rim. The lower edge of the free cheeks forms a concave arc with large radius near the genal angle.

"The dissociated thoracic segments show that the rachis was salient, with curved section. The pleuræ are large and are traversed by a well-marked, slightly oblique furrow; the pleural ends are inflected backwards. Some of the pygidia are arched, others semicircular. It is probable that the longest belonged to the long variety and the shorter ones to the short variety. In all other characteristics they do not differ in any way. The axis is salient, truncato-conical, it is formed by seven segments; the terminals are obsolete. The lateral lobes have six furrowed segments, separated from the edge by an oblique and flattened limb."

Mansuy compared this species with *P. campe* Walcott from the Upper Cambrian of Chau-Mi-Tien of Shantung; and he also mentioned that this species differs from Walcott's species in the angular anterior edge of the frontal rim and also in the small eye lobe.

Two varieties were described by him. The width of the glabella equals 84 hundredths of the length in one variety, while in the other variety the width does not represent more than 60 hundredths of the length. He also mentioned that the short glabella is higher and more incurved longitudinally than the long glabella.

In the Kaolishan material four cranidia are represented.

This new variety differs from the type species in the anterior lobe enlarging forward in the presence of very broad rounded frontal groove separating the frontal rim from the glabella, and in the distinctly punctate character of the surface.

This variety is rather similar to *Ptychaspis acamus* var. *punctata* both in the form of the glabella and the surface character, but it differs from the latter greatly in the angular edge of the frontal rim which has a very obtuse angle.

Measurements:—	1 a	1 b
Length of cranidium	9.4 mm.	—
Length of glabella	6.4 mm.	6.5 mm.
Frontal width of glabella	4.0 mm.	5.0 mm.
Width of anterior lobe	4.6 mm.	5.0 mm.
Width of second lobe	1.5 mm.	1.4 mm.
Width of frontal rim and groove combined	1.5 mm.	1.6 mm.
Anterior angle of frontal rim	135°	135°

Horizon and Locality:—Late Upper Cambrian: from the uppermost part of the Kaoli formation in the conglomerate limestone of Tai-An, Shantung. (Y. C. Sun Coll.)

Ptychaspis walcotti Mansuy

Plate V, Figs. 2 a.

1915 *Ptychaspis Walcotti* Mansuy. Faunes Cambriennes du Haut-Tonkin, p. 22, pl. 11, fig. 1 6a, b, pl. III, fig. 1 a-z. Mêm. du Serv. Géol. de L'Indochine. Vol. IV, fasc. II.

1916 *Ptychaspis Walcotti*: Faunes Cambriennes de L'Extrême-Orient Méridional, pp. 33-34, pl. V, fig. 10 a-j, fig. 11 a-b.

Dr. Mansuy Described this species very fully and the translation of the description is as follows:—

"The two species attributed to the genus *Ptychaspis* Hall found in the Cambrian of Upper Tonking, are very imperfectly known, being represented only by fragments of heads, by a few free cheeks and thoracic segments, and by pygidia which seem to be closely related to the forms of the same genus described by Mr. Walcott from the Cambrian of Shantung and of Shansi.

"The species herein described is represented by two varieties, well differentiated in their proportions, one with a longer glabella the other with a shorter glabella; the glabella of the first is somewhat contracted. These differences in the length and width of the glabella, separating these two forms, seem furthermore to represent only individual variations, for, as we will see later, very characteristic details of organization of specific order are common to both. *Ptychaspis angulata* nov. sp., described further on, found in another locality than *Pt. walcotti* nov. sp., is also represented by two varieties differentiated in the same degree and possessing common specific characteristics as strong as those observed in both varieties of the preceding species. In both *Pt. walcotti* and *Pt. angulata* the two varieties differ in certain parts but are similar in their fixed common characteristics. If we add that no intermediate variety has been observed, with one partial exception, in spite of the large number of specimen gathered, we are forced to the deduction (with due reservations) that the two varieties of our species are perhaps but the expression of sexual differences.

"We will describe in the first place the long variety of *Pt. walcotti* (nov. sp.). The glabella of the long variety of this species is subrectangular, the anterior side and the posterior side measuring in a large individual 11 mm. and 15 mm. The convexity is fairly well marked without reaching the high relief shown by certain species of the same genus. The longitudinal incurvation becomes progressively accentuated from the middle of the length and ends anteriorly in a rather abrupt curve. Dorsal furrows large and very deep, their depth being increased by the increased height of the fixed cheeks. The occipital furrow, equally well marked, deeper laterally and inflected backwards in the same parts, is slightly sinuous in the middle. Anterior lobe rectangular, the anterior edge of the glabella being almost straight, very gently convex. It is much wider than long and limited backwards by transverse marginal furrows, not very noticeable. The second lateral furrows, are still very oblique backwards, deeply furrowed, are separated one from the other by an interval equal to their length. The third lateral furrows are still more marked than the preceding ones and with the same obliqueness at their ends, are continuous. The second and third lateral furrows as well as the occipital furrow, are separated by almost equal intervals. The occipital ring, in the same relief as the glabella, is large, with curved arc section, its width is greater in the middle than at the ends; on its posterior margin is inserted a strong occipital spine of which only the base, having the appearance of a large tubercle, is visible. The fixed cheeks, incomplete in all our specimens, are narrow and show a convexity almost as marked as that of the glabella; The rim which bounds them posteriorly is smaller than the occipital ring. Ocular lobes small, raised in the vertical plane and almost parallel to the dorsal furrows of the glabella. The width and the convexity of the frontal limb are almost equal to the width and convexity of the fixed cheeks; Its surface blends laterally and backwards in the surface of the fixed cheeks, in such a way that the glabella is surrounded by a perfect rectangular frame, which gives to the cranidium of our species a very individual appearance. The whole surface is covered by little tubercles, either subcircular or elliptical, drawn close together and sometimes mingling and scattered without symmetry.

"The free cheeks, the thoracic fragments and the separated pygidia which accompany the heads described above, are simply mentioned here, with all reservations as to their belonging to one or the other of the two varieties of *Pt. walcotti*. The free cheeks are large, one of the specimens is a little smaller than the others and this peculiarity allows us to suppose that it belongs to the long and narrow variety rather than to the short variety of *Pt. walcotti*, the glabella of this one being much larger than that of the long variety. The genal angles are not raised, they are situated in the prolongation of the posterior edge of the head. The genal spine is not very long but wide and robust, very diverging. It makes way without any deviation to the marginal rim. The thoracic fragments observed on the same fragments of shale, are much mutilated, with furrowed pleuræ and rounded arched axis. No other characteristic is noticeable.

"All the pygidia are of the same type and identical, one with the other. They are particularly remarkable because of their very transverse form and the strong inflection of the upper edge. The entire marginal region of these pygidia are thrown backwards and form a very obtuse angle sometimes even, in certain specimens, showing a rectilinear trace (perhaps as the result of a slight deformation). The rachis, with semicircular section, truncato-conical, is composed of five large segments, rounded and separated by deep furrows. The posterior segment, larger than the preceding ones, joins the posterior edge by an abrupt inflexion. On the lateral lobes can only be distinguished the proximal end of two upper segments, the following ones being entirely erased; the whole surface of these lobes is covered by fine sinuous lines, drawn close together, resembling cracks, interrupted or joining, whose general direction is parallel to the edge.

"The glabella of the second variety of *Pt. walcotti*, of almost equal length and breadth, shows a subtrapezoidal contour; its longitudinal inflection becomes abruptly accentuated towards the anterior third of its length. The length and obliqueness of the anterior lateral furrows, the anterior concavity of the third lateral furrows, continuous, reproduce all the traits of the corresponding parts of the long variety. The marginal anterior rim is equally very wide, arched and contiguous to the glabella. This glabella of the short form, seem to represent the glabella of the long form but shortened, as if contracted with a stronger incurvation.

"Similarities and differences. The 14 species of Upper Cambrian trilobites from Shantung and from Shansi, attributed to the genus *Ptychaspis* Hall, by Mr, Walcott, are all as poorly represented as are ours, by very mutilated heads, sometimes reduced to internal moulds of dorsal teguments from the glabella and from the fixed cheeks, by a few incomplete free cheeks and by three pygidia. From such insufficient material we may only venture on some limited comparisons, all conclusion being forbidden, particularly as we foresee that a revision of these forms based on the study of less fragmentary specimens, will modify in a large measure the interpretation which has heretofore been given, either by the reduction of the number of species already described, or by the reference of some of them to other genera.

"Among the Chinese species, *Pt. walcotti* (nov. sp.) represents closer affinities with *Ptychaspis acamus* Walc. from the Upper Cambrian limestone of the Chau-Mi-Tien, in Shantung. The glabella of *Pt. acamus* joins intermediate proportions to those of the two varieties of *Pt. walcotti;* its anterior edge is more convex. The occipital ring is smaller; finally in the Tonking species, the convexity of the long variety, in its anterior half, is much fainter, while it is more marked in the short variety. The granulations which cover the surface of our species, are bigger and closer and through the superficial structure of the integuments, *Pt. walcotti* draws closer to *Pt. cadmus* Walc. a species from the same locality as *Pt. acamus;* besides, *Pt. acamus*, *Pt. cadmus* and *Pt. campe* Walc. from Shantung, resemble each other closely. The differences in the proportions of the glabella, in the height and in the relative development of the frontal lobe and the lateral lobes, in these species, are faint, they vary in fact, very little from *Pt. walcotti*, and the comparison of the figures given by Mr. Walcott with those representing *Pt. walcotti* in the same work, will give a more exact notion of the similarity of these three Chinese species between them, and with the Tonking species, than the best description.

"*Ptychaspis walcotti* differs in both varieties from *Pt. angulata* characteristic of a little older horizon from the Cambrian of the region of Yen-minh, by the more clearly rectangular contour of the glabella and by its fainter convexity. The marginal anterior rim, in *Pt. walcotti* is large and continuous to the glabella, while a narrow limb separates it in *Pt. angulata*. These notable differences are also noticeable between the pygidia found with the fragments of heads of these two species. The pygidia associated with the cranidia of *Pt. angulata* are bounded by a smooth limb all over their circumferencial contour. The segments of pleural lobes are very apparent; it has been noted that on the pygidia found with *Pt. walcotti*, they are almost entirely erased."

One cranidium from Sha-Kuo-Tun probably belongs to the long variety of the Tonking species. It has a broad occipital ring, a straight anterior edge of the anterior lobe, moderately convex rectangular anterior lobe and large elliptical tubercles.

In these respects, as well as in size, our specimen agrees fairly well with Mansuy's species. This is the first example of this species found in China, although it occurs abundantly in the Upper Cambrian of Tonking. This suggests that the Shakuotun limestone of Fêngtien is equivalent to the zone of *Ptychaspis walcotti*, the uppermost zone of the Upper Cambrian of Tonking.

MEASUREMENTS:—

Length of cranidium	9.5 mm.
Length of glabella	6.5 mm.
Antero-posterior width of anterior lobe	5.2 mm.
Width of second lobe	1.5 mm.
Width of occipital ring	2.0 mm.
Width of frontal rim	1.2 mm.

HORIZON AND LOCALITY:— Upper Cambrian: from Shakuotun limestone, Sha-Kuo-Tun, Chin-Hsi-Hsien, Fêng-Tien. Collected by Dr. J. G. Andersson.

Ptychaspis subglobosa Grabau (Mss) (sp. nov.)

Plate V, Figs. 3 a-d

1923 *Ptychaspis subglobosa* (Grabau), Sun. Bulletin of the Geological Society of China Vol. II No. 1-2 (listed)

"This species is represented by four glabellas with parts of fixed cheeks attached (one of the specimen is shown from the under side and two are very imperfect).

Associated with these is a large number of free cheeks and genal spines which apparently belong to this species.

"Glabella large, almost parallel-sides except for the slightly wider subglobose anterior lobe, which is strongly convex and but slightly wider transversely, its antero-posterior dimension somewhat less than half the length of the entire glabella. Anterior glabellar furrow complete slightly less pronounced in the center and very gently arcuate; second furrow more strongly deflected backwards and faint in the center; occipital furrow similar to the anterior furrow but broader at the sides and somewhat fainter in the center; the convexity of the posterior segments somewhat less than that of the anterior lobe. Occipital segment slightly broader than second and third segments which are of equal width.

"Fixed cheeks flat or very gently convex; their width somewhat more than half the width of the glabella, broadly grooved posteriorly by the lateral extension of the occipital furrow.

"The associated free cheeks are large and extended into a long gently curved genal spine. The outer contour is gently and regularly convex, and the inner side contracts rapidly to the very gently tapering genal spine, which has a subcircular or broadly ovoid section with the narrow end on the inside. It is marked by subequally spaced, rather distint and more or less continuous longitudinal striæ. The length of the genal spine is considerable, being much greater than that of the glabella; its terminal end tapers rather more rapidly.

"Surface apparently smooth, though in one specimen there is a suggestion of faint discontinuous and concentrically placed wrinkles on the anterior lobe of the glabella.

"The specimens occur in a limestone conglomerate (intraformational) with large worn limestone pebbles. The slender genal spines are by far the most numerous, and they are mostly fragmentary, the anterior expansion of the free cheek being shown only in a few specimens. They are very like the genal spines of some species of *Paradoxides*, but more curved, and they are longer and more slender than those of any other species of *Ptychaspis* from the Cambrian of China. They are also much longer proportionately, more cylindrical and less rapidly-tapering than are those of *P. minicaensis* Owen, the type species of the genus, from the St. Croix beds of Wisconsin.

"This species approaches *Ptychaspis calyce* Walcott, from the Upper Cambrian Ch'aumitien limestone of Shantung, in the form of the glabella but the anterior lobe is longer more nearly subglobose while the second furrow is more deflected backwards medially and less continuous than in that species. The Fêngshan specimens are also uniformly larger. The free cheeks of our species are very distinct.

"*Measurements:* The length of the most perfect glabella is 25.5 mm., width of anterior lobe (longitudinal) 12.5 mm., width of central part of glabella 13.5 mm. The diameter of the median portion of the genal spines varies from 3.5 to 4 mm.

