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THE CANADIAN AND ORDOVICIAN FORMATIONS AND FOSSILS OF SOUTH MANCHURIA

BY

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The present work forms No. 164 of the *Bulletin* series.

ALEXANDER WETMORE,
Assistant Secretary, Smithsonian Institution.

WASHINGTON, D. C., *July 30, 1932.*

CONTENTS

THE CANADIAN AND ORDOVICIAN FORMATIONS AND FOSSILS OF SOUTH MANCHURIA

By Riuji Endo

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INTRODUCTION

An attempt is made in this monograph to bring into systematic order the facts that have thus far been ascertained regarding the Canadian and Ordovician strata of South Manchuria. For convenience the report is divided into two parts: Part 1 deals with the stratigraphy, containing descriptions of the formations and sections as they occur at the various localities; Part 2 is biologic in scope, comprising mainly descriptions of the new material found by me, although an endeavor is made to present a complete critical review of previous studies. In addition, by request, I have studied a number of Ordovician fossils collected in China in 1915 by Prof. George D. Louderback, of the University of California. As will be noted in the following pages, all the type specimens resulting from my studies are preserved in the collection of the United States National Museum.

I began the study of the early Paleozoic strata in the spring of 1924, when I first went to Manchuria. What I learned regarding the Sinian, Cambrian, and Ozarkian beds will be presented in a forthcoming paper written in collaboration with Dr. C. E. Resser.

In the spring of 1928, I published in Japanese a preliminary report, entitled "On the Cambro-Ordovician Strata in South Manchuria," which briefly summarized the results obtained during four years of field work. Since that time my knowledge of the South Manchurian geology has considerably increased through additional field studies, particularly because I have since had the advice and assistance of both American and Japanese geologists. I have corrected herein many mistakes appearing in my preliminary work, and the conclusions presented are naturally somewhat different and, it is hoped, more advanced.

ACKNOWLEDGMENTS

I take this opportunity to express my sincerest thanks to Dr. E. O. Ulrich for his many helpful suggestions and criticisms, and to Drs. R. S. Bassler and Charles E. Resser for their assistance and cooperation, but chiefly for the opportunities afforded me during my two

years of research at the United States National Museum, without whose collections no adequate study can be made of faunas with Arctic elements. I wish also to express my indebtedness to Dr. August Foerste for his many helpful notes and suggestions, particularly in my study of the cephalopods.

I further wish gratefully to acknowledge my obligation to Prof. H. Yabe, of the Tohoku Imperial University, from whom I have received much encouragement and help in my field work. Likewise I am indebted to S. Iwata, president of the Iwata Institute of Plant Biochemistry in Japan, for considerable funds donated to carry on my studies. Similarly, the Scholarship Foundation of the South Manchuria Railway Co. rendered me invaluable financial assistance.

Finally, I must express my hearty and sincere recognition of the encouragement given me by the late Dr. Charles D. Walcott, secretary of the Smithsonian Institution. It was his inspiration that led me to continue my geological work in South Manchuria, and eventually to come to America to complete my studies.

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CHINESE PLACE NAMES REFERRED TO IN THIS REPORT

Chinese place names referred to in the text appear below in English, either transliterated, translated, or otherwise described. With the localities on the map (pl. 1) are also given the Chinese names.

Aigawa: Village, northwestern Kuantung.

Bantatsu: Hill, 5 kilometers east of Heijo, Korea. Type locality of Kobayashi's Bantatsu formation.

Chang-chia Hill: 1 mile south of Yen-tai.

Cheng-chang-kou: Village, 1.5 miles southeast of Hsiao-shih.

Chiao-tou: Town on the Antung–Mukden line. Type locality of the Sinian Chiaotou formation.

Chien-chang-tzu: Small village, 1 mile southwest of Tao-yuan-kou.

Chin-chia-cheng-tzu: Town, 12 miles south of Fu-chou. A very famous fossil locality of the Cambrian.

Chiu-shu-kou: Small village in the Niu-hsin-tai coal field. A good fossil locality for the Ssuyen formation.

Chuan-shui-ho-tzu: Village, 3 miles northeast of Hsiao-shih.

Feng-huang-cheng: Town on the Antung-Mukden line.

Feng-mi-la-tzu: Village, 5 miles southeast of Hsiao-shih.

Fu-chin-kou: A ridge, 2.5 miles southwest of Miyanohara station. A good fossil locality for Ssuyen formation.

Hsia-kang-yao: Village, 3.5 miles southeast of Yen-tai.

Hsiao-cha-kou: Small village, 3.5 miles south of Hsiao-shih.

Hsiao-nan-kou: Small village, 1 mile southwest of Hung-lien-kou. A very good fossil locality for Ssuyen formation.

Hsiao-shih: Town, 21 miles east of Pen-hsi-hu. A center of the Hsiao-shih coal field.

Hsieh-chia-wei-tzu: Village, 1 mile west of Hsiao-shih.

Hsi-kou: Village, near the center of the Wu-hu-tsui coal field.

Hsi-tien-chia-tun: Village, 1 mile south of Aigawa, Kuantung.

Huang-chi-kou: Small village, 1 mile southeast of the Tao-yuan-kou colliery.

Huang-kan-kou: Small village, 1.5 miles south of the Tao-yuan-kou colliery.

Hui-kou: Small village, 6 miles southeast of Yen-tai.

Hui-shan: Small village, 4 miles northeast of Pen-hsi-hu.

Hung-lien-kou: Chief mining village in the center of the Niu-hsin-tai coal field.

Hun-ho: A tributary of the Liao River.

Huo-lien-chai: Station on the Antung-Mukden line. Good fossil localities of the older Paleozoic formations.

Kan-cheng: Large town, 38 miles east of Pen-hsi-hu.

Kan-chia-tun: Small village in the southern part of the Wu-hu-tsui coal field. A good fossil locality of the Ssuyen formation.

Kan-tao-tzu: Small island near Aigawa, Kuantung.

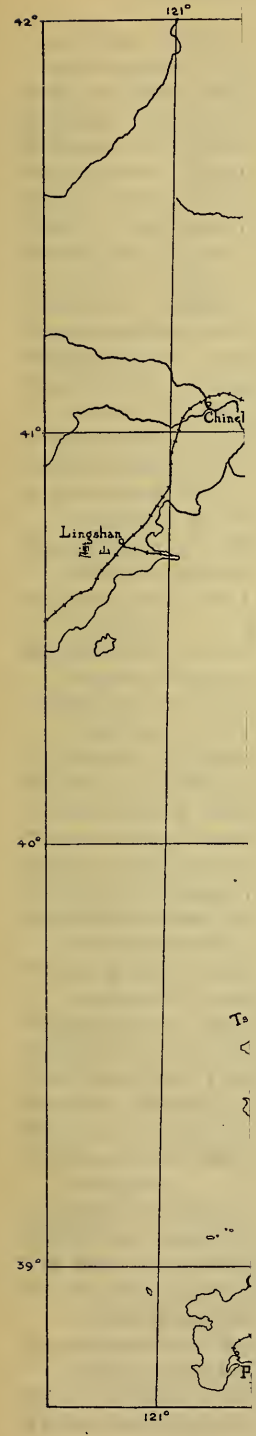
Kan-tien Hill: Hill near the Wu-hu-tsui coal field.

Ku-chia-tsu: Village, 2.5 miles south of Tao-yuan-kou. A fossil locality for the Santao formation.

Kuo-chia-tien: Station on the South Manchuria Railway main line, 215 kilometers northwest of Mukden.

Lao-hu-ti-kou: Small village near the Tao-yuan-kou colliery.

Lao-hu-shan: Hill, 1 mile north of Aigawa.