"*Horizon and Locality:* The specimens occur in a limestone conglomerate of Upper Cambrian collected by Dr. J. G. Andersson at Luan-Hsien, Chihli province." (Grabau Mss.)

Five more cranidia of this species were obtained from the Koali limestone. Two large ones occur in the same limestone conglomerate and are essentially of the same type as those of the Fêngshan limestone. Three other small specimens were found in the crystalline limestone full of *Obolus,* 2 or 3 meters below. The Shantung specimens are well preserved especially in the fixed cheeks, eye lobes and the surface while the Chihli specimens are nearly worn away and difficult for description.

Fixed cheeks flat, moderately convex near the palpebral lobe and sloping down the postero-lateral portion; triangular in outline, exclusive of the palpebral lobe, very broad in the posterior part about the width of the glabella and becoming narrow gradually toward the front; marked posteriorly by a broad and distinct groove, which extends outward from the furrow a little below the occipital furrow to the postero-lateral extremities and broadens slightly outward. It is also marked by distinct raised undulating ridges which are the characteristic feature of this species.

Palpebral lobe small, elongate, situated just opposite the first glabellar furrow and separated from the fixed cheeks by an incurved furrow and elevated. The occipital ring usually broader than the third lobe, slightly narrow in the center, becoming broad at both sides. It is distinctly marked by a median node.

The facial sutures cut the antero-lateral portion with a regular convexity to the anterior part of the palpebral lobe; and curving around this lobe, extend outward and backward to the postero-lateral extremities, forming angles of 45° with the posterior margin.

Surface strongly marked by elevated ridge, and wrinkles and also punctate.

The concentric wrinkles of the anterior lobe, and the general form of the cranidium suggest *P. ceto* Walcott from the Upper Cambrian Chaumitien limestone of Chau-Mi-Tien, Shantung, but our species differs in the longer subglobose form of the anterior lobe of the glabella, the punctate surface with distinct wrinkles and ridges, and also in the greater deflection of the transverse furrow of the glabella.

MEASUREMENTS:—

	a	b	c	d
Length of cranidium	25.5 mm.	19.0 mm.	......	6.0 mm.
Width of cranidium at the palpebral lobe	......	17.0 mm.	12.2 mm.	7.0 mm.
Length of glabella	21.8 mm.	16.0 mm.	9.0 mm.	5.0 mm.
Antero-posterior dimension of anterior lobe	12.5 mm.	10.0 mm.	5.0 mm.	3.0 mm.
Width of glabella	14.2 mm.	10.5 mm.	6.2 mm.	3.5 mm.
Width of the second lobe (antero-posterior)	4.8 mm.	3.5 mm.	2.0 mm.	1.3 mm.
Width of the third lobe ,, ,,	4.0 mm.	3.0 mm.	1.5 mm.	1.0 mm.
Width of occipital ring ,, ,,	......	3.0 mm.	......	1.0 mm.
Length of palpebral lobe	......	.....	3.0 mm.	2.0 mm.

HORIZON AND LOCALITY:—Late Upper Cambrian: from the conglomerate limestone and crystalline limestone of Kaolishan formation of Tai-An, Shantung. (Y. C. Sun Coll.): also the upper Cambrian of Luan-Hsien, Chihli (J. G. Andersson Coll.).

PTYCHASPIS SUNI Grabau (mss.) (sp. nov.)

Plate V, Figs. 4a, b.

1923 *Ptychaspis suni* (Grabau) Sun, Bulletin of the Geological Society of China, Vol. II, No. 1-2 p. 98.

"Only the cephalon exclusive of the free cheeks is known but one free cheek, probably of this species is associated with this. Glabella with parallel sides, moderately convex, the greatest convexity apparently in the anterior lobe, though this is worn. Anterior and second lobe separated by a very faint furrow which is transverse; the width (longitudinal) of the two lobes combined being equal to the width of the glabella which in the specimens described is 5.75 mm. The second furrow is more pronounced, and more concave forward, the third or occipital furrow is strong and transverse. Length of entire glabella, 9 mm; width of occipital ring 1.7 mm.

"Fixed cheeks half the width of the glabella, subsemicircular in outline, with a pronounced narrow palpebral lobe defined by a well-marked furrow.

"Entire surface of cranidium strongly pustulose except where worn.

"The associated free cheek has about the width of this fixed cheek at the center of the occular lobe. Behind this it curves outward at first obliquely then abruptly ending in a narrow gently tapering genal spine of subcircular section and forming nearly half the length of the cheek. Anterior portion terminating in an angle of about 45°. Outer edge of free cheek gently but regularly curving from anterior end to the tip of the genal spine.

"This species resembles *Ptychaspis campe* Walcott from the Upper Cambrian Ch'aumitien limestone of Shantung in the form of the glabella, fixed cheeks and palpebral lobes, and in the pustulose character of the carapace. The occipital furrow of our species is however very much deeper than in that species, being moreover continuous, while it is interupted in the center in the Shantung species. Our species is more over nearly twice as large as *P. campe*.

"HORIZON AND LOCALITY: In the thin-bedded argillaceous limestone of Fêngshan formation of Yeh-Li, Luan-Hsien, Chihli, Collected by H. C. T'an. The species is named after Mr. Y. C. Sun, of the National Geological Survey."

PTYCHASPIS ACAMUS var. PUNCTATA Sun (var. nov.)

Plate V, Figs. 5a-d.

1905 *Ptychaspis acamus* Walcott, Proc. U. S. Nat. Mus., Vol. XXIX, p. 69.

1913 *Ptychaspis acamus* Walcott, Research in China Vol. III, p. 179, pl. 16, Fig. 18, 18 a.

1923 *Ptychaspis acamus* Walcott, Sun; Bulletin of the Geological Society of China. Vol. II, No. 1-2 p. 101 (listed).

This variety is represented by six cranidia, and associated free cheeks. Glabella strongly convex on the frontal lobe, but moderately convex at the back; Subrectangular in outline with two sides parallel to each other; frontal margin of the glabella very straight and separated from the uniformly narrow border by a straight pronounced groove. Anterior lobe quadrate in form, marked by two pairs of short slightly impressed glabellar furrows; the posterior pair little longer than the posterior ones, extending backward and inward for very short distance; second lobe very narrow antero-posteriorly about as wide as the occipital ring and separated from the large longer anterior lobe by a broad strong backward arching furrow.

Fixed cheeks very narrow about the same width as the frontal border. Dorsal furrow deep and distinct.

Frontal border narrow elevated and straight, of uniformly width throughout.

Occipital ring narrow of uniform width throughout.

Surface strongly marked by very large pustules and also finely punctated.

As only the glabella of the type species is known, the detail comparison is not possible.

This variety differs from type species in the distinctly punctate character of the surface, straighter frontal edge of the glabella, in the narrower anterior lobe and in the free cheeks.

The general form of the cranidium and the pustulose and distinctly punctate character of the surface suggest *Pt. angulata*, but it differs greatly in the straightened margin of the frontal border instead of the angular one.

This variety was obtained from the highest cambrian beds of Chau-Mi-Tien five meters above the *Orthoceras* horizon. It is associated with *Changia chinensis*.

Measurements:—

	a	b	c	d
Length of glabella	8.8 mm.	8.0 mm.	7.5 mm.	12.0 mm.
Width of glabella	6.0 mm.	6.0 mm.	6.0 mm.	8.5 mm.
Width of anterior lobe	7.0 mm.	6.0 mm.	7.0 mm.	9.5 mm.
Width of second lobe	1.5 mm.	1.57 mm.	1.5 mm.	2.0 mm.
Width of occipital ring	2.0 mm.	......	......	......
Width of frontal border	......	1.5 mm.	1.5 mm.	......

Horizon and Locality: Uppermost Cambrian: from the upper limestone at Chau-Mi-Tien, Shantung. I tentatively put it in the Fêngshan horizon, separating these beds from the Chaumitien limestone. Collected by University Excursion of 1923. (Y. T. Chao, K. M. Wang, C. C. Yang and C. C. Tien Coll.)

Anderssonia Sun, subgenus of **Ptychaspis** (Subgenus nov.)

Cranidium gently convex, the width at the palpebral lobe and the length subequal. Glabella moderately convex, short, usually broad opposite the palpebral lobe by outcurving at the sides of the glabella, the front narrowly rounded. A very distinct backward-curving posterior furrow separates the anterior lobe and the narrow transverse lobe; the anterior lobe laterally extended at the base becoming less so toward the front, marked by one pair of very short and distinct furrows extending obliquely inward and backward; the second lobe slightly narrow in the middle, becoming wide at the sides, separated from the occipital ring by a transverse occipital furrow; occipital ring little wider than the second lobe and of uniform width; dorsal furrows rounded, distinct and subparallel.

Fixed cheeks very narrow, about one half the width of the glabella, slightly convex; the facial suture first cuts the posterior border and then bends inward to the base of the palpebral lobe, curving around it and finally extending outward and forward, and then inward again to cut the frontal border; frontal limb narrow slightly convex separated from the narrow elevated frontal rim by a very narrow distinct transverse furrow, frontal rim very narrow, extended transversely with a uniform width throughout. Palpebral lobe large and long extending from the very faint anterior furrow of the anterior lobe nearly to the occipital furrow, and separated from the fixed cheeks by an incurving furrow.

Associated free cheeks large with slender genal spine.

An associated segment of the thorax, probably of this subgenus is known. Axial lobe and pleural lobe subequal in length; axial lobe convex; pleural lobes of nearly uniform width throughout except the pleural end.

An associated pygidium transverse, with the narrow conical axis and flattened margins.

This new subgenus is included in the subfamily *Dikelocephalinæ* and is characterized by its slight, convex frontal limb, large and elongate palpebral lobes, narrow fixed cheeks and the narrow elevated frontal rim.

The narrow frontal limb, elongate palpebral lobe and the form of the glabella suggest the genus *Conokephalina*, but the strong lateral furrows, absence of the palpebral ridge and the broad form serve to distinquish it.

It differs also from *Ptychaspis* in the presence of the frontal limb and in the form of the glabella which is broad in the middle.

This new subgenus is named in honor of Dr. J. G. Andersson, who collected these specimens.

PTYCHASPIS (ANDERSSONIA) FENGTIENENSIS Sun (subgen. and sp. nov.)

Plate V, Fig. 7a-c

This species is represented by three fragmentary cranidia, and separated free cheeks, segment of thorax and pygidia associated with it.

The subgeneric description of *Anderssonia* is based on this species and the specific name is derived from Fêngtien where it was found.

Horizon and Locality: This species is associated with *Pty. chinhsiensis*, *Pty. walcotti* and *Eoorthis shakuotunensis* etc. in the Shakuotun limestone of Fêngtien.

Measurements:—

Cephalon	7a	7b
Length of cranidium	6.5 mm.	4.5 mm.
Width of cranidium	6.5 mm.	5.5 mm.
Length of glabella	4.3 mm.	2.9 mm.
Width of glabella opposite the palpebral lobe	3.5 mm.	2.5 mm.
Width of anterior lobe (antero-posterior)	3.5 mm.	2.0 mm.
Width of second lobe	1.0 mm.	0.7 mm.
Width of occipital ring	1.1 mm.	0.9 mm.
Width of frontal limb	5.5 mm.	0.5 mm.
Width of frontal rim	0.6 mm.	0.5 mm.
Length of palpebral lobe	2.5 mm.	1.8 mm.
Pygidium (associated)	7c	
Length	4.0 mm.	
Anterior width	6.0 mm.	

Ptychaspis (Anderssonia) tani Sun (sp. nov.)

Plate V, Fig. 6.

This species is represented by one broken portion of the cephalon.

Glabella moderately convex; divided by two backward arching transverse furrows into one large transverse lobe and two narrow transverse lobes; the combined width of the two narrow transverse lobes being nearly as great as that of the anterior lobe. Occipital furrow distinct.

Fixed cheeks narrow, about one half the width of the glabella at the palpebral lobe; palpebral lobe very large, extending from near the anterior part of the glabella to the occipital furrow, and separated from the fixed cheeks by an infra-curving furrow. Frontal rim elevated and of uniform width, separated from the glabella by a broad concave limb.

Surface strongly marked by pustules and irregularly curving ridges but not punctate.

This species resembles both *Pt. calyce* Walcott and *Pt. ceto* Walcott in the transverse form of the anterior lobe, but differs greatly from both in having a very large palpebral lobe, narrow fixed cheeks and also in the presence of the frontal limb.

The large palpebral lobe and the pustulose character of this species suggest *Pt. campe* from Chaumitien limestone of Chau-Mi-Tien, but the distinct, continuous arching transverse furrow and the concave frontal limb serve to distinguish it.

This species is characterized by the transverse form of the anterior lobe, large palpebral lobe, concave frontal limb and pustulose and ridged character of the surfaces. It is named after Mr. H. C. T'an, (譚錫疇) geologist of the Survey, in recognition of the geological work done by him in Shantung.

Measurements:—

Length of glabella	3.9 mm.
Width of Anterior lobe (longitudinal)	2.3 mm.
Width of second lobe	1.0 mm.
Width of third lobe	1.0 mm.
Width of frontal limb and rim combined	1.0 mm.

HORIZON AND LOCALITY:— Upper Cambrian: from the Upper Cambrian limestone of Chau-Mi-Tien. Collected by University Excursion.

Genus **ANOMOCARE** Angelin

ANOMOCARE FLAVA Walcott

Plate V, Figs. 8a–d.

1906 *Anomocare flava* Walcott, Proc. U. S. Nat. Mus., Vol. XXX, p. 583.

1913 *Anomocare flava* Walcott, Research in China. Vol. III, pp. 190-191, pl. 18; figs. 8; 8a-c.

This species was found by Willis and Blackwelder in the Kichou formation of Shansi and very fully described by Walcott. In the collection from the Kaiping Basin it is represented by more than 50 individuals and certainly is one of the most common species in the Changhia formation of North China. It is associated with *Dorypyge richthofeni*, *Solenopleura nodosa*, and two species of *Lisania*.

It is characterized by its quadrilateral cranidium, short and moderately convex glabella with slight indications of glabellar furrows, shallow occipital furrow, low and broad palpebral ridge, slightly convex, broad frontal rim, presence of the occipital node; and by a pygidium with a broad, planulate margin and with a narrow convex axis, slightly segmented.

Measurements:—

Cranidium	8a	8b
Length of cranidium	6.0 mm.	5.5 mm.
Width of cranidium at palpebral lobe	6.2 mm.	5.6 mm.
Length of glabella	3.5 mm.	3.4 mm.
Width of occipital ring	1.0 mm.	1.0 mm.
Width of frontal limb	0.4 mm.	0.4 mm.
Width of frontal rim	1.0 mm.	1.0 mm.
Pygidium	8c	8d
Length	5.0 mm.	6.0 mm.
Width	8.0 mm.	9.5 mm.

HORIZON AND LOCALITY:— Middle Cambrian: from the cliff limestone of Chêngshan, 8 li from Chao-Kou-Chuang, Chihli. Collected by University Excursion (K. S. Hsu 徐光熙 Coll.).

Genus **Dolichometopus** Angelin

Dolichometopus deois Walcott

Plate V, Fig. 9.

1905 *Dolichometopus deois* Walcott, Proc. u.s. Nat. Mus. Vol. XXIX, p. 94.

1906 *Bathyuricus asiaticus* Lorenz, Zeitschr. deutsch geol. Gesellsch., Vol. LVIII, pt. 2 p. 73, Pl. V, fig. 1-5. (species characterized and illustrated)

1900 *Amphoton steinmanni* Lorenz, idem., Vol., LVIII, pl. 2, p. 75, plate IV, figs. 15-17. (Species characterized and illustrated).

1913 *Dolichometopus deois* Walcott, Research in China, Vol. III, pl. 21, figs. 13, 13 a-d., Plate 22, figures 1, 1 a-h, 2, 2a-b.

Dr. Walcott gives a full description of this species.

This species is characterized by its prominent glabella diverging anteriorly with three pairs of rather short, very faintly impressed furrows; the presence of a small backward pointing occipital spine; narrow fixed cheeks; long palpebral lobe; and short and slightly convex frontal limb.

Dr. Walcott compared this species with *D. svecicus* Angelin and mentioned that this species differs from the latter in the greater convexity of the glabella, more convex frontal limb, and other minor details of the glabella and the fixed cheeks.

This species is represented by only one cranidium in the Luan-Chou (灤州) material. Our specimens agrees closely with the type of the species figured by Walcott both in form and size.

HORIZON AND LOCALITY:— Middle Cambrian: from Changhia limestone of Kwan-Hsi-Ying (關西營), Luan-Chou. Collected by Dr. J. G. Andersson.

Measurements:—

Length of cranidium	11.0 mm.
Width of cranidium at palpebral lobe	9.8 mm.
Length of glabella	8.5 mm.
Basal width of glabella	5.0 mm.

Genus **ILLÆNURUS** Hall

Illænurus pagoda Sun (sp. nov.)

Plate V, Figs 10a-c.

Of this species only three pygidia are known.

Pygidium subtriangular in outline, usually broader than long, moderately convex.

Shell perfectly smooth without segmentation of the axis except at the frontal part where it is more strongly rounded. One specimen with a part broken away shows very slight axial segmentation in the cast of the interior. This may be one of Walcott's pecies. On account of the strong forward-projection, I refer it for the present, to a snew species—*Illænurus pagoda.*

Three specimens measure respectively: length 7.5 mm., 7.5 mm., 8.0 mm.; width 10 mm., 10 mm., 12.0 mm.

HORIZON AND LOCALITY:— Upper Cambrian: from the conglomerate limestone of Kao-Li-Shan, Tai-An, Shantung (Y. C. Sun Coll.).

Several pygidia of this type have been obtained from the Fêngshan limestone of Chihli by Mr. H.C. T'an. They may belong to this species but on account of their weathered character precise identification is not possible. This species differs from the similar pygidia described by Walcott mainly in the absence of distinct demarkations of the axis.

Genus **TAIANOCEPHALUS** Sun (gen. nov.)

Cephalon semielliptical in outline, very transverse. The greatest convexity lies in the central posterior portion, sloping down both to the frontal margin, and to the antero-lateral angles.

Glabella truncato-conical, with broad base, the front about two-thirds of the basal width of the glabella; slightly contracted just opposite the palpebral lobes by a slight incurving of the sides. It is marked by two pairs of very broad shallow and short glabellar furrows in the form of shallow basin-like depressions, extending obliquely backward; A median longitudinal ridge extends from the frontal margin nearly to the occipital furrow. The occipital furrow is represented by one pair of broad lens-shaped depressions separated from each other by a broad space about equal in length to the depression.

Fixed cheeks narrow in the front and becoming very broad in the posterior parts. Dorsal furrows shallow and distinct; palpebral area at fixed cheek opposite the palpebral lobes moderately convex. Palpebral lobe small and situated nearly at the antero-lateral margin of the cephalon.

The facial suture cuts the frontal border and extends along the palpebral lobe and then backward and outward to the extremities of the postero-lateral limbs.

Postero-lateral limb triangular in outline and marked by a distinct shallow groove confluent with the dorsal furrow, and becoming gradually broader up to the postero-lateral margin.

Surface marked by pustules visible under a lens, outer test not known.

This genus is distinct from any known in China and characterized by its semielliptical cephalon, truncato-conical glabella, marked by two pairs of broad shallow depressions and the shallow occipital furrow separated by a broad central space, and the large triangular postero-lateral limb.

Probably it represents one form of the order *Proparia* with extended postero-lateral limbs.

This genus is represented by only one specimen, and associated with *Kaolishania pustulosa*, *Mansuyia orientalis*, etc.

Genotype: *Taianocephalus grabaui* Sun.

The specimen representing this genus was obtained from Kao-Li-Shan of the Tai-An region from which the generic name is given.

Taianocephalus grabaui Sun (gen. and sp. nov.)

Plate V, Fig. 11.

The generic description is based on this species.

This species is characterized by a large triangular postero-lateral limb, absence of the distinct frontal limb, the elevated palpebral area near the antero-lateral angle, and the truncato-conical glabella marked by a pair of glabellar depressions and the occipital furrow in the form of very broad, shallow pits.

Thorax and pygidium unknown.

Measurements:—

Length of cranidium	12.0 mm.
Width of cranidium at the palpebral lobe	12.0 mm.
Length of glabella	9.0 mm.
Anterior width of glabella	5.2 mm.
Posterior width of glabella	8.8 mm.
Width of postero-lateral limb	11.0 mm.

This species is named in honor of Prof. A. W. Grabau, Chief Palæontologist of the Survey.

Horizon and Locality:— Upper Cambrian: Kaolishan limestone of Tai-An region (Collected by Y. C. Sun).

Genus **Wongia** Sun (gen. nov.)

Cranidium subtriangular, exclusive of genal spine; glabella truncato-conical, moderately convex, not marked by glabellar furrows; occipital furrow very shallow and broad slightly arching backward. Occipital ring moderately convex, its transverse dimension about one half the length of the glabella and of about the same width throughout.

Fixed cheeks very broad, the greatest width of the fixed cheeks opposite the palpebral lobe is nearly equal to the frontal width of the glabella; they rise up moderately from the dorsal furrow to the palpebral lobe; dorsal furrow deep and distinct.

Frontal border with the same convexity as the fixed cheeks, with a regularly rounded frontal margin and separated from the glabella by a distinct frontal groove.

The course of the facial suture is rather remarkable, it curves first from the middle part of the frontal border with a regularly rounded arc to the anterior part of the palpebral lobe, and curving around this extends outward and backward so as to cut the free cheeks from the genal spine of the cranidium.

The postero-lateral limb becomes abruptly depressed, forming a subtriangular area. Genal spine pronounced, long and slender extending outward at about an angle of 45° with the longitudinal axis and forming a part of the fixed cheeks.

Thorax, free cheeks and pygidia are not known.

Cranidium faintly marked by pustules under a strong lens.

Because this form has the genal spines or genal angles on the fixed cheeks, it belongs to the order *Proparia.*

The members of this order are very common from the Ordovician onwards but are rarely found in the Cambrian strata.

Dr. C. D. Walcott mentioned that two Chinese Cambrian genera-*Damesella* and *Stephanocare*-have the characters of the order *Proparia.* But in the typical form of this order, the genal spines and the genal angles coincide and form one part of the fixed cheeks. Probably *Damesella* and *Stephanocare* may belong to a suborder of the *Proparia;* but the genus *Wongia* is quite distinct and certainly belongs to the typical form of the order *Proparia.*

I take extreme pleasure in naming this new genus *Wongia* in honor of Prof. W. H. Wong, President of the Geological Society of China and Director of the national Geological Survey.

Genotype-*Wongia triangulata* Sun.

Wongia triangulata Sun (gen. sp. nov.)

Plate V, Figs. 12a-b.

This species is represented by four individuals in one fossil band; only cranidia are known.

The description of the genus is based on this species and therefore nothing needs be added except the measurements of the type specimen.

Length of cranidium	2.8 mm.
Width of cranidium at the palpebral lobe	3.0 mm.
Length of glabella	1.5 mm.
Width of glabella at the base	1.4 mm.
Width of frontal border	0.8 mm.
Width of fixed cheeks at palpebral lobe	0.95 mm.

This species is characterized by its triangular cranidium, the long curved lateral spines and the course of the facial suture.

Horizon and Locality:— Late Middle Cambrian: from the thin platey limestone in Kushan shale of Lincheng, Chihli.

Collected by Y. T. Chao and C .C. Tien.

BIBLIOGRAPHY

1. BERGERON, J. 1899:—Etude de quelques trilobites de Chine. Bulletin de la Société Géologique de France, 3d sér., Vol. 27, No. 5, Paris.
2. DAMES, WILHELM. 1883:—Cambrische Trilobiten von Liau-Tung. China, by Ferdinand von Richthofen, Vol. 4.
3. GOTTSCHE, C. 1886:—Geologische Skizze von Korea. Sitzungsberichte d. k. Preuss. Akad. d. Wiss. Berlin. Vol. XXXVI, pp. 9-11.
4. KAYSER, E. 1883:—Cambrische Brachiopoden von Liau-Tung. China, by Ferdinand von Richthofen, Vol. 4.
5. LORENZ, TH. 1904:—Ascosomaceæ, Eine Neue Familie der Siphoneen aus dem Cambrium von Schantung. Centralbl. f. Min. Geol. u. Pal.
6. LORENZ, TH. 1905:—Beiträge zur geologie und Palæontologie von Ostasien unter besonderer Berücksichtigung der Provinz Schantung in China. Zeitschrift der deutschen geologischen Gesellschaft, Bd. 57.
7. LORENZ, TH. 1906:—Beiträge zur Geologie und Palæontologie von Ostasien unter besonderer Berücksichtigung der Provinz Schantung in China; II; Palæontologischer Teil. Zeitschrift der deutchen geologischen Gesellschaft, Bd. 58.
8. MANSUY, H. 1915:—Faunes Cambriennes du Haut-Tonkin. Mém. du Serv. Géol. de l'Indo-Chine, Vol. IV, fasc. 2.
9. MANSUY, H. 1916:—Faunes Cambriennes de l'Extrême-Orient Méridional. Mém. du Serv. Géologique de l'Indochine, Vol. V, fasc. 1.
10. MOBERG, J. C. AND SEGESBERG, C. O. 1906:—Bidray Till Kännedomen om Ceratopyge-Regionen. Meddelande Från Lunds Geologiska Fältklubb. Serv. B. N: 02.
11. MONKE, H. 1903:—Obercambrische Trilobiten von Yen-Tzy-Yai. Jahrbuch der Königlich-Preussischen Geologischen Landesandstalt und Bergakademie zu Berlin, Bd. 23, Hft 1, 1902. Beiträge zur Geologie von Schantung.
12. REDLICH K. A. 1901:—The Cambrian Fauna of the Eastern Salt-Range. Memoirs of the Geological Survey of India, Palæontologia Indica, New Ser., Vol. 1, No. 1.
13. REED, F. R. C. 1906:—The Lower Palæozoic fossils of the Northern Shan States, Burma. Memoirs of the Geological Survey of India, Palæontologia Indica, New. Ser., Vol. 2.
14. REED, F. R. C. 1910:—The Cambrian Fossils of Spiti. Memoirs of the Geological Survey of India, Palæontologia Indica, ser. 15, Vol. 7.

15. SCHMIDT, FR. 1886:—Ueber einige neue ostsibirische Trilobiten und verwandte Thierformen. Mélanges Physiques et Chimiques tirés du Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg, Vol. 12.§

16. SUN, Y. C. (孫雲鑄) 1923:—Upper Cambrian of Kaiping Basin, Bull. Geol. Soc. China, Vol. II.

17. SUN, Y. C. (孫雲鑄) 1923:—Upper Cambrian Fossils from Fêngtien. Ibid.

18. TOLL, E. VON. 1899:—Beiträge zur Kenntniss des Sibirischen Cambriums. Mémoires de l'Académie impériale des Sciences de St. Pétersbourg, 8th ser., Vol. 8. No. 10.§

19. WALCOTT, C. D. 1905:—Cambrian Faunas of China, Proc. U. S. Nat. Mus. Vol. XXIX.

20. WALCOTT C. D. 1906:—Cambrian Faunas of China, paper No. 2, proc. U. S. Nat. Mus. Vol. XXX.

21. WALCOTT, C. D. 1908:—Cambrian Brachiopoda: Smithsonian Miscellaneous Collections. Vol. I, No. 3.

22. WALCOTT, C. D. 1911:—Cambrian Faunas of China. Smithsonian Miscellaneous Collections Vol. 57, No. 4.

23. WALCOTT, C. D. 1912:—Cambro-Ordovician Boundary in British Columbia with Description of Fossils. Smithsonian Miscellaneous Collections. Vol. 57. No. 7.

24. WALCOTT, C. D. 1912:—New York Potsdam-Hoyt Fauna. Smithsonian Miscellaneous Collections. Vol. 57, No. 9.

25. WALCOTT, C. D. 1912:—Cambrian Brachiopoda. U. S. Geological Survey. Monograph LI Part I & II.

26. WALCOTT, C. D. 1914:—Dikelocephalus and other genera of the Dikelocephalinæ. Smithsonian Miscellaneous Collections. Vol. 57, No. 13.