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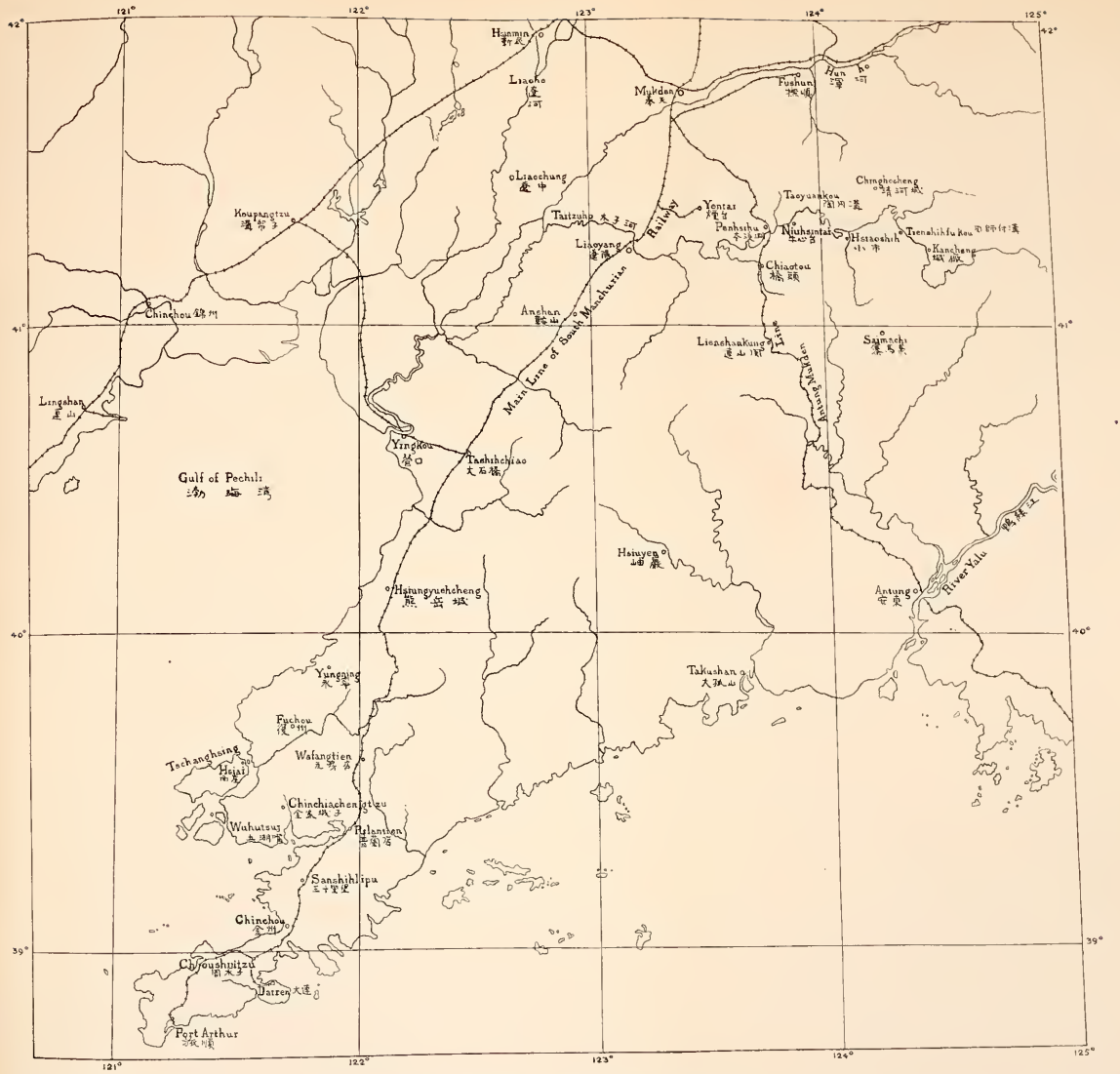


OUTLINE MAP OF SOUTH MANCHURIA

Showing important towns, rivers, and other features mentioned in the text and intended to facilitate location of places, particularly since scarcely no two atlases use the same spelling.

Liao-yang: City, 65 kilometers southwest of Mukden.
Lung-feng-ssu: Temple, 5.5 miles south of Yentai.
Lung-wan-tien: Hill, 2 miles east of Tao-yuan-kou.
Ma-shan: Hill, near the Wu-hu-tsui coal field.
Miyanohara: Station on the Antung-Mukden line.
Niu-hsin-tai: Village in the Niu-hsin-tai coal field.
Niu-ma-tai-kou: Small village, 2 miles northeast of Hsiao-shih.
Pechili: Gulf, west of Liao-tung peninsula.
Pen-hsi-hu: City on the River Tai-tzu. Center of the Pen-hsi-hu coal field.
Pi-chia-kou: Small village, 3 miles southeast of Hsiao-shih.
Ping-chou: Village, 8 miles east of Liao-yang.
Ping-ting-shan: Hill, 13 miles northeast of Kang-cheng.
Po-chia-pu-tzu: Village, 2 miles south of Hsiao-shih.
Po-chia-wan: Village, 3 miles southwest of Miyanohara station. A good fossil locality for Ssuyen formation.
San-fang-la-tzu-shan: Hill, 1.8 miles east of the Niu-hsin-tai colliery.
San-leng-shan: Hill near Wu-hu-tsui coal field.
San-tao-kang-tzu: Small village, 1.2 miles north of Pen-hsi-hu. A good fossil locality of the Wuting formation.
Shang-kang-yao: Village, 3 miles southeast of Yen-tai. Type locality of the Kangyao formation.
Shih-ho: Small hill, 8 miles east of Liao-yang. A fossil locality on the Ssuyen formation.
Ssu-yen-kou: Small village, just north of Pen-hsi-hu. Type locality of the Ssuyen formation.
Tai-chia-pu-tzu: Small village, 3 miles west of Chiao-tou station. A good fossil locality of the Wuting and Santao formations.
Tai-tzu-ho: Tributary of Liao River.
Tai-tzu-shan: Hill, near Wu-hu-tsui coal field.
Ta-ling: Hill, 2 miles southeast of Yen-tai.
Tao-yuan-kou: Small colliery, 5 miles northwest of Pen-hsi-hu.
Ta-pu: Small village, just north of Pen-hsi-hu.
Ta-wan-kou: Small village, 1.5 miles east of the Niu-hsin-tai colliery.
Tien-shih-fu-kou: Town, 37 miles east of Pen-hsi-hu. A center of the Tien-shih-fu-kou coal field.
Tou-fang-kou: Village, 2.5 miles northwest of Pen-hsi-hu. A good fossil locality of the Ssuyen formation.
Tung-chia-kou: Small coal basin in Kuantung.
Tung-kou: Small village, 5 miles east of Hsiao-shih.
Wan-chia-tung: 1 mile southwest of Aigawa.
Wo-lung: Village, 5 miles east of Pen-hsi-hu.
Wu-hu-tsui: Coal field in the southernmost part of the Pechili district.
Wu-ting-shan: Hill, 3 miles south of Yentai. Type locality of the Wuting formation.
Yao-kou-pu: Village, 2 miles south of Miyanohara station.
Yao-pu-tzu: Small village, 2.5 miles northeast of Hsiao-shih.
Yao-tsui: Small village, 0.5 mile west of Tao-yuan-kou.
Yao-tzu-ku-pan-kou: Small village 1 mile east of Tao-yuan-kou. A fossil locality of the Ssuyen formation.
Yen-chou-cheng: Hill, 4.5 miles south of Yen-tai. A fossil locality of the Ssuyen formation.
Yen-tai: Colliery, 12.5 miles northeast of Liao-yang.
Yu-ho-shan: Small hill, 8 miles east of Liao-yang.

PART 1: STRATIGRAPHICAL GEOLOGY

GEOGRAPHIC DISTRIBUTION OF THE CANADIAN AND ORDOVICIAN STRATA IN MANCHURIA

The Canadian and Ordovician strata of South Manchuria are generally developed adjacent to the Ozarkian [1] and Cambrian and therefore are limited to the south side of the watershed between the Hun and Tai-tzu Rivers, thus occurring south of Mukden. (See map, pl. 1.) Their outcrops may be grouped into two areas, one chiefly on the two sides of the Tai-tzu River and the other in the southernmost part of the Pechili district. Moderately extensive outcrops are also found near Aigawa and Tung-chia-kou in the Kuantung district. As far as I know, no Ordovician strata occur in the extensive pre-Cambrian area between the Chin-chia-cheng-tzu region and the Tai-tzu-ho district. In addition, a small outlying basin of Ordovician strata is reported by J. Hata in the vicinity of Kuo-chia-tien Station, 135 miles northeast of Mukden.