27. WALCOTT, C. D. 1916:—Cambrian Trilobites. Smithsonian Miscellaneous Collections. Vol. 64. No. 3.

28. WESTERGARD, A. H. 1909:—Studier öfer Dictyograptusskiffern Och Dess. Gränslager. Meddelande Fran Lunds Geologiska Fältklubb. Ser. A. N: γ4.

29. WOODWARD, H. 1905:—Trilobites from Shantung. The Geological Magazine, New Series, Decade V. Vol. II. No. V.

30. YABE, H. I. AND HAYASAKA, I. 1920:—Palæontology of South China. Tokyo Geographical Society.

31. 青地乙治 19240:—大連圖幅地質說明書

§ not seen.

List of Localities referred to, arranged Alphabetically under Provinces.

(see map, fig. 1.)

Chihli 直隸省

*	1.	Chang-Shan	長山	*	2.	Chao-Kou-Chuang	趙各莊
*	3.	Chêng-Shan	稱山	*	4.	Fêng-Shan	鳳山
*	5.	Jên-Chuang	任莊	*	6.	Kwang-Hsi-Ying	關西營
*	7.	Lei-Chuang	雷莊	*	8.	Lin-Cheng	臨城
*	9.	Lin-yu	臨榆				

Shantung 山東省

	10.	Chang-Hia	張夏	*	11.	Chau-Mi-Tien	炒米店
	12.	Kao-Kia-Pu	高家坡	*	13.	Kao-Li-Shan	高里山
*	14	Ku-Shan	崮山		15.	Lien-Hua-Shan	蓮花山
	16.	Sin-Tai	新泰		17.	Ta-Wen-Kou	大汶口
	18.	Tsing-Chou-Fu	青州府		19.	Tsing-Lung-Shan	青龍山
	20.	Wang-Chuang	王莊		21.	Yen-Chuang	顏莊
	22.	Yen-Tsy-Yai	燕子崖				

Shensi 陝西省

	23.	Ch'ou-P'ing-Hsien	鎮平縣				

Shansi 山西省

	24.	Fang-Lan-Chen	芳蘭鎮		25.	Ting-Hsiang-Hsien	定襄縣
	26.	Tung-Yü	東寓(嵎)		27.	Yau-To'	岩頭

Fêngtien 奉天省

	28.	Fu-Chou	復州	*	29.	Sha-Kuo-Tun	沙鍋屯
	30.	Sai-Ma-Ki	寨馬集		31.	Ta-Ling	大嶺
	32.	Tschang-Hsing-Tao	長興島		33.	Wa-Fang-Tien	瓦房店
	34.	Wu-Lo-Pu	五路坡				

* Localities which have furnished material described in this memoir.

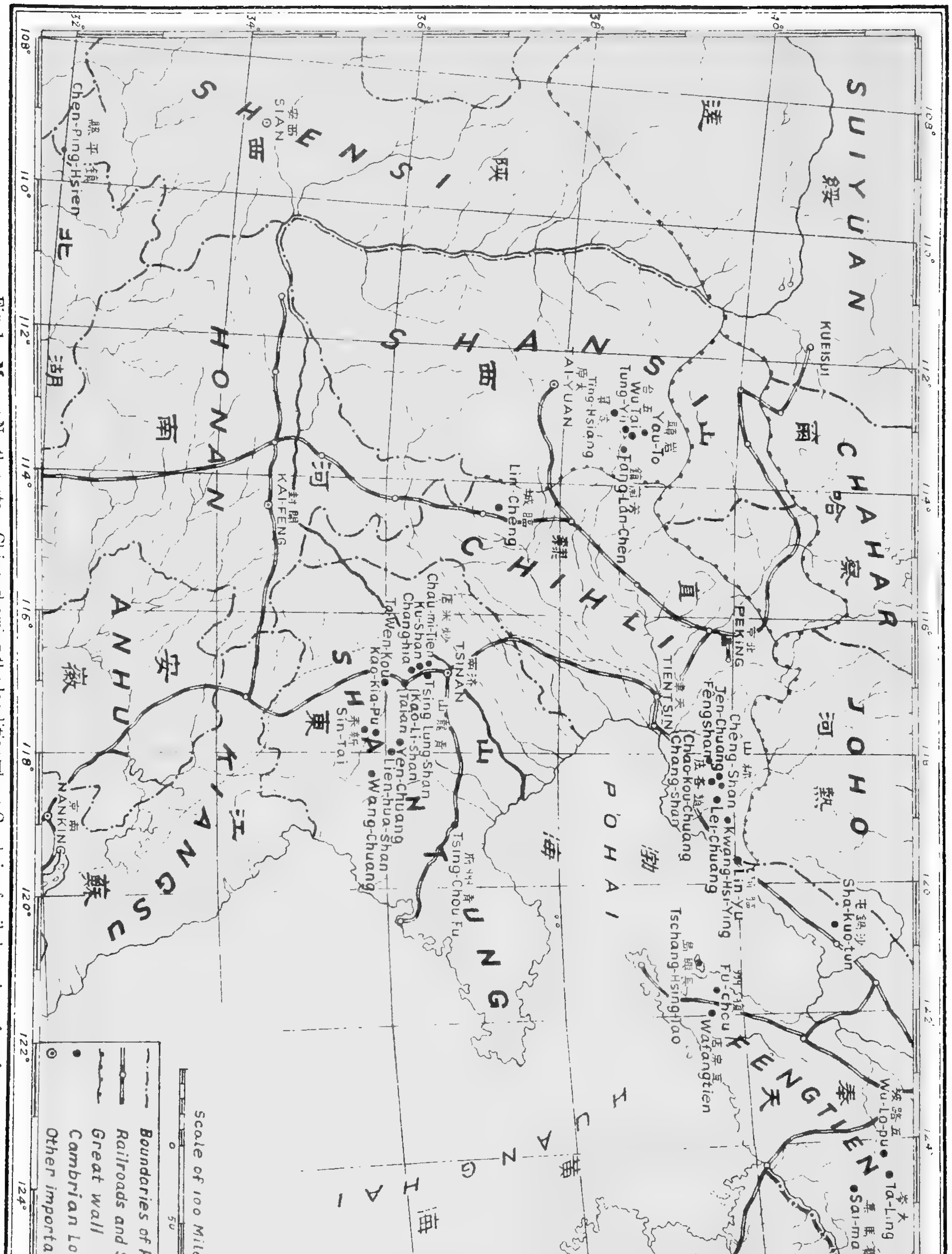


Fig. 1. Map of North-eastern China, showing the localities where Cambrian fossils have been found (see the list on the preceding page)

EXPLANATION OF

PLATE I

PLATE I.

Cambrian Brachiopoda etc. from North China. Drawings by K. C. Liu (劉光誠)

Fig. 1. *Clonograptus? cambria* Sun .... p. 15

1 one stripe × 3

Upper Cambrian, Kaolishan limestone, Kao-Li-Shan, Tai-An, Shantung (Coll. K. W. Hsu. Holotype, G. S. Ch. Cat. No. 629).

Fig. 2. *Climactichnites mathieui* Sun .... p. 16

2 an impression of the trails on the under side of the rock, showing the character in relief.

Lower Cambrian, Manto shale, Luan-Chou, Chihli (Coll. F. F. Mathieu. Holotype, G. S. Ch. Cat. No. 630).

Fig. 3. *Obolus* (*Westonia*) *leei* Sun .... p. 17

3a exterior of the ventral valve × 3

3b counter-part of the same × 3

3c portion of the surface character 8 times enlarged.

Cambrian, from purple shale of Luan-Chou, Chihli (Coll. F. F. Mathieu. Holotype, G. S. Ch. Cat. No. 631).

Fig. 4. *Obolus mollisonensis* Walcott (?) .... p. 17

4a crushed valve × 4 4b crushed valve of another individual × 4

Early Upper Cambrian, Changshan Shale, Jen-Chuang, Luan-Hsien, Chihli (Coll. A. W. Grabau, F. F. Mathieu, G. S. Ch. Cat. No. 632 a, b).

Fig. 5. *Obolus linyuensis* Sun .... p. 18

5 exterior of ventral valve × 6

Lower Cambrian, Manto Shale, Hung-Shan-T'ou, Lin-Yu-Hsien, Chihli (Coll. University Expedition. Holotype, G. S. Ch. Cat. No. 633).

Fig. 6. *Obolus taianensis* Sun .... p. 19

6a one portion of limestone with several individuals of this species, natural size (Paratypes and Holotype).

6b one valve enlarged × 5. (Holotype).

Upper Cambrian, Kaolishan limestone, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun. Cotype, G. S. Ch. Cat. No. 634).

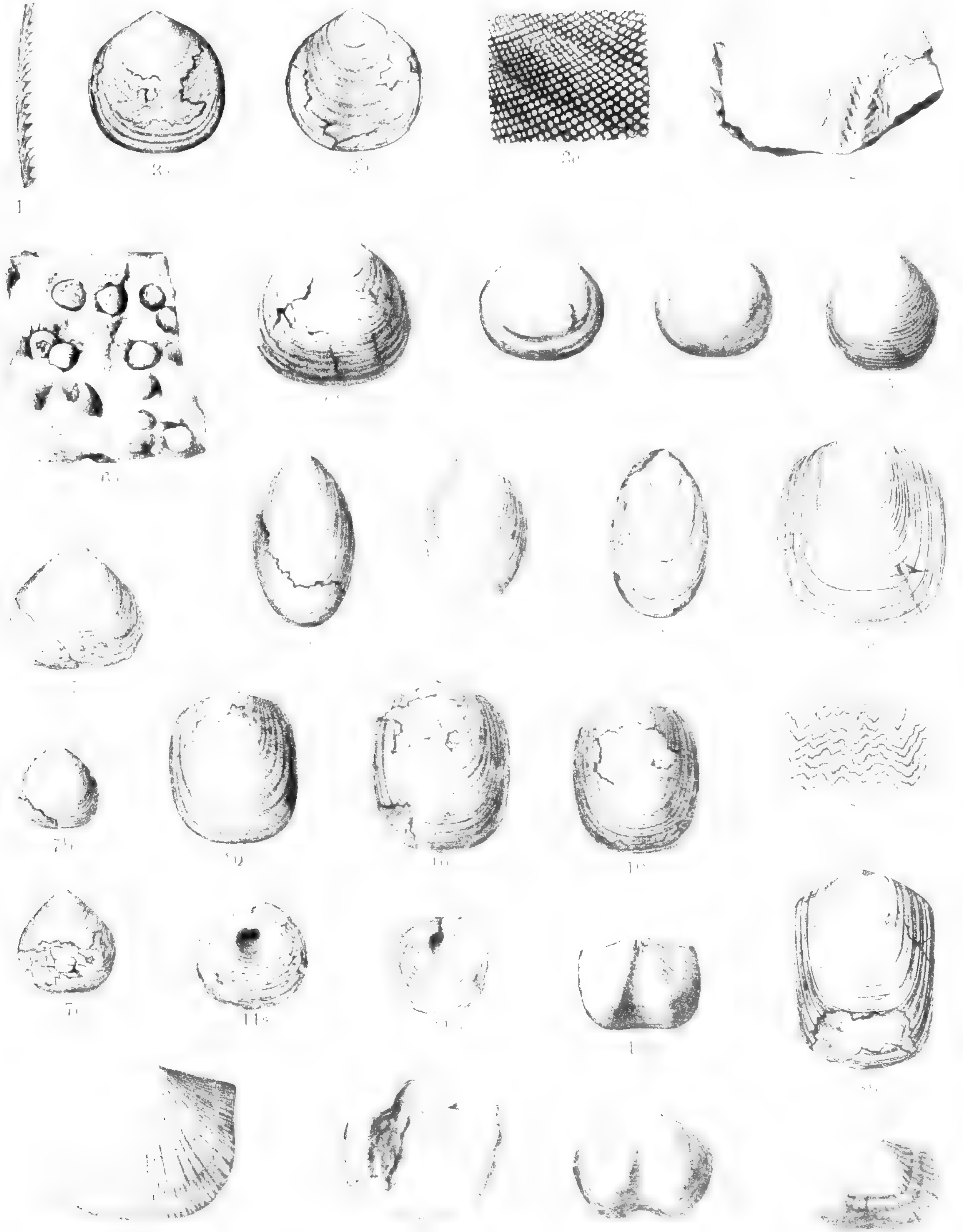
Fig. 7. *Obolus luanhsiensis* Grabau .... p. 19

7a exterior of a ventral valve × 3

7b exterior of another valve × 3

7c exterior of the crushed ventral valve × 3

Upper Cambrian, Fengshan limestone, Yeh-Li, Luan-Hsien, Chihli (Coll. H. C. Tan. Cotypes, G. S. Ch. Cat. Nos. 635, 636, 637).



中國北部寒武紀動物化石　孫雲鑄

Fig. 8. *Lingulella dimorpha* Sun..p. 20

8a exterior of the shell from Luan-Chou × 3 (Holotype).

8b exterior of the shell from Yeh-Li × 3 (Paratype).

8c portion of the shell of Fig. 8a enlarged × 8, showing its undulating growth lines.

Upper Cambrian, from Fêngshan limestone (Coll. F. F. Mathieu and Y. C. Sun. G. S. Ch. Cat. Nos. 638, 639.).

Fig. 9. *Lingulella liui* Sun..p. 21

9a exterior of a ventral? valve × 6; 9b exterior of a dorsal? valve × 6

9c exterior of another ventral? valve × 6

Cambrian from purple shale of Luan-Chou, Chihli (Coll. F. F Mathieu. Cotypes, G. S. Ch. Cat. Nos. 640, 641, 642.).

Fig. 10. *Lingulella kayseri* Grabau..p. 22

10a exterior of a characteristic shell × 3

10b exterior of a slightly larger shell × 3

10c exterior of an imperfect shell × 3

Upper Cambrian, Fêngshan limestone, Yeh-Li, Chihli (Coll. H. C. T'an. Cotypes, G. S. Ch. Cat. Nos. 643, 644, 645.).