The Eopaleozoic strata of South Manchuria occur chiefly in structural basins. Although the outcrops of the older beds fail to form complete circles and are much faulted, the strata ranging from the Sinian Tiaoyutai to the Ordovician Ssuyen formation are in general arranged concentrically around the Wu-hu-tsui, Yen-tai, Pen-hsi-hu, and Niu-hsin-tai coal fields. The arrangement of the Hsiao-shih and the Tien-shih-fu-kou fields, which also show a basin structure, is much less regular, owing to a greater degree of faulting. In the Pen-hsi-hu field, not only the Permo-Carboniferous strata but also the reddish to purple, tuffaceous sandstones and conglomerates of the Cretaceous(?) Penhsihu formation were deposited in the basin immediately on the Ordovician. Throughout all North China, South Manchuria, and Korea, the coal, which is Permo-Carboniferous in age, occurs in these structural basins, which, notwithstanding considerable vertical and horizontal faulting, retain enough of their original shape to cause a concentric arrangement of the outcrops of the contained beds. In some of these basins a thick Sinian series initiates the sedimentation on the Pre-Cambrian gneisses; in others the first inundation came in Lower Cambrian time; but in no case does the Ordovician rest directly on the gneiss or even on the Sinian sediments. In none of these basins are there any beds between the Ordovician and Carboniferous and, as stated, sedimentation first took place in the Pen-hsi-hu field supposedly during the Cretaceous.

[1] After this bulletin was submitted for printing several of Kobayashi's papers appeared, and consequently certain of the Ozarkian names used herein must give way to his terms. For example, Pingchou becomes Wanwan.

PREVIOUS STRATIGRAPHIC WORK

When Baron F. von Richthofen published his Manchurian stratigraphy in 1883, he considered the Canadian and Ordovician limestones as Carboniferous (Kohlenkank), correlating them with the Mountain Limestone of Europe (Dinantian). He pointed out that these limestones are extensively developed in South Manchuria, Chihli, Shantung, and in fact throughout the whole of northern China and northern Korea. In 1906, Lorenz found several characteristic Ordovician fossils in von Richthofen's so-called Carboniferous limestone in Shantung, and therefore designated it Ordovician. Willis and Blackwelder (1907), in their reexamination during 1903–4, also recognized the Ordovician age of these beds and named the entire series the Tsinan dolomitic limestone from its occurrence in the vicinity of Tsi-nan-fu in Shantung. In 1911 Frech described two characteristic Ordovician species, *Actinoceras richthofeni* [*Armenoceras richthofeni* (Frech)] and *Raphistoma* cf. *aequilaterum*, which von Richthofen had collected in the vicinity of Hsiao-shih (?) during his travels in the Orient in 1869, consequently referring these beds to the older series. Later (1924) Grabau restudied the Tsinan limestone in North China and subdivided it into several distinct formations, publishing the following statement:

The most detailed studies of this series have been made in eastern Chihli where the following subdivisions are recognized:

I. In the Kaiping Basin	II. In the Liu-Kiang Coal Field
Upper Ordovician	*Upper Ordovician*
(absent)	(absent)
Middle Ordovician	*Middle Ordovician*
Machiakou limestone 300 m	(absent)
(Hiatus and disconformity)	
Lower Ordovician	*Lower Ordovician*
(absent)	Liangchiashan formation 275 m
(absent)	Shihmenchai formation 155 m
Coralline limestone 200 m	Peilintze formation 100 m
Yehli limestone 200 m	(Base not exposed).
(Hiatus and disconformity)	
Upper Cambrian	
Fêngshan limestone	

In 1926 T. Kobayashi (1927) studied the Ozarkian, Canadian, and Ordovician strata exposed near Fau-ren-zai (Huo-lien-chai) and Pen-hsi-hu in South Manchuria, and made the following subdivisions, in ascending order:

A. Grey colored limestone with Cryptozoon sometimes intraformational conglomerate layers are found in the upper part ..... 50–60 m.
B. Alterations of greyish white crystalline limestone and black marl ..... 50–60 m.
C. Grey banded limestone sometimes intercalating intraformational conglomerate layers ..... 40–50 m.
D. Tofango fossil bed. Dark limestone, sometimes dolomitic, with many brown colored nodular masses ..... 50–80 m.
E. Grey compact dolomitic limestone containing flinty nodules in the lower part ..... 140–180 m.

In more recent years, O. Aoji, formerly a member of the Geological Institute of the South Manchuria Railway Co., studied the Manchurian geology in considerable detail, and in 1927, in the explanatory text accompanying his geological map of Feng-huang-cheng, summarized the Ordovician strata occurring in the Tai-tzu district. The order of succession recognized by him is as follows, in descending order:

Black or grey limestone ..... 75–120 m.
Maclurea
Actinoceras
Greyish black limestone, with some nodules of hornstone-like substances ..... 12–75 m.
Maclurea
Piloceras
Calymene
Kumogata limestone with edgewise conglomerate ..... 20–30 m.
Brachiopoda
Maclurea
Actinoceras
Greyish white crystalline limestone ..... 25–50 m.
Greatest Uzumaki limestone ..... 10–25 m.
Actinoceras

In the same year, K. Ozaki, of the Tohoku Imperial University, published the results of many years' field work in the Ordovician of the Yen-tai and portions of the Tai-tzu-ho districts. His columnar section is as follows, in descending order:

Upper grey limestone zone.
Grey limestone zone, containing some nodules.
Maclurea limestone zone.
Maclurea
Piloceras
Manchuriocoras new genus
Actinoceras
Lower grey limestone, intercalating wide edgewise conglomerates.
Crystalline limestone zone.
Edgewise conglomerate zone.
Uzumaki limestone zone.

He states that in his opinion the lower boundary of the Ordovician lies at the top of the Uzumaki limestone, but hitherto most of the Manchurian as well as Japanese geologists maintained that the lower margin of the Uzumaki limestone is the boundary between the Cambrian and Ordovician strata.

In 1930 Ozaki redescribed his columnar section, summarizing it as follows, in descending order:

Tapu limestone.
Shanpingchou limestone
Toufangkou limestone
Taling limestone
Hsiapingchou dolomite
Chingchiawan limestone

T. Kobayashi (1929) restudied the strata from the Middle Cambrian to the Ordovician and subdivided the so-called Ordovician beds near Huo-lien-chai on the Antung-Mukden line as follows, in descending order:

Toufangkou Series.	
X. Nodular and banded limestone	50–170 m.
IX. Toufangkou limestone	8–100 m.
VIII. Banded limestone with interbedded edgewise conglomerates	40–60 m.
Wolung Series.	
VII. Wolung limestone	30–40 m.
VI. Banded limestone with interbedded edgewise conglomerate	20–30 m.
Wanwan Series.	
V. Crystalline limestone	5–15 m.
IV. Chiushukou shale	5–15 m.
III. Wanwankou limestone	20–30 m.

In my 1928 paper, I summarized the section as follows:

The order of succession of the Ordovician strata in the Tai-tzu-ho and Pechili districts is, in general, the same, and consists of the largest sized algal limestone, edgewise conglomerate, crystalline limestone, lower banded limestone, dolomitic limestone and upper banded limestone in ascending order.

Subsequently further field work and more exact paleontologic studies have shown that the beds from the crystalline limestone down to the algal limestone really represent the Ozarkian. What I formerly called the lower banded limestone is now subdivided into three formations, viz, the Wuting, the Kangyao, and the Santao; the last yields characteristic Canadian fossils, while the other two belong to the lower Ordovician. The so-called dolomitic limestone and the upper banded limestone of my preliminary report are herein grouped as the Middle Ordovician Ssuyen formation.

As this report was in preparation, I received a paper entitled "On the Geology of the Chinchou District in the Kuantung Province, South Manchuria," by S. Matsushita, a professor of the Ryojun Engineering College, Manchuria. He gives a detailed description of

each geological series and divides what he calls the Ordovician into a middle division, designated as the Aigawa series, and a lower subdivision, named the Chiaomaishan series.

So far as I can judge from his description, his Chiaomaishan series belongs to the Ozarkian, while his Aigawa formation apparently corresponds to the Middle Ordovician Ssuyen and Lower Ordovician Wuting formations.

GEOLOGICAL NOMENCLATURE

Since I have found many characteristic Black River, Upper Chazyan (Blount), Stones River, and Upper Canadian fossils in the South Manchurian beds formerly called simply Ordovician, it becomes necessary to subdivide the series into four distinct formations, for which I propose the names Ssuyen, Wuting, Kangyao, and Santao. It is likely that the Ssuyen formation may correspond to the middle and upper parts of Kobayashi's Toufangkou series—that is, it includes his nodular (X) and banded limestones (IX). Unfortunately, since detailed descriptions of the lithologic characters are not given in Kobayashi's 1930 paper, I can not determine the exact relations between his Wolung series and my Wuting, Kangyao, and Santao formations, but, so far as I can now tell, my three formations apparently correspond to the lower part of Kobayashi's Toufangkou and part of the Wolung series.

Kobayashi (1930) studied also the Middle Ordovician strata developed at Bantatsu hill, 5 kilometers east of Heijo, Korea, and summarized the sequence as follows, in descending order:

Group I. (Nanso bed)—Gray coloured, more or less crystalline limestone. Thickness about ..... 50–70 m.
Group II. (Unkaku bed)—Fossiliferous limestone with irregular gray dolomitic patches in black matrix. Thickness about ..... 60 m.
Group III. (Bantatsusan bed)—Alternation of dark gray massive limestone and bluish gray thinly bedded limestone. Thickness about .. 200 m.
Group IV. (Kosei bed)—Alternation of gray marly slates and bluish white, sometimes crystalline limestone.

According to his explanation, the Unkaku and Bantatsuan beds are exactly contemporaneous with his Toufangkou limestone.

In a later chapter of this paper I discuss, in detail, the correlations of the formations in Manchuria, China proper, Korea, and North America; hence this matter need not be considered further here.

In the accompanying chart (p. 11) the views of the various authors referred to in the preceding pages are tabulated, in order to facilitate a clear understanding of the stratigraphic nomenclature involved.

Tai-tzu district

Endo (1928)	Aoji (1929)	Kobayashi (1930)		Ozaki (1930)	Endo (1932)	
Ordovician					Ordovician	
Upper banded limestone 60 m.	Black or gray limestone 50-120 m.	Toulangkou series	X. Nodular limestone and platy limestone 50-70 m.	Tapu limestone		Ssuyen formation
Dolomitic limestone 30 m.	Grayish black limestone, with flinty nodules 12-75 m.		IX. Toufangkou limestone 80-100 m.	Shanpingchou limestone		Wuting formation
			VIII. Platy limestone, with "Wurmkalk" 40-60 m.	Toufangkou limestone		Kangyao formation
Lower banded limestone 70-80 m.	Mottled limestone intraformational conglomerate layers 20-30 m.	Wolung series	VII. Wolung limestone 30-40 m.	Taling limestone	Canadian	Santao formation
			VI. Platy limestone with "Wurmkalk" 5-15 m.			
Crystalline limestone 30-80 m.	Gray crystalline limestone 25-50 m.	Wanwan series	Crystalline limestone 20-30 m.	Hsiapingchou dolomite	Ozarkian	Pingchou formation
Edgwise conglomerate 15 m.			IV. Chiushukou shale 5-15 m.			
Limestone with a peculiar large concentric structure 30 m.	Limestone with a peculiar, large concentric structure 10-20 m.		III. Wanwankou limestone 20-30 m.	Chingchiawan limestone		

DESCRIPTION OF THE FORMATIONS

ORDOVICIAN SYSTEM

Thus far three formations containing Ordovician faunas, the Ssuyen, the Wuting, and the Kangyao have been delimited in South Manchuria.

BOUNDARIES OF THE ORDOVICIAN

The top of the Ordovician Ssuyen formation is everywhere apparently conformably overlain by the variegated siliceous shales of Inai's Wuhutsui formation, which is likely of Carboniferous age, although some geologists insist that it may represent the Silurian, a view not accepted by most of the Asiatic geologists.

If the Wuhutsui is really Carboniferous, it overlaps apparently conformably on the Ordovician Ssuyen formation without trace of the Devonian and Silurian. So far as we now know, nowhere in South Manchuria, North China, or North Korea is there any physical evidence of the unconformity between the Wuhutsui formation and the underlying Ordovician Ssuyen. In the Kuantung district, the Ordovician Wuting formation rests apparently conformably on the Ozarkian, and in the Pechili district, the Kangyao overlies the Ozarkian, while in the Tai-tzu district, the Kangyao formation, which is subjacent to the Wuting, appears to rest on the Canadian Santao formation. As yet, however, the exact contact between the Kangyao and Santao has not been located.

SSUYEN FORMATION

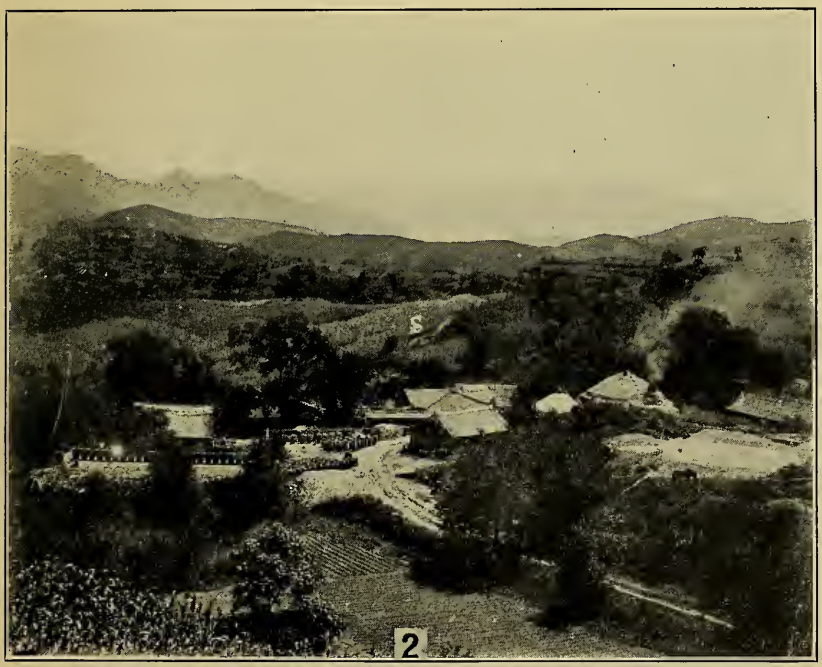
Type locality.—Near Ssu-yen-kou, just north of the Pen-hsi-hu colliery. (Pls. 2, 3.)

Character.—The upper division is composed of moderately thick-bedded, gray to light gray limestone intersected by many calcite veins. In this upper section there are several irregular edgewise conglomerates and thin dolomitic limestone beds. The lower portion consists of moderately thick-bedded, light gray arenaceous, dolomitic limestone. Two fossil-bearing horizons occur in the Ssuyen, one in the uppermost part and the other near the base of the formation.

Thickness.—As follows:

Aigawa subdistrict	280 m (918.4 feet).
Liaoyang-Yentai subdistrict, estimated about	200 m (656 feet).
Pen-hsi-hu section	160 m (524.8 feet).
Near Hui-shan, 4 miles northeast of the Pen-hsi-hu colliery	160 m (524.8 feet).
Niu-hsin-tai section, estimated about	200 m (656 feet).
Hsiao-shih subdistrict, about	280 m (918.4 feet).

TYPE LOCALITY OF THE SSUYEN FORMATION
Just north of Pen-hsi-hu, Liao-tung, Manchuria.



PEN-HSI-HU COAL BASIN, LIAO-TUNG, MANCHURIA
The best locality for the lower fossil horizon of the Ssuyen formation is at S.

PEN-HSI-HU CAVE IN THE WUTING LIMESTONE

Just north of Pen-hsi-hu, Liao-tung, Manchuria. The Chinese name of Pen-hsi-hu (Hu=lake) refers to the very clear water issuing from a spring in the cave.

LIMESTONE STRATA OF THE SSUYEN FORMATION

Near Pen-hsi-hu. These strata are here quarried for the manufacture of natural cement. The buildings are those of a cement plant.