Fig. 11. *Acrothele cheni* Sun..p. 23

11a external mold of a crushed valve × 2

11b an imperfect crushed valve × 2 (the figure is drawn somewhat too narrow).

Late Lower Cambrian, from Manto Shale, Chêng-Shan, Luan-Hsien, Chihli (Coll. S. Chen. Cotypes G. S. Ch. Cat. Nos. 646, 647.).

Fig. 12. *Nissusia hayasakai* Sun..p. 23

12 exterior of the brachial valve × 3

Middle Cambrian, from Changhia limestone, Chêng-Shan, Luan-Hsien, Chihli (Coll. K. S. Hsu. Holotype, G. S. Ch. Cat. No. 648).

Fig. 13. *Eoorthis shakuotunensis* Sun..p. 24

13a exterior of a pedicle valve × $2\frac{1}{2}$

13b interior of another pedicle valve × 2

Upper Cambrian, from Shakuotun limestone, Chin-Hsi-Hsien, Fêngtien (Coll. J. G. Andersson. Cotypes, G. S. Ch. Cat. Nos. 649, 650.).

Fig. 14. *Syntrophia orthia* Walcott..p. 25

14a exterior of the pedicle valve × 5

14b interior of the pedicle valve × 3

Upper Cambrian, Kaolishan limestone, Kao-Li-Shan, Tai-An, Shan-Tung (Coll. Y. C. Sun. Plesiotypes G. S. Ch. Cat. Nos. 651, 652.).

EXPLANATION OF

PLATE II

PLATE II.

Cambrian Trilobites from North China. Drawings by K. C. Liu (劉光誠)

Fig. 1. *Agnostus cyclopygeformis* Sun...p. 26

1a cephalon × 4	1b cephalon × 4
1c ,, × 4	1d ,, × 7
1e pygidium × 3	1f pygidium × 5
1g ,, × 5	1h ,, × 5

Upper Cambrian, Kaolishan formation, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun. Cotypes, G. S. Ch. Cat. Nos. 501, 502, 503, 504, 507, 508, 509, 510.).

Fig. 2. *Agnostus hoi* Sun..p. 28

2a-b cephala × 8

2c-d pygidia × 6, Upper Cambrian, Changshan formation, Jên-Chuang, Luan-Hsien, Chihli (Coll. A. W. Grabau, F. F. Mathieu and Y. C. Sun. Cotypes, G. S. Ch. Cat. Nos. 513, 514, 515, 516.).

Fig. 3. *Dorypyge richthofeni* Dames...p. 29

3a cranidium of granulated surface × 2

3b cranidium of granulated surface × $1\frac{1}{2}$

3c pygidium with very cylindrical axis × 2

3d pygidium with very cylindrical axis × 3

Middle Cambrian, Changhia limestone, Chêng-Shan, Chao-Kou-Chuang, Chihli (Coll. K. S. Hsu 徐光熙 G. S. Ch. Cat. Nos. 517, 518, 519, 520.).

Fig. 4. *Teinistion subconica* Sun...p. 31

4 fragmentary cranidium × 7

Middle Cambrian, Kushan formation, Lin-Cheng, Chihli (Coll. Y. T. Chao & C. C. Tien. Holotype, G. S. Ch. Cat. No. 521.).

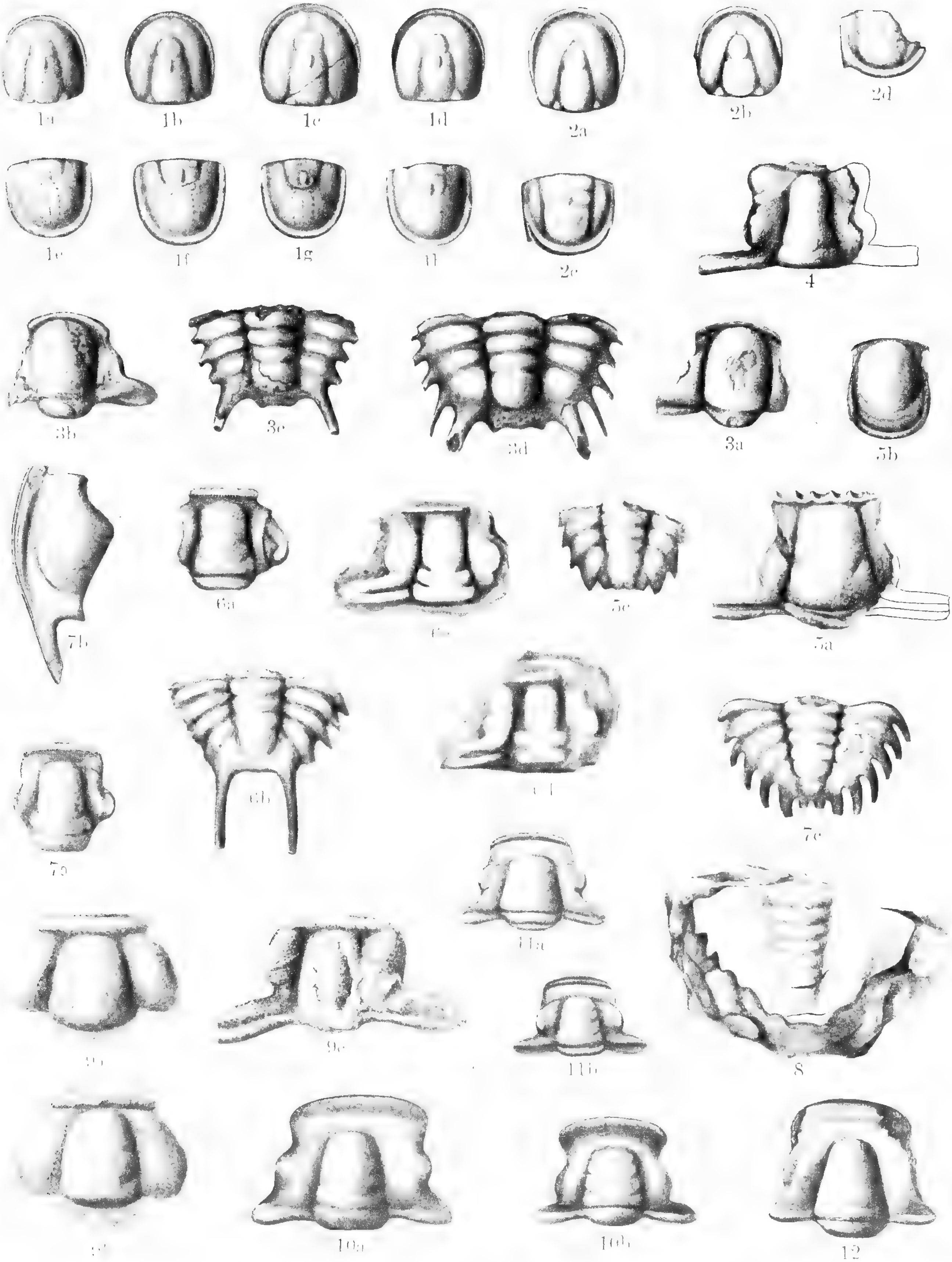
Fig. 5. *Stephanocare richthofeni* Monke..p. 32

5a cranidium × 3

5b associated hypostoma × 5

5c small pygidium × 5

Middle Cambrian, Kushan formation, Lin-Cheng, Chihli (Coll. Y. T. Chao & C. C. Tien, G. S. Ch. Cat. No. 522.).



中國北部寒武紀動物化石　孫　雲　鑄

Fig. 6. *Blackwelderia sinensis* var. *linchengensis* Sun................ ....p. 33

6a fragmentary cranidium × 2

6b associated pygidium probably of this species × 3

6c cranidium × 2 6d cranidium × 2

Middle Cambrian, Kushan formation, Lin-Cheng, Chihli (Coll. Y. T. Chao & C. C. Tien. Cotypes, G. S. Ch. Cat. Nos. 523 a-b 524, 525).

Fig. 7. *Blackwelderia tieni* Sun. ....p. 36

7a fragmentary cranidium × 2

7b associated free cheek × 2

7c associated pygidium × 2

Middle Cambrian, Kushan formation, Lin-Cheng, Chihli (Holotype G. S. Ch. Cat. No. 526.).

Fig. 8. *Blackwelderia gigas* Sun... p. 37

8a large pygidium, natural size.

Late Middle Cambrian, Kushan formation, Ku-Shan, Shantung. (Coll. C. C. Tien & Y. T. Chao. Holotype, G. S. Ch. Cat. No. 527.).

Fig. 9. *Damesella blackwelderi* var. *minor* Sun........ ....p. 38

9a cranidium × 4 9b cranidium × 6

Middle Cambrian, Changhia limestone, Chêng-Shan, Chihli (Coll. K. S. Hsu. Cotypes G. S. Ch. Cat. Nos. 528, 529.).

9c (*D. blackwelderi*) Natural size, for comparison, Kushan formation of Shantung. Cat. No. 530.)

Fig. 10. *Ptychoparia fongi* Sun..p. 40

10a cranidium × 3 10b cranidium × 3

Late Lower Cambrian, Manto formation, Chêng-Shan, Chihli (Coll. Y. C. Sun & S. S. Yoh. Cotypes, G. S. Ch. Cat. Nos. 531, 532.).

Fig. 11. *Ptychoparia leichuangensis* Sun..p. 41

11a cranidium × 10 11b cranidium × 8

Late Lower Cambrian, Manto Shale, Lei-Chuang, Luan-Chou (Coll. F. F. Mathieu. Cotypes, G. S. Ch. Cat. No. 533, 534.).

Fig. 12. *Ptychoparia yohi* Sun..p. 42

12 cranidium × 3

Late Lower Cambrian, Manto Shale, Chêng-Shan, Chao-Kou-Chuang, Chihli (Coll. Y. C. Sun. Holotype, G. S. Ch. Cat. No. 535.).

EXPLANATION OF

PLATE III

PLATE III.

Cambrian Trilobites from North China. Drawings by K. C. Liu (劉光誠)

Fig. 1. *Ptychoparia (Emmerichella) chengshanensis* Sun................................p. 43

1a cranidium × 4 1b cranidium × 8

Late Lower Cambrian, Manto shale, Chêng-Shan, Chao-Kou-Chuang, Chihli (Coll. Y. C. Sun. Cotypes G. S. Ch. Cat. Nos. 536, 537.).

Fig. 2. *Changshania conica* Sun.......... ....p. 45

2a cranidium × 2 2b cranidium × 3

2c cranidium × 3 2d cranidium × 3

2e hypostoma × 3 2f pygidium × 4

2g pygidium × 4 2h pygidium × 3

2i pygidium × 3 2j free cheek × 2

2k free cheek × 2

Early Upper Cambrian, Changshan Shale, Jên-Chuang, Chao-Kou-Chuang, Chihli (Coll. A. W. Grabau. F. F. Mathieu & Y. C. Sun. Cotypes, G. S. Ch. Cat. Nos. 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548.).

Fig. 3. *Changshania? truncata* Sun..p. 46

3 cranidium × 3

Early Upper Cambrian, Changshan shale, Jên-Chuang, Chao-Kou-Chuang, Chihli (Coll. A. W. Grabau. Holotype, G. S. Ch. Cat. No. 549.).

Fig. 4. *Conokephalina kaipingensis* Sun...p. 47

4a cranidium × 3

4b one fragmentary segment of thorax × 3

Late Lower Cambrian, Manto shale, Chêng-Shan, Chao-Kou-Chuang, Chihli (Coll. H. T. Yu. Holotypes, G. S. Ch. Cat. Nos. 550, 551.).

Fig. 5. *Conokephalina gerardi* Sun...p. 48

5a fragmentary cranidium × 3 (Paratype)

5b cranidium × 2 (Holotype)

5c fragmentary cranidium × 2 (Paratype)

Late lower cambrian, Manto shale, Chêng-Shan, Chao-Kuo-Chuang, Chihli (Coll. H. T. Yu, 余新都 G. S. Ch. Cat. Nos. 552, 553, 554.).

Fig. 6. *Crepicephalus sp.*...p. 49

6 pygidium × 4.

Middle Cambrian, Changhia limestone, Chêng-Shan, Chao-Kou-Chuang, Chihli (Coll. K. S. Hsu, G. S. Ch. Cat No. 555.).

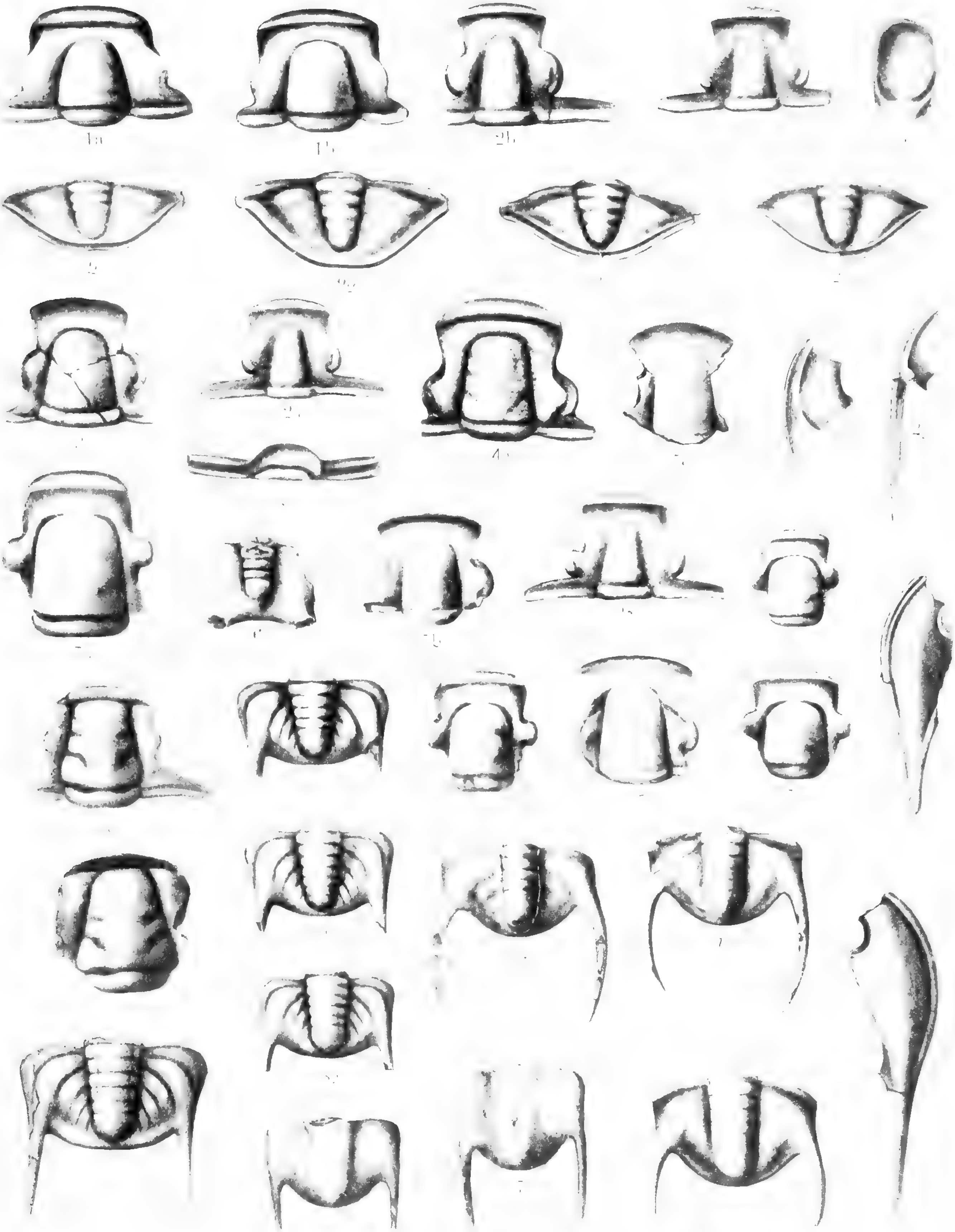


Fig. 7. *Mansuyia orientalis* (Grabau) Sun..p. 50

7a cranidium × 2 — 7b cranidium × 2

7c cranidium × 2 — 7d cranidium × 2

7f pygidium × 2 — 7g pygidium × 2

7h pygidium × 2

Late Upper Cambrian, Kaolishan formation, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun. Cotypes G. S. Ch. Cat. Nos. 556, 557, 558, 559, 560, 561, 562.).

7i weathered pygidium × 2

7j weathered pygidium × 2

Late Upper Cambrian, Fêngshan limestone, Yeh-li, Ma-Chia-Kou, Chihli (Coll. H. C. T'an. Types of *Ceratopyge orientalis* Grabau. G. S. Ch. Cat. Nos. 563, 564.).

Fig. 8. *Kaolishania pustulosa* Sun..p. 53

8a cranidium × 2 — 8b fragmentary cranidium × 2

8c free cheek × 2 — 8d free cheek × 2

8e pygidium × 2 — 8f pygidium × 2

8g pygidium × 2 — 8h pygidium × 2

Upper Cambrian, Kaolishan limestone, Kao-Li-Shan, Tai-an, Shan-Tung (Coll. Y. C. Sun & Class 1923, N. U. P. Cotypes, G. S. Ch. Cat. Nos. 565, 566, 567, 568, 569, 570, 571, 572.).

EXPLANATION OF

PLATE IV

PLATE IV

Cambrian Trilobites from North China. Drawings by K. C. Liu (劉光誠)

Fig. 1. *Lisania? hsuchiachuangensis* Sun.....p. 54

1a cranidium × 3 1b cranidium × 5

Middle Cambrian, Changhia limestone, Chêng-Shan, Chao-Kou-Chuang, Chihli (Coll. K. S. Hsu. Cotypes G. S. Ch. Cat. Nos. 573, 574.).

Fig. 2. *Lisania rectangularis* Sun.....p. 55

2a cranidium × 6 2b cranidium × 6

Middle Cambrian, Changhia limestone, Chêng-Shan, Chao-Kuo-Chuang, Chihli (Coll. K. S. Hsu. Cotypes G. S. Ch. Cat. Nos. 575, 576).

Fig. 3. *Solenopleura nodosa* Sun.....p. 56

3a cranidium × 2 (Holotype) 3b cranidium × 3 (Paratype)

Middle Cambrian, Changhia limestone, Chao-Kou-Chuang, Luan-Hsien, Chihli (Coll. C. C. Yu 俞建章, G. S. Ch. Cat. Nos. 577, 578.).

Fig. 4. *Chuangia batia* Walcott.....p. 58

4a cranidium × 2 4b cranidium × 3 4c cranidium × 3

4d cranidium × 3 4e hypostoma × 2

Upper Cambrian, Kaolishan formation, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun and class 1923 of N. U. P. Cat. Nos. 579, 580, 581, 582, 583.).

Fig. 5. *Changia chinensis* Sun.....p. 60

5a cranidium, natural size 5b cranidium × 2 5c cranidium × 2

5d free cheeks, natural size 5e free cheeks, natural size

5f free cheeks × 2 5g fragmentary pygidium, natural size.

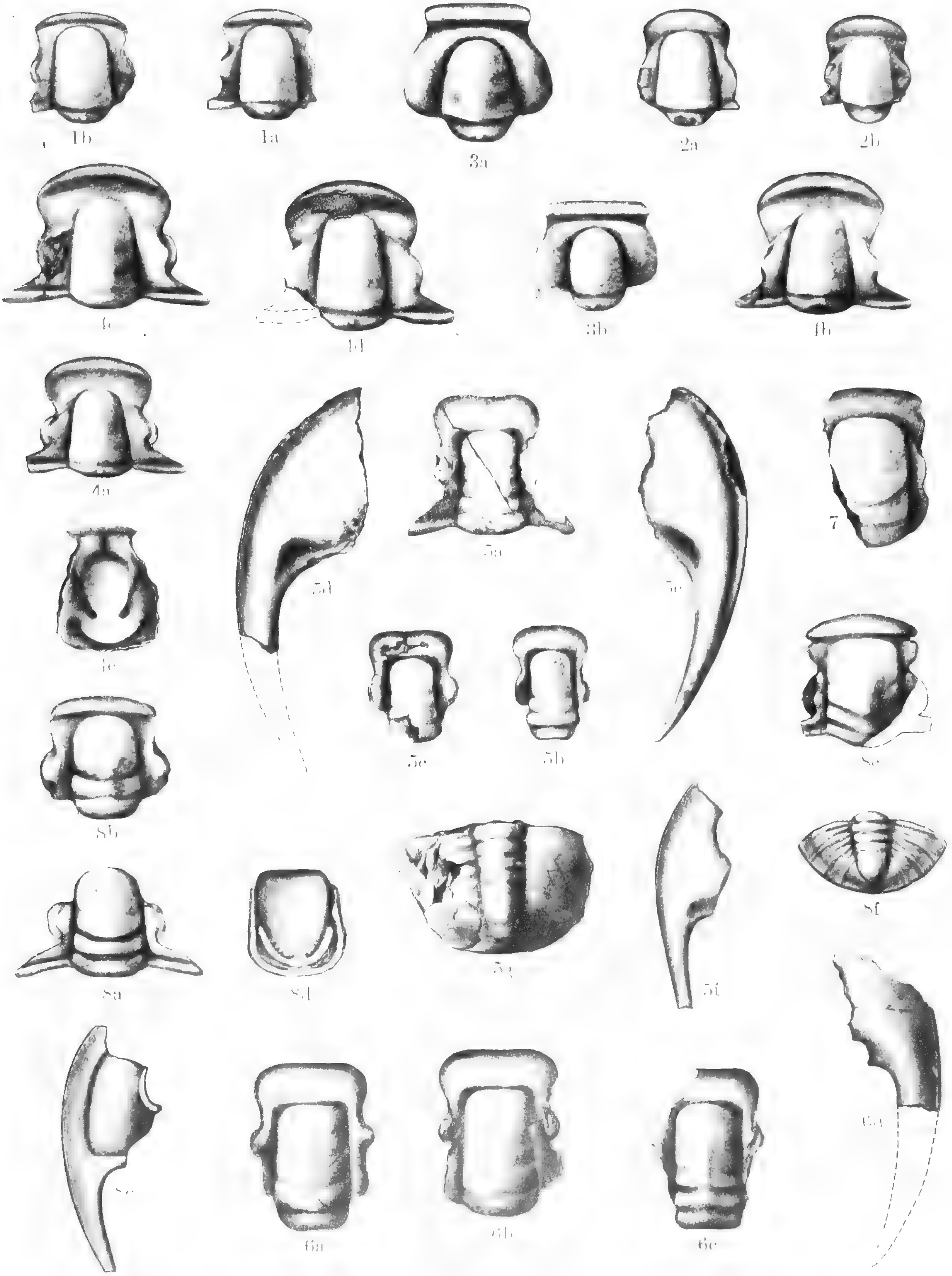
Upper Cambrian, from upper limestone of Chau-Mi-Tien, Shantung (Coll. Chass 1923 of N. U. P.. Cotypes. G. S. Ch. Cat. Nos. 584, 585, 586, 587, 588, 589, 590.).

Fig. 6. *Quadraticephalus walcotti* Sun.....p. 63

6a cranidium × 2 6b cranidium × 2

6c cranidium × 2 6d associated cheek, natural size.

Uppermost Cambrian, Kaolishan formation, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun. Cotypes, G. S. Ch. Cat. Nos. 591, 592, 593, 594.).



中國北部寒武紀動物化石 孫 雲 鑄

Fig. 7. *Quadraticephalus? convexus* Sun ....p. 63

7 fragmentary cranidium × 2

Uppermost Cambrian, Kaolishan formation, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun. Holotype, G. S. Ch. Cat. No. 595.).

Fig. 8. *Ptychaspis chinhsiensis* Sun ....p. 64

8a broken cranidium × 3

8b broken cranidium × 2

8c broken cranidium × $1\frac{1}{2}$

8d associated hypostoma × 3

8e associated free cheek × 3

8f associated pygidium × 3

Upper Cambrian, Shakuotun limestone, Sha-Kuo-Tun, Chin-Hsi-Hsien, Fêngtien (Coll. J. G. Andersson. Cotypes G. S. Ch. Cat. Nos. 596, 597, 598, 599, 600, 601.).

EXPLANATION OF

PLATE V

PLATE V.

Cambrian Trilobites from North China. Drawings by K. C. Liu (劉光誠)

Fig. 1. *Ptychaspis angulata* var. *chinensis* Sun...p. 67

1a cranidium × 3 1b cranidium × 3

Uppermost Cambrian, Kaolishan formation, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun. Cotypes, G. S. Ch. Cat. Nos. 602, 603.).

Fig. 2. *Ptychaspis walcotti* Mansuy...p. 68

2 weathered cranidium × 2

Upper Cambrian, Shakuotun limestone, Sha-Kuo-Tun Chin-Hsi-Hsien, Fêngtien (G. S. Ch. Cat. No. 604. Collected by Dr. J. G. Andersson).

Fig. 3. *Ptychaspis subglobosa* Grabau...p. 72

3a weathered cranidium, natural size (Holotype).

Upper Cambrian from Fêngshan limestone, Yeh-Li, Chihli (Coll. H. C. T'an, G. S. Ch. Cat. No. 605.).

3b cranidium × 1½ 3c cranidium × 3 3d cranidium × 3

Upper Cambrian, Kaolishan formation, Kao-Li-Shan, Tai-An, Chihli (Coll. Y. C. Sun, Plesiotypes G. S. Ch. Cat. Nos. 606, 607, 608.).

Fig. 4. *Ptychaspis suni* Grabau...p. 75

4a crushed cranidium × 2 4b associated free cheek × 3

Uper Cambrian, Fêngshan formation, Fêng-Shan, Yeh-Li, Chihli (Coll. H. C. T'an, Holotype G. S. Ch. Cat. Nos. 609.).

Fig. 5. *Ptychaspis acamus* var. *punctata* Sun...p. 76

5a crushed cranidium × 2 5b crushed cranidium × 2

5c crushed cranidium × 2 5d crushed cranidium × 2

Upper Cambrian, from the Upper limestone of Chau-Mi-Tien, Shantung (Coll. National University Excursion. Cotypes, G. S. Ch. Cat. Nos. 610, 611, 612, 613, 614.).