Geographic distribution.—In the Kuantung district, the Ssuyen outcrops in the eastern part on Kan-tao-tzu Island and near Hsi-tien-chia-tun, one mile south of Aigawa. It also appears in the vicinity of Chien-shih-hui-yao, northern slope of Tai-tzu-shan, and several other small places.

Near Wu-hu-tsui colliery, it forms the greater portion of San-leng, Tai-tzu, and Kan-tien hills; it also appears south of Kan-chia-tun.

In the Liaoyang-Yentai subdistrict it outcrops on the eastern lower slope of Chang-chia hill, and on both eastern and western low hills of Hsia-kang-yao; it also reappears on Shih-ho hill, 8 miles east of Liao-yang.

In the Pen-hsi-hu subdistrict is occurs at the northern rim of the Pen-hsi-hu coal field and is also present on the Fu-chin-kou ridge, southwest of Miyanohara station on the Antung-Mukden line.

In the vicinity of Tao-yuan-kou colliery, it is found near Lao-hu-ti-kou, Huang-kan-kou, and Huang-chi-kou.

In the Niu-hsin-tai subdistrict it occurs on the slope of the semi-circular ridge surrounding the Niu-hsin-tai basin.

In the Hsiao-shih subdistrict it is found near Cheng-chang-kou, Chuan-shui-ho-tzu, Tung-kou, Hsiao-cha-kou, Pi-chia-kou, and Niu-ma-tai-kou.

Stratigraphic relations.—The upper limit of the Ssuyen is clearly defined throughout Manchuria, being overlain by the lithologically distinct Carboniferous Wuhutsui formation. Everywhere it rests conformably on the underlying Upper Chazyan, Wuting formation, but the boundary between them is not so well defined.

Fauna.—As stated previously there are two remarkable fossil horizons in the Ssuyen formation. In general, a great many fossils are found in this formation throughout South Manchuria. The following localities have yielded interesting fossils that have been identified as well as the material will permit:

From the black-banded limestone beds on the 60-meter hill, just south of the Wu-hu-tsui colliery, I have identified the following fossils:

Armenoceras coulingi (Grabau).
Armenoceras nanum takayamai, new variety.
Armenoceras elongatum, new species.
Armenoceras tani (Grabau).
Ormoceras orientale, new species.

At a point 0.5 mile east of Kang-yao in the Yen-tai area another good fossil locality has yielded the following:

Maclurites bigsbyi (Hall).
Armenoceras orientale, new species.
Armenoceras asiaticum, new species.
Armenoceras bassleri, new species.

A group of well-known fossil localities of the Ssuyen formation are at points from Ta-ming-kou, just north of the Pen-hsi-hu coal basin. Here I collected the following species:

FROM THE UPPER FOSSIL HORIZON

Camarocladia arborescens, new species.
Camarocladia fucoides, new species.
Camarocladia plana, new species.
Maclurites bigsbyi (Hall).

FROM THE LOWER FOSSIL HORIZON

Stromatocerium regulatum, new species.
Maclurites bigsbyi (Hall).
Cycloceras aokii, new species.
Sactoceras kobayashii, new species.
Sactoceras inaii, new species.
Armenoceras elegans, new species.
Armenoceras asiaticum, new species.
Armenoceras resseri, new species.
Armenoceras hatai, new species.
Armenoceras harioi (Kobayashi).
Armenoceras manchurense (Kobayashi).
Playfairia cf. *deltoidea* (Conrad).
Cycloceras (?) *manchuriense*, new species.
Armenoceras nanum takayamai, new variety.
Armenoceras penhsiense, new species.
Armenoceras richthofeni (Frech).
Armenoceras suzukii, new species.
Ormoceras chinense, new species.
Isoteloides sp. undetermined.

I also collected the following Ssuyen fossils on Fu-chin-kou ridge, 2.5 miles southwest of Miyanohara Station on the Antung-Mukden line:

Stromatocerium regulatum, new species.
Maclurites nitida (Ulrich and Scofield)?
Maclurites bigsbyi (Hall).
Sactoceras liaotungense, new species.
Armenoceras asiaticum, new species.
Armenoceras murakamii (Kobayashi)
Armenoceras tani (Grabau).

Both the upper and lower fossil horizons of the Ssuyen occur around the Niu-hsin-tai coal basin, where I have collected the following species:

FROM THE UPPER FOSSIL HORIZON

Maclurites bigsbyi (Hall).
Cycloceras (?) *pcitoutzense* Grabau.
Armenoceras elongatum, new species.
Ormoceras orientale, new species.

FROM THE LOWER FOSSIL HORIZON

Stromatocerium regulatum, new species.
Maclurites nitida (Ulrich and Scofield)?
Maclurites bigsbyi (Hall).
Cycloceras (?) *pcitoutzense* Grabau.
Sactoceras niuhsinense, new species.
Armenoceras elongatum, new species.
Armenoceras manchurense (Kobayashi).
Armenoceras magnitubulatum, new species.
Armenoceras nanum (Grabau).
Armenoceras sondai, new species.
Ormoceras kimurai, new species.
Ormoceras taii, new species.

Furthermore, a number of good fossil localities of this formation are found at several places in the Aigawa, Chiao-tou, Tao-yuan-kou, and Hsiao-shih areas.

Correlation.—As will be seen by reference to the foregoing fossil list, the Ssuyen formation contains a typical North American Black

River fauna and is therefore to be regarded as of that age. This fauna also shows that it is to be correlated with part of Grabau's Machiakou limestone in Chihli to the southwest, and on the other hand, to the east, with part of Kobayashi's Unkaku on Bantatsu hill, east of Heijo, North Korea.

Even though, as discussed in the paragraphs dealing with nomenclature, the Ssuyen formation apparently is the eqiuvalent of about the upper two-thirds of Kobayashi's Toufangkou series (that is, it corresponds with his zones X and IX), a new formational name is necessary to conform to the rules governing stratigraphic terms.

The Ssuyen formation also corresponds to the upper part of Matsushita's Aigawa series.

WUTING FORMATION

Type locality.—The top and southern slope of Wuting hill, 3 miles south of the Yen-tai colliery. (Pl. 4.)

Character.—This formation consists essentially of moderately bedded gray to dark limestones with some edgewise conglomerates. In its lower portion arenaceous limestone bands with numerous fossils are present:

Thickness.—As follows:

Kan-tao-tzu section of the Kuantung district	160 m (524.8 feet).
Ma hill near Wu-hu-tsui colliery, estimated	160 m (524.8 feet).
Shan-ping-chou section, 8 miles east of Liao-yang, about	280 m (918.4 feet).
On the top and southern slope of the curved ridge, just west of Hui-kou, about	200 m (656 feet).
Pen-hsi-hu section, about	80 m (262.4 feet).
Niu-hsin-tai section, about	80 m (262.4 feet).
Hsiao-shih subdistrict, estimated about	100 m (328 feet).

Geographic distribution.—In the Kuantung district, the Wuting formation occurs in both the western and eastern portions of Kan-tao-tzu Island; also near Wan-chia-tung, 1 mile southwest of Aigawa, and on the southwestern lower slope of the Lao-hu ridge, 1 mile north of Aigawa. In the Chin-chia-cheng-tzu area, it is present on Ma hill, on the outer lower slope of San-leng hill, and at the eastern end of Tai-tzu hill.

In the Liaoyang-Yentai subdistrict the outcrops are on Yu-ho hill, 8 miles east of Liao-yang, and on the western lower slope of the curved ridge, just west of Hui-kou. It also occurs on the top and southern slope of Wu-ting hill and its environs.

In the Pen-hsi-hu subdistrict it is present on the ridge north of Tai-chia-pu-tzu, 2 miles west of Chiao-tou station; and also near Ta-pu and San-tao-kang-tzu, just north of the Pen-hsi-hu colliery. In the vicinity of the Tao-yuan-kou colliery, it is distributed near

Chien-chang-tzu, Yao-tsui, Huang-kan-kou, Lao-hu-ti-kou, and on Lung-wan-tien hill.

In the Niu-hsin-tai subdistrict it occurs on the slope of the semicircular ridge surrounding the Niu-hsin-tai basin, and in the Hsiao-shih subdistrict it is found near Hsiao-cha-kou, Po-chia-pu-tzu, and Feng-mi-la-tzu; it also occurs south of Hsieh-chia-wei-tzu and Yao-pu-tzu.