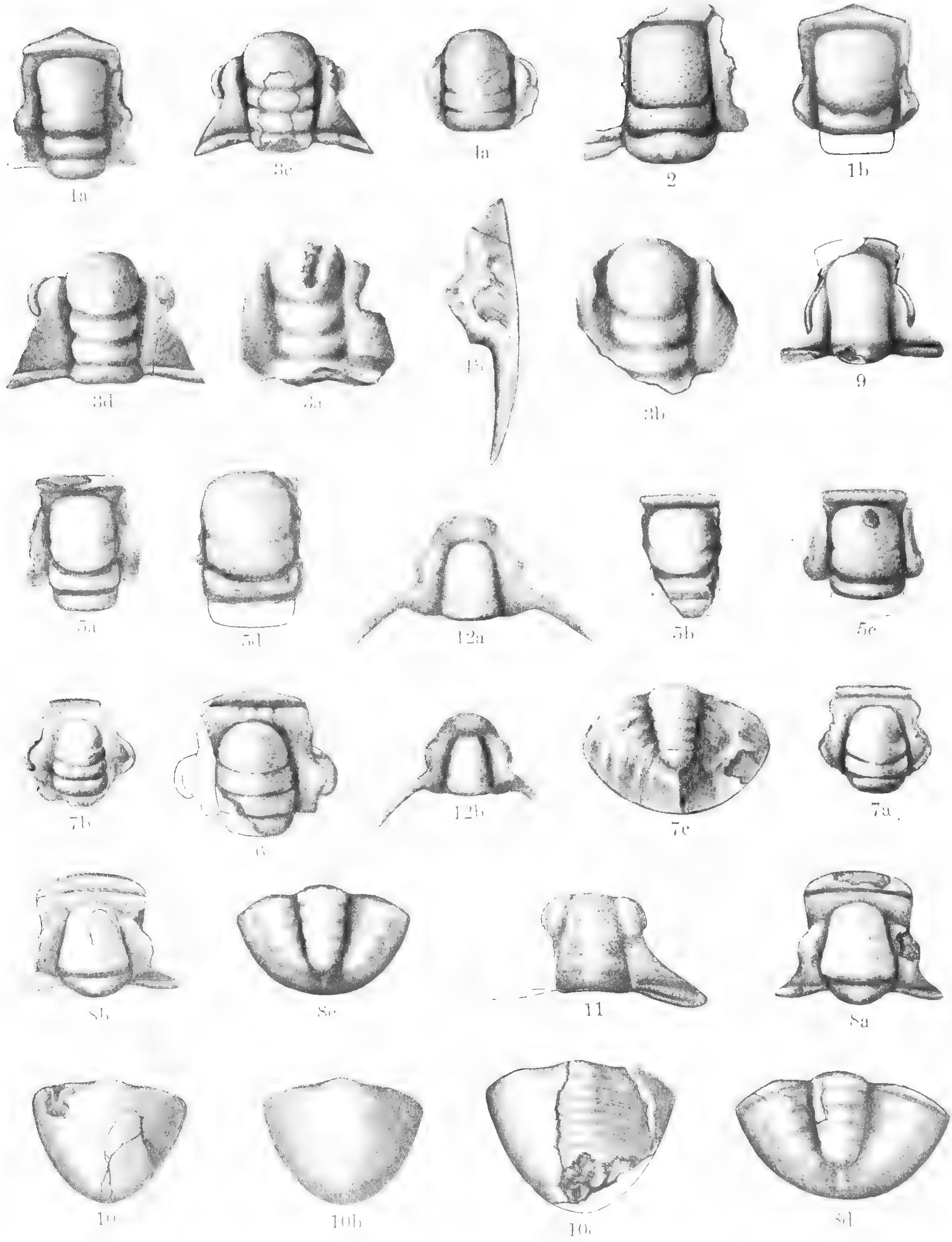
Fig. 6. *Ptychaspis (Anderssonia) tani* Sun...p. 79

6 cranidium × 5

Upper Cambrian, from the highest zone of Chau-Mi-Tien. (Collected by National University Excursion. Holotype, G. S. Ch. Cat. No. 615.).

Fig. 7. *Ptychaspis (Anderssonia) fêngtienensis* Sun...p. 78

7a cranidium × 4 7b cranidium × 3 7c associated pygidium × 6



中國北部寒武紀動物化石　孫　雲　鑄

Upper Cambrian, Shakuotun limestone, Sha-Kuo-Tun, Chin-Hsi-Hsien, Fêngtien (Coll. J. G. Andersson. Cotypes, G. S. Ch. Cat. Nos. 616, 617, 618.).

Fig. 8. *Anomocare flava* Walcott..p. 80

8a cranidium × 4 8b cranidium × 4

8c pygidium × 4 8d pygidium × 4

Middle Cambrian, Changhia limestone, Chêng-Shan, Chao-Kuo-Chuang, Chihli (Coll. K. S. Hsu. G. S. Ch. Cat. Nos. 619, 620, 621, 622.).

Fig. 9. *Dolichometopus deois* Walcott..p. 81

9. cranidium × 2

Middle Cambrian, Changhia limestone, Kwang-Hsi-Ying 關西營 Luan-Chou, Chihli (Coll. J. G. Andersson, G. S.Ch. Cat. No. 623.).

Fig. 10. *Illænurus pagoda* Sun..p. 82

10a pygidium × 3 10b pygidium × 3 10c pygidium × 3

Upper Cambrian, Kaolishan formation, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun. Cotypes G. S. Ch. Cat. Nos. 624, 525, 626.).

Fig. 11. *Taianocephalus grabui* Sun..p. 84

11 cranidium × $1\frac{1}{2}$

Upper Cambrian, Kaolishan limestone, Kao-Li-Shan, Tai-An, Shantung (Coll. Y. C. Sun. Holotype, G. S. Ch. Cat. No. 627.).

Fig. 12. *Wongia triangulata* Sun..p. 85

12a cranidium × 7 (Holotype, G. S. Ch. Cat. No. 628a).

12b associated cranidium × 8 (Paratype, G. S. Ch. Cat. No. 628b).

Late middle Cambrian, Kushan formation, Lin-Cheng, Chihli (Coll. Y. T. Chao and C. C. Tien.).

ERRATA.

Page 8 line 34 for Dolinometopus read Dolichometopus
Page 12 line 4 for Brachipoda read Brachiopoda
Page 12 line 7 add side heading Trilobita
Page 13 line 24 add (Anderssonia) after Ptychaspis
Page 14 line 24 for chinhsihsiensis read chinhsiensis
Page 16 line 21 for 8 read 5
Page 23 line 23 for middle read Lower
Page 23 line 23 for Changshan read Manto
Page 27 line 5 for furrow read furrows
Page 27 line 29-31 for length read width
Page 33 line 8 for deviding read dividing
Page 37 line 19 for length read width
Page 44 line 32 for two-third read two-thirds
Page 48 line 25 for Shantung read Chihli
Page 49 line 19 for 6a, 6b, 6c, read 5a, 5b, 5c.
Page 50 line 19 add (sp.nov.) after sun
Page 56 line 11 for wider read narrower
Page 57 line 28 for dupwar read downward
Page 59 line 24 for palpebra read palpebral
Page 68 line 32 for 2a read 2
Page 74 line 9 for Koail read Kaoli
Page 82 line 20 for pecies read species
Page 82 line 21 for snew read new
Page 84 line 9 for one read two
Page 92 line 8 add natural nize after relief

奉天	錦西	沙鍋屯灰岩				
		長山系				
直隸	開灤	鳳山層	長山層	崮山層	張夏層	饅頭層
		九龍系				
山東	張夏	直角石層	炒米店層	崮山層	張夏層	饅頭層
	泰安	高里層	炒米店層	崮山層		饅頭層
			上寒武紀	中寒武紀		下寒武紀

自上述地層及化石觀之、中寒武紀地層多爲鮞狀灰岩、上寒武紀岩層漸變爲頁岩礫狀灰岩及竹葉狀灰岩、蓋中國中寒武海本屬深海、至上寒武紀則由深而淺、又下寒武海之 Redlichia 屬爲我國及印度特產、從未發見於歐美、可證當時海洋與太平洋及大西洋完全隔斷、至寒武中上兩紀、海洋似漸與美洲西部及大西洋相通、然我國多數寒武紀各屬及各種化石、究與歐美異、

7. Stephanocare richthofeni Monke

8. Damesella sp.

9. Blackwelderia sp.

奉天省

僅寒武紀上部發見於奉天錦西縣沙鍋屯、化石爲安特生博士所採集、岩層風化過甚、種名頗不易定、可鑒定者列下、

三葉虫

1. Ptychaspis walcotti Mansuy

2. Ptychaspis acamus Walcott

3. Ptychaspis chinhsiensis Sun (新種)

4. Ptychaspis (Anderssonia) fengtienensis Sun (新屬新種)

5 Agnostus sp.

腕足類

6. Eoorthis shakuotunensis Sun (新種)

1 爲安南上寒武紀特產化石、3 4 均爲新種、考其地層似與直隸之鳳山層相當、

以上所述中國北部寒武系可總列爲表如次、

3. Orthoceras nanshanensis Sun

上列兩種將於古生物誌專論之

三葉虫

4. Changia chinensis Sun （新屬新種）

5. Ptychaspis acamus var. punctata Sun （新族）

6. Ptychaspis (Anderssonia) tani Sun （新種）

5為上寒武紀標準化石、2 3 兩種似屬奥陶紀、4 6 均新屬及新種、余以此層產 Ptychaspis acamus、似屬上寒武紀上部而與鳳山層相當、

丙・大汶口 此處距泰安城南五十里、產蝙蝠石、（俗又稱燕子石）最著名、去年余領北大同學實習於此、並採集下列各化石、然均非新種、亦未列入此誌、

1. Drepanura premesnili Bergeron

2. Drepanura kettleri Monke

3. Agnostus douvilli Bergeron

4. Liostracina krausi Monke

5. Shantungia spinifera Walcott

6. Agnostus kushanensis Walcott

11. Quadraticephalus? convexus Sun (新屬新種)

12. Quadraticephalus walcotti Sun (新屬新種)

華可脫氏定高里山地層爲炒米店層下部、余以此層多爲頁岩及礫狀灰岩組成、迥異炒米店層、層位極高、應另屬一新層、名曰高里層、或高里山層、

Mansuyia orientalis (Grabau) Sun 及 Ptychaspis subglobosa Grabau 二種爲鳳山層之特產、亦爲此層之標準化石、可知鳳山層與高里層實同屬一層已無疑義、

Ptychaspis angulata 曾發見於安南東京上寒武紀之最上層、高里山亦產此種、可知此處地層與安南產此種化石之岩層相當、

Quadraticephalus 新屬隸 Dikelocephalinae 科、盛產北美上寒武紀、中國尚少發見、

又從前地質研究所仝人旅行至此曾得筆石一、茲定爲 Clonograptus? cambria、是屬產歐美寒武奧陶過渡層中、中國寒武紀地層從未發見、今於高里山中發現一種、足證此層去奧陶紀地層不遠、

乙・炒米店南山　炒米店爲炒米店層主產地、余於炒米店南山頂部發見一新層、產下列化石、

腕足類

1. Billingsella sp.

頭足類

2. Loxoceras cambria Sun

3. Kaolishania pustulosa Sun (新屬新種)

4. Mansuyia orientalis (Grabau) Sun (新屬新種)

5. Taianocephalus grabaui Sun (新屬新種)

6. Chuangia batia Walcott

第二層(距第一層高八尺)

腕足類

7. Obolus taianensis Sun (新種)

三葉虫

8. Ptychaspis subglobosa Grabau (新種)

第三層(距第二層高八尺)

三葉虫

8. Ptychaspis subglobosa (Grabau) Sun (新種)

9. Illaenurus pagoda Sun (新種)

最上層(距第三層約高三十七尺)

三葉虫

10. Ptychaspis angulata var. chinensis Sun (新族)

三葉虫

2. Wongia triangulata Sun (新屬新種)

3. Blackwelderia tieni Sun (新種)

4. Stephanocare richthofeni Monke

5. Blackwelderia sinensis var. linchengensis Sun (新族)

6. Tienistion subconica Sun (新種)

4 5 爲崮山期之特產、3 6 爲新種、2 爲新屬 Wongia 隸前頰類、爲中國之特產、

山東省

甲・高里山　高里山距泰安城西僅兩里、岩層每爲灰岩礫狀灰岩及頁岩、間有竹葉狀灰岩及鮞狀灰岩、下部極少發見化石、且夾有竹葉狀灰岩、或屬炒米店層之一部、上部多爲礫狀灰岩頁岩及灰岩、全部厚度約一百五十尺、化石層位有四、自下而上列之如左、

最下層

腕足類

1. Syntrophia orthia Walcott

三葉虫

2. Agnostus cyclopygeformis Sun (新種)

上列新動物羣中之 Mansuyia orientalis (Grabau) Sun 及 Ptychaspis subglobosa Grabau 兩種、均爲鳳山之特產、亦發見於高里山、又兩處產此同種化石之岩層均爲礫狀灰岩、是其地層時代同隸上寒武紀上部實無疑義、他種 Ptychaspis 及 Illænurus 屬、兩處均同產之、

乙、臨城　臨城地層層序如次、(見趙亞曾田奇㻙直隸臨城地層報告)

上部層系　下奧陶紀

平行不整一層

中寒武系

崮山層	五十至一百尺
張夏灰岩	七百至八百尺

下寒武系

饅頭層	二百至三百尺

平行不整一層

下部層系　前寒武系

僅崮山層發現化石、產下列各種、

腕足類

1. Obolus linchengensis Sun (新種)

2. Eoorthis sp.

三葉虫

3. Changshania conica Sun（新屬新種）

4. Changshania? truncata Sun（新種）

5. Agnostus hoi Sun（新種）

鳳山層　此層爲頁岩及薄層灰岩組成、代表上寒武紀之最上部、以治里村附近鳳山爲最發達、故名鳳山層、此層上與奧陶紀岩層間之間斷極顯、產下列化石、

腕足類

1. Obolus luanhsiensis Grabau（新種）

2. Lingulella kayseri Grabau（新種）

三葉虫

3. Ptychaspis subglobosa Grabau（新種）

4. Ptychaspis suni Grabau（新種）

5. Mansuyia orientalis (Grabau) Sun（新屬新種）

6. Illaenurus sp.

7. Anomocare sp.

三葉虫

2. Solenopleura nodosa Sun (新種)

3. Anomocare flava Walcott

4. Lisania rectangularis Sun (新種)

5. Lisania? hsuchiachuangensis Sun (新種)

6. Damesella blackwelderi var. minor Sun (新種)

7. Dorypyge richthofeni Dames

8. Dolichometopus deois Walcott

9. Crepicephalus sp.

崮山頁岩　或有一部代表此層、惜未發見化石、終難證明、

長山層　此層爲紅紫色頁岩、常夾竹葉狀灰岩七八層、紅頁岩頗似饅頭層、惟化石迥異、且竹葉狀灰岩爲長山層之特徵、化石又多屬新種、顯係新層、考其層位當屬上寒武紀下部、或中寒武紀最上層？余以此層、含有竹葉狀灰岩及 Eoorthis 等化石、暫定此層爲上寒武紀下層、趙各莊北任莊產化石最富、種類列下、

腕足類

1. Obolus mollisonensis? Walcott

饅頭層　此層爲寒武系之最下層、多爲頁岩、呈紫紅色或綠色、常夾有砂質灰岩、灤州及趙各莊均有此層露頭、稱山產下列各種化石、

腕足類

1. Acrothele cheni Sun（新種）
2. Lingulella machuriensis? Walcott
3. Obolus sp.

三葉虫

4. Conokephalina gerardi Sun（新種）
5. Conokephalina kaipingensis Sun（新種）
6. Ptychoparia (Emmrichella) chêngshanensis Sun（新種）
7. Ptychoparia sp.
8. Ptychoparia yohi（新種）
9. Ptychoparia fongi Sun（新種）

張夏灰岩　此層爲鲕狀灰岩及堅質灰岩之互層、趙各莊東北稱山北坡產下列化石、

腕足類

1. Nissusia hayasakai Sun（新種）

茲復分省詳述如下

直隸省

甲・開平　開平盆地之寒武系、以灤州趙各莊鳳山稱山等處爲發達、岩層自上而下可分之如次、

奧陶系

　冶里灰岩

　　平行不整一層

上寒武系

五、鳳山層　二百至三百尺

四、長山層　一百五十至二百尺

中寒武系

三、崮山層(一部)　○至五十尺

二、張夏層　三百至四百尺

下寒武系

一、饅頭層　四百至五百尺

震旦系

　黑灰岩

地層概論

中國北部之寒武系、分佈於直隸山東山西陝西奉天等省、岩層性質隨處而異、即以上寒武紀而論、南部（山東）多灰岩、北部（直隸）多頁岩及竹葉狀灰岩、東北部（奉天）張夏層之一部爲頁岩、且產 Dorypyge richthofeni 等種、

中國北部寒武系、照現在研究之結果、自上而下可分之如次、

上部層系　下奧陶系

平行不整一層

寒武系

上寒武系

鳳山層（或高里層）（新增）

炒米店層（維理士初定）

中寒武系

崮山層（仝　上）

張夏層（仝　上）

下寒武系

饅頭層（仝　上）

省寒武紀地層亦分布頗多、而化石所得尚少、深望後有所得再爲續編、至南方寒武紀地層、惟雲南特多、丁文江所長所採化石、余正在研究中、他日續爲發表、

上層（鳳山層）

三葉虫

舊名	今名
Ceratopyge orientalis Grabau	= Mansuyia orientalis (Grabau) Sun
Anomocare punctatus Sun	
Ptychaspis subglobosa Grabau	
Ptychaspis sumi Grabau	
Illaenurus canens Walcott	
Teinistion? sp.	

最近日本青地乙治著大連圖幅地質說明書、論及關東州復州砲台子瓦房店金家城子長興島等處寒武紀化石，種名經鑒定者凡三十八種、（內有一種屬名不能確定六種係與他種比較）均非新種、總之從前華氏等研究中國北部寒武紀動物化石、其標本均採自山東山西及遼東等處、而於直隸各處向未發見、且其時代多屬中寒武及下寒武兩紀、若上寒武紀化石發見尚屬寥寥、近數年來地質調查所於山東奉天直隸各處採集上寒武紀化石甚夥、共得新屬八新種四十一、除 Wongia 一屬屬中寒武紀上期外、餘均屬上寒武紀、由此化石之鑒定、而知于維理氏等所分之張夏崮山炒米店三層外、尚應加入新層、故照現在研究之結果、不特化石種類多所新得、即於地層次序亦應增補、故特先為紀錄以成此篇、此外江蘇（江北）河南等

Ptychaspis sp.

Anomocare leei Sun

一九二三年、余著直隷開平上寒武紀化石、（中國地質學會誌第二卷第一二期）多屬新種、分上下兩層、種名列下、

下層（長山層）

三葉虫

Agnostus hoi Sun

Changshania truncata Sun

Changshania conica Sun

Anomocarella transversa Sun

Anomocare cf. minus Dames

Anomocarella sp.

腕足類

Obolus mollisonensis Walcott

Obolus (Bröggeria) salteri (Hall)

Obolus sp.

Obolella gracilis Lorenz	= cf. Obolus obscurus Walcott
Orthis sp.	
Acrothele sp.	

一九一三年、華可脫著中國北部寒武紀動物化石最爲詳盡、（見 Research in China Vol. III）含下列各類化石、有孔虫類一種、海綿類二種、珊瑚類一種、蠕虫類一種、腕足類三十六種、腹足類十一種、翼足類十一種、頭足類一種、三葉虫一百七十五種及介形類六種、

一九二一年、安特生博士自奉天錦西採集上寒武紀化石多種、由余鑒定、（見 Upper Cambrian Fossils from Fengtien 中國地質學會誌第二卷第一二期）種名列下、

腕足類

Eoorthis shakuotunensis Sun

三葉虫

舊名	今名
Ptychaspis chinhsihsiensis Sun	= Ptychaspis chinhsiensis Sun
Ptychaspis nodosa Sun	= Ptychaspis walcotti Mansuy
Ptychaspis acamus Walcott	
Ptychaspis cf. campe Walcott	

Agnostus fallax Linnarsson = Agnostus chinensis Dames

Agnostus parvifrons latelimbatus Lorenz = Agnostus latelimbatus (Lorenz) Walcott

Acrothele granulata Linnarsson = Acrothele matthewi eryx Walcott

中層

Teinistion (?) sp. = Damesella cf. blackwelderi Walcott

Drepanura (?) sp. = Damesella cf. blackwelderi Walcott

上層

Shantungia buchruckeri Lorenz = Chuangia nitida Walcott

Liostracus latus Lorenz

勞氏於泰安泰山附近採得三葉虫碎片、並定種名爲

舊名	今名
Lioparia blautoeides Lorenz	= Anomocarella baucis Walcott

勞氏又報告山東靑州府產下列各種化石、

舊名	今名
Lioparia latelimbata (Dames) Lorenz	= Anomocare latelimbatum Dames
Shantungia monkei Lorenz	= Pagodia monkei (Lorenz) Walcott

Olenoides (Dorypyge) richthofeni (Dames) Lorenz	= Dorypyge richthofeni Dames, Wal.
Agnostus fallax var. laiwuensis Lorenz	= Agnostus chinensis Dames
A. parvifrons Linnarsson	= A. cf. parvifrons Linnarson
Anomocare commune Lorenz	= Anomocarella chinensis Walcott
Anomocare ovatum Lorenz	= Anomocare temenus Walcott
Alokistocare sp.	
Amphoton steinmanni Lorenz	= Dolichometopus deois Walcott
Ptychoparia (Solenopleura) sp.	= Solenopleura sp.
Hyolithes sp.	
Raphistoma bröggeri Lorenz	= Platyceras willisi Walcott
Acrothele bohemica Barrande	= Acrothele matthewi eryx Wal.

勞氏又謂山東王莊(蒙陰縣附近)化石可分下列三層、

下層

舊名	今名
Anomocare speciosum Lorenz	= Anomocarella speciosa (Lorenz) Wal.
Bathyuriscus asiaticus Lorenz	= Dolichometopus deois Wal.

T. sodeni Monke

Drepanura premesnili Bergeron

D. ketteleri Monke

Stephanocare richthofeni Monke

S. sp?

一九〇四年、羅倫斯 Th. Lorenz 鑒定類似藻類化石兩種、一為 Ascosoma phaneroporata Lorenz、一為 Mitscherlichia chinensis Lorenz、均係新屬且同隸 Ascosomacea 新科、

一九〇五至一九〇六兩年、華可脫 C. D. Walcott 發表中國寒武紀化石論文兩短篇、兼論及美國康迺吉學會調查隊維理士 B. Willis 與勃拉克維達 E. Blackwelder 二氏在華調查之結果、維理士氏等分山東寒武系為饅頭頁岩及九龍灰岩二部份、而九龍灰岩又自下至上分為張夏崮山炒米店三層、歷來言中國寒武系者所倚為不易之標準者也、

一九〇五年、俄德瓦特 H. Woodward 於山東上寒武紀化石三葉虫篇中評論麥根著作、兼論及山東西部及青州府等處三葉虫化石數種、

一九〇六年、勞倫斯 Th. Lorenz 著山東化石誌、所載化石為彼所採集多屬新屬及新種、並謂萊蕪動物羣可代表瑞典 Andrarum 灰岩底部、且與產 Paradoxides davidus 及 P. forschhammeri 岩層同時、種名列下、

舊名　今名

Anomocare majus Dames　(亦曾發見於賽馬集)

Lingulella cfr. nathorsti Linnarsson

此外 Theca, Orthis, Lingulella (兩種) Agnostus, Conocephalites, Crepicephalus 及 ? Remnophourides 等屬種名均不易鑒定、

山東寒武紀化石于一八九九年首經皮正龍 M. Bergeron 研究、並鑒定下列六種、

舊名	今名
Agnostus douvilléi Bergeron	
Olenoides leblanci Bergeron	
Drepanura premesnili Bergeron	
Arthricocephalus chauveaui Bergeron	
Dicellocephalus? sinensis Bergeron	= Stephanocare sinensis (Bergeron) Walcott
Calymene? sinensis Bergeron	= Blackwelderia sinensis (Bergeron) Walcott

一九〇三年、麥克 H. Monke 著山東地質誌、並鑒定下列化石、其時代均屬以後所稱爲崮山期者、

Agnostus koerferi Monke

Liostracina krausei Monke

Teinistion lansi Monke

A. minus Dames

A. nanum Dames

A. planum Dames

A. subcostatum Dames

Liostracus megalurus Dames = Anomocare megalurus Walcott

L. talingensis Dames

? Liostracus (兩種)

兩尾部屬與種名、均不能鑑定、

產上列三葉虫化石爲奉天賽馬集大嶺五路坡三處、德曼曾以此與歐美印度寒武紀化石比較、且謂賽馬集大嶺二處三葉虫羣與斯干的那維亞 Scandinavia 之 Andrarum 灰岩及北美之 Potsdam 層所產者爲同時、惜未採得同種化石、又五路坡產 Dorypyge richthofeni 一種、時代或與美國歐泰省 Utah 之 Quebec 層相當、以該處亦產 Dorypyge 屬故也、

一八八六年、葛特斯 C. Gottsche 于朝鮮東北部渭原等處採集寒武紀化石多種、並謂產此化石之灰岩與斯干的那維亞 Andrarum 灰岩相當、葛氏所定各種名列後、

Anomocare planum Dames

Dorypyge richthofeni Dames (亦曾發見于五路坡)

中國寒武紀化石研究歷史

中國寒武紀化石、首爲德人李希霍芬 Von Richthofen 採集、概爲腕足類及三葉虫兩類、前者經克縒 E. Kayser 鑒定爲下列兩種、

舊名	今名
Orthis linnarssoni Kayser	= Eoorthis linnarssoni Walcott
Lingulella sp.	

後者係德曼 W. Dames 鑒定、共十四種、

Agnostus chinensis Dames	
Dorypyge richthofeni Dames	
Conocephalites frequens Dames	
C. quadriceps Dames	
C. subquadratus Dames	= Anomocare subquadratus Walcott
C. typus Dames	= Ptychoparia typus Walcott
Anomocare latelimbatum Dames	
A. majus Dames	

多係新屬及新種、然僅限於該處地層上部、其時代屬上寒武紀上期、其下部岩層似有一部爲竹葉狀礫岩、或屬炒米店層、

大汶口北距泰安五十里、以產蝙蝠石 Drepanura 著、他屬亦有發見、均非新種、

同年秋、余偕北大地質系同學往臨楡開平兩盆地研究地層、並採集中寒武紀及下寒武紀化石、惟新種極少、

最近本所趙亞曾田奇瓗兩君於直隸臨城發見中寒武紀上期化石、屬崮山期、並見有饅頭頁岩及張夏灰岩兩層、惜未發見化石、產此化石之地層屬中寒武紀上期、上與下奧陶系成一間斷、(即平行不整一)

開灤鑛務局地質技師馬底幼 F. F. Mathieu 君亦曾由灤州等處寄贈寒武紀化石多種、均載入此誌、

是誌所載化石僅限于中國北部、新屬八、新種四十一、

是誌古生物研究葛利普博士殷勤指導、應矢勿諼、本篇編輯如翁文灝章鴻釗何杰諸先生亦嘗有所指示、劉君光誠任繪圖、均深爲感激、謹誌於此、

中國寒武紀動物化石

孫雲鑄著

緒言

中國寒武紀動物化石、外人研究多詳于是紀中下兩期、上寒武紀化石至今尙少研究、民國以來、本所於山東直隸奉天等省之寒武紀地層迭有詳細調查、譚錫疇君安特生博士先後往灤州馬家溝等處採集寒武紀化石多種、其層位較山東之炒米店層爲高、實屬上寒武紀之上部、茲名曰高里層或鳳山層、

民國十年春丁文江所長派余與葛利普博士及錢聲駿巴爾博兩君往開平唐山馬家溝一帶研究寒武奧陶兩紀地層、並採集此兩紀化石、歸京後、葛博士擔任研究中國北部奧陶紀動物化石 (見葛著 Ordovician Fossils from North China 古生物誌乙種第一卷第一册)、余任研究中國北部寒武紀動物化石、是年夏安特生博士因研究奉天錦西縣煤鑛、復得上寒武紀化石多種、產此化石之灰岩下與前寒武系成一間斷、(見 Upper Cambrian Fossils from Fengtien 中國地質學會誌第二卷第一二期)

民國十二年春、北京大學地質學系古生物學門同學楊鍾健張席禔田奇瓗趙亞曾王恭睦等往山東炒米店泰安大汶口等處實習、由余率領、余藉得研究山東寒武紀地層以與直隸比較、並得次第採集各層化石、濟南炒米店南山上部灰岩產直角石及他種頭足類、並有 Ptychaspis, Eoorthis 及 Dikelocephalinæ 科之 Changia 新屬同產、此類頭足類化石似屬奧陶紀初期動物、產此殊爲不類、然岩層性質與寒武紀岩層無少差異、且有上寒武紀標準化石 Ptychaspis 證之、時代似當屬上寒武紀、

泰安高里山寒武紀化石所中仝人先有所得、余因其性質特異、復親往考察、其所產三葉虫及腕足類等化石

古生物誌乙種第一號

第四冊

孫雲鑄著

中國北部寒武紀動物化石

中華民國十三年十二月

農商部地質調查所印行

Founder and Patron
of
Palæontologia Sinica

中國古生物誌提倡及贊助人

FOUNDER

提倡人

Ivar Kreuger Sweden

克魯格 瑞典

PATRON

贊助人

Sinyuan Daw King Chekiang

金 燾沁園浙江吳興前清中書科中書

古生物誌乙種第一號
第四冊

孫雲鑄著

中國北部寒武紀動物化石

中華民國十三年十二月
農商部地質調查所印行