Stratigraphic relations.—The Wuting is conformably overlain by the Ssuyen formation throughout Manchuria, its upper boundary being placed at the base of the dolomitic limestone of the overlying Ssuyen. The lower boundary is somewhat difficult to place. In the Kuantung district, it rests apparently conformably on the Ozarkian Pingchou formation, but at the east end of the Wu-ting hill, 3 miles south of the Yen-tai colliery, the Kangyao, referred to the Stones River, is situated between it and the Canadian Santao formations.

Even though I have not yet found beds unquestionably referable to the Kangyao formation, except in the immediate vicinity of Yen-tai and on the eastern slope of San-leng hill, near Wu-hu-tsui colliery, it is quite reasonable to assume from faunal relationships that it may be developed throughout most of the Tai-tzu-ho and Pechili districts.

Fauna.—As the fossiliferous sandy limestone of the Wuting formation is developed at many places, I have collected numerous fossils. From the type locality, on the top of Wu-ting hill, I collected the following species:

Orthis calligramma orthambonites von Buch.
Raphistoma cf. *aequilaterum* Koken?
Helicotoma sp.

Near Tai-chia-pu-tzu, 2 miles west of Chiao-tou station:

Phyragmolites sp.
Oxydiscus planulatus, new species.

A remarkable fossil locality of this formation found in the vicinity of the second tunnel, north of Pen-hsi-hu, produced the following species:

Orthis calligramma orthambonites von Buch.
Raphistoma cf. *acquilaterum* Koken.
Helicotoma sp.
Eccyliopterus sp.
Cycloceras (?) *marginale*, new species.
Plectoceras ohtakai, new species.
Nybyoceras foerstei Endo.
Armenoceras numatai, new species.
Ormoceras manchuricnse, new species.
Bathyurus? sp.

Besides the above localities, a few Wuting fossils were recovered at several places in the Wu-hu-tsui, Niu-hsin-tai, and Hsiao-shih subdistricts.

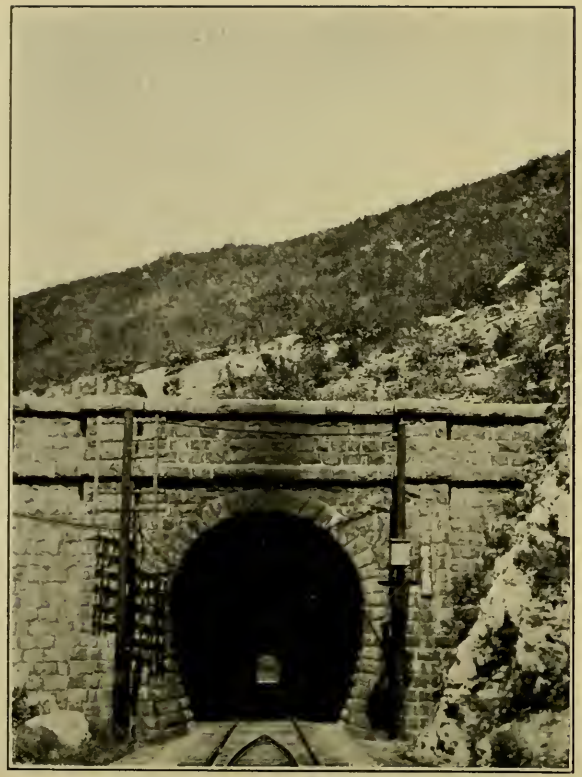
Correlations.—From the presence of the fauna listed above it is clear that the Wuting is equivalent to a portion (about Athens

VIEW FROM THE SOUTH OF WU-TING-SHAN (MEANING A HILL COMPOSED OF FIVE PEAKS)

This hill is 3 miles south of Yen-tai colliery, Liao-tung, Manchuria.

NEARER VIEW OF THE HIGHEST PEAK SHOWN IN FIGURE 1

Rather good fossils are found on the top of this hill, which is the type locality of the Wuting formation.



TYPE LOCALITY OF THE SANTAO FORMATION, NORTH OF PEN-HSI-HU, LIAO-TUNG, MANCHURIA

The pictures are of the same limestone at the two entrances to the same tunnel.

stage) of the North American Blount (Upper Chazyan). It also appears to be the equivalent of the lower part of Kobayashi's Toufangkou series, and the lower part of Matsushita's Aigawa series.

KANGYAO FORMATION

Type locality.—Half a mile west of Shang-kang-yao, 3 miles southeast of the Yen-tai colliery.

Character.—Moderately thick-bedded, grayish-black limestone that is crossed by many calcite veins.

Thickness and geographic distribution.—Except at the type locality and on the eastern slope of San-leng hill, near Wu-hu-tsui colliery, I have separated no undoubted Kangyao, but I found fragments of *Lophospira* and other gastropods in the lower part of the Ordovician limestone in the Wu-hu-tsui, Pen-hsi-hu, and Niu-hsin-tai subdistricts.

T. Kobayashi also collected a number of *Lophospira* specimens from his Tofango series in both Pen-hsi-hu and Niu-hsin-tai subdistricts, as well as from his *Actinoceras* zone in the Wu-hu-tsui subdistrict. It seems, therefore, that the Kankyao may occur rather extensively in the Wu-hu-tsui area and in the Tai-tzo-ho district. This question is hereafter discussed in greater detail (p. 30).

In a maize field near Shang-kang-yao, I found a very much weathered limestone, 20 m (65.6 feet) in thickness, from which I collected the characteristic Stones River fossils listed below.

Stratigraphic relations.—The base and top of the Kangyao have not yet been located and its relationships to the adjacent formations are, therefore, not definitely fixed.

Fauna.—As follows:

Anthaspidella discoidalis, new species.
Orthis calligramma orthambonites von Buch.
Lophospira aojii, new species.
Lophospira grabaui, new species.
Lophospira kangyaoensis, new species.
Lophospira manchuriensis, new species.
Lophospira cf. *oweni* Ulrich and Scofield.
Lophospira producta pagodai, new variety.
Lophospira turritiformis, new species.
Lophospira yentaiensis, new species.
Eotomaria barbouri (Grabau).
Eotomaria ulrichi, new species.
Solenospira sp.

Correlations.—From the presence of *Lophospira* and other gastropods it is clear that the Kangyao formation is the stratigraphic equivalent of the lower portion of the Stones River (about Mosheim stage) of North America.

CANADIAN SYSTEM

The Canadian is represented in South Manchuria by only one formation, at least so far as beds definitely determinable as such from their contained fossils are concerned.

SANTAO FORMATION

Type locality.—Above the second tunnel near San-tao-kang-tzu, 1.5 miles north of the Pen-hsi-hu colliery. (Pl. 5.)

Characters.—Moderately thick-bedded, gray, arenaceous limestones crossed irregularly by many fissures now filled by calcite.

Thickness and geographic distribution.—The Canadian Santao formation, so far as now known, appears to be undeveloped in the Kuantung and Pechili districts. In the Tai-tzu-ho district, on the contrary, it has a comparatively wide distribution.

In the Yen-tai subdistrict, it occurs on the eastern lower slope of Wu-ting hill, 3 miles south of the Yen-tai colliery, where it is estimated as about 60 m (196.8 feet) thick. In the Pen-hsi-hu subdistrict, it outcrops above the second tunnel near San-tao-kang-tzu, and here it has a thickness of about 80 m (262.4 feet). It also appears near Tai-chia-pu-tzu, 2 miles west of Chiao-tou station on the Antung-Mukden line, where it is estimated at about 60 m (196.8 feet). In the vicinity of Niu-hsin-tai it occurs on the upper slope of the San-fang-la-tzu hill, 1.8 miles east of the Niu-hsin-tai colliery, and again an equal distance west of the same place on the western slope of the Wo-lung ridge, and at this place it is about 60 m (196.8 feet) in thickness.

Unfortunately I have not yet been able to find Santao fossils in the Hsiao-shih subdistrict, but I think further search may yield characteristic examples.

Stratigraphic relations.—The Santao rests apparently conformably on the Ozarkian Pingchou formation at all outcrops. On the eastern lower slope of Wu-ting hill the lower Chazyan Kangyao is situated between the Santao and the Wuting formations, but exact boundaries have not yet been established. In fact, at most localities the upper and lower boundaries of the former are not well defined, since all adjacent formations are lithologically similar.

Fauna.—From the fossil locality of the Santao formation on the eastern lower slope of Wu-ting hill I have collected the following species: *Hormotoma* sp. and *Calathium frechi*, new species.

In the gray limestone beds above second tunnel, north of Pen-hsi-hu, a larger fauna was collected (pl. 3):

Calathium frechi, new species.
Anthaspidella? planulata, new species.
Anthaspidella? radiata, new species.
Polytoechia? tapuensis, new species.
Piloceras manchuriense, new species.
Penhsioceras fusiforme, new genus and species.
Cameroceras cf. *styliforme* Grabau.

In addition I collected *Piloceras manchuriense* and fragments of other species near Tai-chia-pu-tzu, 2 miles west of the Chiao-tou station, and near the Niu-hsin-tai colliery.

Correlations.—The fossils listed above show that the Santao represents the North American uppermost Canadian. The Santao for-

mation, though lithologically very similar to the overlying Lower Ordovician strata, has a very distinctive fauna that enables the two to be readily differentiated. The Santao may correspond with some part of Grabau's (1922) Peilintze or Lingchiashan formation, in Chihli, as their faunas are similar.

The Santao formation appears to represent a part of Kobayashi's Wolung series, which he included in the Ordovician.

DESCRIPTION OF THE STRATIGRAPHIC SECTIONS

Detailed sections for all the more important localities where the Ordovician and Canadian beds outcrop in South Manchuria are herewith included. The sections are in natural order; that is, the highest beds present or studied are described first, followed by the others in descending order, and since the formations have been described in the preceding pages the names may be used without further definition. The sections are also arranged in geographic order, beginning with the most southerly.

KUANTUNG DISTRICT

The Kuantung district includes the larger part of and practically coincides with the Kuantung Leased Territory. The southern part is covered by the rather massive-bedded quartzite of the Sinian Tiaoyutai formation and the limestones of the Kuantung, Pre-Cambrian gneiss and gneissoid granites occupy much of the northeastern part, while most of the northwestern portion consists of rocks belonging to the Cambrian. Therefore, the area of Ordovician strata is rather restricted in this district. The most important localities of the Ordovician are found on Kan-tao-tzu Island and on the isolated comparatively small hills situated between Wan-chia-tung and Hsi-tien-chia-tun, south of Aigawa.

Inai has informed me that fossiliferous limestones occur in the Ssuyen outcrop in the vicinity of Tung-chia-kou colliery, 10 miles east of Chin-chou station on the South Manchurian line. Unfortunately, however, I have not yet visited this place and consequently can not include a description of it here.

KAN-TAO-TZU SECTION

Kan-tao-tzu Island lies on the coast 1.5 miles southwest of Aigawa, a famous Japanese farming settlement. Both the Ozarkian and Ordovician strata are finely exposed on this island in the form of a structural dome with Ozarkian formations occupying the central part, surrounded by the Ordovician in the marginal portion of the island.

Ordovician

SSUYEN FORMATION:

1. Moderately thick-bedded, gray and light-gray limestone in layers 10 to 20 cm thick, with several irregular edgewise conglomerate and thin dolomitic limestone beds at certain horizons.

Fauna.—Occasionally fragments of cephalopods (*Armenoceras*) and gastropods occur.

2. Moderately thick-bedded, light-gray arenaceous, dolomitic limestones, in layers 5 to 20 cm thick, 60 m (196.8 feet).

Total thickness of Ssuyen formation, 280 m (918.4 feet).

WUTING FORMATION:

Moderately thick-bedded, gray to dark limestone, with a few edgewise conglomerates in layers 10 to 20 cm thick, 160 m (524.8 feet).

Fauna.—Traces of annelid borings.

The Wuting occurs on the eastern slope of the 128-meter hill and at the western end of Kan-tao-tzu Island. It rests apparently conformably on the Pingchou, and thus far I have not found the Santao or any Lower Chazyan formation in this region.

The Ssuyen and Wuting formations also outcrop in the five isolated hills that stretch between Wan-chia-tung and Hsi-tien-chia-tun, near Kan-tao-tzu Island. The lithologic characters and geologic relations are the same as on Kan-tao-tzu Island. Only a few unidentifiable fragments of *Armenoceras* were found in these isolated hills.

PECHILI DISTRICT

Except for comparatively small areas at Wu-hu-tsui, Chin-chia-cheng-tzu, and on Tschang-hsing-tao, most of the Pechili district is occupied by rocks belonging to the Sinian series. The Cambrian strata are finely developed in the vicinity of Chin-chia-cheng-tzu and in the northeastern part of Tschang-hsing-tao, while the Ordovician beds are confined to the area surrounding the Wu-hu-tsui coal field.

WU-HU-TSUI SUBDISTRICT

Surrounding the Wu-hu-tsui coal field, except on its northern flank, Ordovician rocks make up the Ma, San-leng, Tai-tzu, and Kan-tien hills. Since three rather large faults are present in this area, it is necessary to present a composite and somewhat diagrammatic section. (Pl. 6.)

Ordovician

SSUYEN FORMATION:

1. Moderately thick-bedded, gray to light-gray limestone, in layers 5 to 20 cm thick, with thin edgewise conglomerates and dolomitic limestones, 100 m (328 feet).

Fauna.—As follows:

Armenoceras coulingi (Grabau).
Armenoceras elongatum, new species.
Armenoceras nanum takayamai, new variety.
Armenoceras tani (Grabau).
Armenoceras orientale, new species.

2. Moderately thick-bedded, light-gray, buff-weathering shaly, arenaceous dolomitic limestone with some thin edgewise conglomerates, 140 m (459.2 feet).

Fauna.—No fossils found.

This dolomitic limestone forms the main body of Tai-tzu, Kan-tien, and San-leng hills.

Total of Ssuyen, 240 m (787.2 feet).

WUTING FORMATION:

Moderately thick-bedded, gray to dark limestone, sometimes very arenaceous, in layers 2 to 20 cm thick, with a few interbedded edgewise conglomerate layers, 160 m (524.8 feet).

Fauna.—I collected *Armenoceras* and crinoid stems from this formation on the northern slope of Ma hill. Some layers show abundant traces of annelid borings within the rock or on its surface.

The Wuting forms the main body of Ma hill and outer lower slopes of San-leng hill.

KANGYAO FORMATION:

Moderately thick-bedded, gray-black limestone, 20 m (65.6 feet).

Fauna.—As follows:

Lophospira aojii, new species.
Lophospira grabauii, new species.
Eotomaria barbouri (Grabau).
Eotomaria ulrichi, new species.
Many fine examples of undescribed species of gastropods.

TAI-TZU-HO DISTRICT

The Ordovician and Canadian strata outcrop extensively along both sides of Tai-tzu River between Liao-yang and Kan-cheng. In addition these beds also cover comparatively large areas south of Ping-ting-shan, 13 miles northeast of Kan-cheng. For convenience in description the Tai-tzu-ho district may be subdivided into four subdistricts: Liaoyang-Yentai, Penhsihu-Niuhsintai, Hsiaoshih-Tienshihfukou, and Ping-ting-shan. As I did not visit the last named, it is omitted from the following description. (Pl. 7.)

LIAOYANG-YENTAI SUBDISTRICT

The Liaoyang-Yentai subdistrict lies in the westernmost part of the district. In this area Ordovician and Canadian rocks occupy about 4 square miles south of Yen-tai. The village of Kang-yao stands in the center of this outcrop.

The Wuting formation is particularly well exposed in typical form on the summit and southern slope of Wu-ting hill, where it yields fine fossils.

The weathered limestone strata of the Kangyao formation are found in the fields 0.5 mile west of Shang-kang-yao, where I collected many very fine Stones River fossils.

SHANG-PING-CHOU SECTION

The Ordovician strata are found on the low hills, Shih-ho-shan and Yu-ho-shan near Shang-ping-chou, 8 miles east of Liao-yang. I examined the Ordovician strata in the section that runs from south to north and is the northward prolongation of the Cambrian and Ozarkian section.

All the beds dip 15° to 20° to the north, thereby making good exposures.

Ordovician

SSUYEN FORMATION:

1. Moderately thick-bedded, gray to light-gray limestone, full of calcite veins; the beds average 15 cm in thickness; interbedded thin edgewise conglomerates and dolomitic limestone beds at irregular intervals, 160 m (524.8 feet).

Fauna.—Annelid trails and borings, *Armenoceras elegans*, new species, and *Maclurites bigsbyi* (Hall).

2. Moderately thick-bedded, light-gray, buff-weathering arenaceous, dolomitic limestone in layers 4 to 20 cm thick, 40 m (131 feet).

Total thickness of the Ssuyen, 200 m (656 feet).

WUTING FORMATION:

Moderately thick-bedded, gray to black limestone with many calcite veins and with a few edgewise conglomerates, varying in thickness from 2 to 20 cm, 280 m (918.4 feet).

Fauna.—Numerous annelid borings; *Raphistoma* cf. *aequilaterum* Koken?

The Wuting, outcropping on a small hill near Lung-feng-ssu, 1 mile east of Yu-ho hill, yields many fragments of *Maclurites* and other gastropods.

Thus far I have not found any Kangyao and Santao fossils in this section, but such may be obtained by further search.

HSIA-KANG-YAO SECTION

The Hsia-kang-yao section lies about 3.5 miles southeast of the Yen-tai colliery. The measured section begins at the western foot of Wu-ting hill and extends eastward via Hsia-kang-yao to the north of Ta-ling.

The strata from the Ssuyen to the Santao, inclusive, form a synclinal structure on the axis of which Hsia-kang-yao is located. The beds outcropping on Wu-ting hill dip 40° to the south.

Ordovician

SSUYEN FORMATION:

1. Moderately thick-bedded, gray to light-gray limestones with many calcite veins, in layers 3 to 20 cm thick; with thin edgewise conglomerates in some horizons, 250 m (820 feet).

Fauna.—As follows:

Maclurites bigsbyi (Hall).
Armenoceras orientale, new species.
Armenoceras bassleri, new species.
Armenoceras asiaticum, new species.
Abundant annelid borings.
Many fragments of gastropods.

2. Moderately thick-bedded, gray, arenaceous, dolomitic limestone; in beds averaging 5 cm in thickness, 30 m (98.4 feet).

Total of the Ssuyen formation, 280 m (918.4 feet).

WUTING FORMATION:

Moderately thick-bedded, mostly black, sometimes gray, limestone with a few edgewise conglomerate layers, averaging 7 cm thick, 200 m (656 feet).

Fauna.—Arenaceous limestones in the lower part of the formation yield numerous fossils:

Orthis calligramma orthambonites von Buch.
Raphistoma cf. *aequilaterum* Koken?
Helicotoma sp.
Several undetermined trilobites.
Annelid borings and trails.

The Wuting formation outcrops typically on the top and southern slope of Wu-ting hill and again on the western slope of the curved ridge just west of Hui-kou, and on the low hill just west of Hsia-kang-yao.

KANGYAO FORMATION:

Moderately thick-bedded, grayish-black limestone, with many calcite veins in beds averaging 18 mm in thickness. The weathered surfaces become yellowish rusty and leave a sticky mud. Many fine Stones River (Mosheim stage) fossils were found in the deeply weathered limestones.

Fauna.—As follows:

Anthaspidella discoidalis, new species.
Orthis calligramma orthambonites von Buch.
Lophospira aojii, new species.
Lophospira grabaui, new species.
Lophospira kangyaoensis, new species.
Lophospira manchuriensis, new species.
Lophospira producta pagodai, new variety.
Lophospira cf. *oweni* Ulrich and Scofield.
Lophospira turritiformis, new species.
Lophospira yentaiensis, new species.
Eotomaria barbouri (Grabau).
Eotomaria ulrichi, new species.
Solenospira species.
Undetermined trilobites.

The Kangyao occurs in a very limited area in the maize field northwest of Hsia-kang-yao.

Canadian

SANTAO FORMATION:

Moderately thick-bedded, grayish dark, somewhat arenaceous limestone, the beds averaging 3 cm in thickness, 60 m (196.8 feet).

Fauna.—Hormotoma sp. and *Calathium frechi*, new species.

The Santao is found on the western slope of the curved ridge west of the Hui-kou Valley and on the eastern slope of Wu-ting hill.

PENHSIHU-NIUHSINTAI SUBDISTRICT

This area extends from Chiao-tou station, on the Antung-Mukden line, to Huo-lien-chai station, thus including a strip about 8 miles wide lying both east and west of the railway line. In this area the Ordovician and Canadian strata outcrop sporadically north of the Pen-hsi-hu colliery, in the vicinity of the Tao-yuan-kou colliery, in the country around the Niu-hsin-tai colliery, on Fu-chin-kou ridge, 2.5 miles southwest of Miyanohara station, and at other places. (Pls. 8, 9.)

The black-banded limestone of the Ssuyen forms a great cliff near Ssu-yen-kou, just north of the Pen-hsi-hu colliery, where it yields many fine fossils.

The Santao formation is typically developed above the second tunnel, 1 mile north of the Pen-hsi-hu colliery, and here are found many fine characteristic Canadian fossils (pl. 5).

FU-CHIN-LING SECTION

The Ordovician and Canadian strata outcrop fairly extensively in the westward prolongation of the Cambro-Ozarkian outcrops 1.5 miles north of Chiao-tou station and near Po-chia-wan, 3 miles southwest of Miyanohara station.

The strata from the Ordovician Wuting to the Ozarkian Yenchou form an anticlinal structure, while the Ssuyen is shifted out to the northward of this section by a large fault; here it is in contact with the strata from the Ordovician Wuting down to the Sinian Tiaoyu-tai in the area from Po-chia-wan via Fu-chin-kou to Yao-kou-pu.

Ordovician

SSUYEN FORMATION:

Moderately thick-bedded, gray to black limestone with many calcite veins, with occasional intercalated dolomitic limestone beds at irregular intervals.

Fauna.—A good fossil locality of this formation is located on the northern slope of the Fu-chin-kou ridge, where I collected the following fossils:

Stromatocerium regulatum, new species.
Maclurites nitida (Ulrich and Scofield)?
Maclurites bigsbyi (Hall).
Sactoceras liaotungense, new species.
Armenoceras asiaticum, new species.
Armenoceras murakamii (Kobayashi).
Armenoceras tani (Grabau).

WUTING FORMATION:

Moderately thick-bedded, gray to black limestone, averaging 4 cm in thickness, with interbedded thin edgewise conglomerates and dolomitic limestone at some horizons, 160 m (524.8 feet).

Fauna.—Annelid trails and borings; *Phragmolites* sp.; and *Oxydiscus planulatus*, new species.

The Wuting outcrops just north of Tai-chia-pu-tzu, 2 miles west of Chiao-tou station, and is faulted against the Taitzu formation.

KANGYAO FORMATION:

Unfortunately, I have not yet collected any specimens from the Kangyao formation in this section, but I think that it may be identified by future study in the field.

Canadian

SANTAO FORMATION:

Moderately thick-bedded, light-gray to gray limestones crossed by many calcite veins, with interbedded arenaceous limestones at some horizons, the beds averaging 3 cm in thickness, 60 m (196.8 feet).

Fauna.—Piloceras manchuriense, new species.

PEN-HSI-HU SECTION

On the northern rim of the Pen-hsi-hu coal field there are fine exposures of Ordovician and Canadian strata. Here we find the type localities of the Ordovician Ssuyen and Canadian Santao formations. The strata from the Wuting down to the Santao form an anticlinal structure just east of San-tao-kang-tzu; while the Ssuyen dips at 20° or 30° to the south on the north rim of the coal field.

Ordovician

SSUYEN FORMATION:

1. Moderately thick-bedded, gray to black limestone with many calcite veins; the limestones are somewhat dolomitic in some horizons; beds vary in thickness from 1 to 30 cm, 120 m (393.6 feet).

There are two important fossil horizons in this formation, one near the top and the other about 100 m below.

From the upper fossil horizon:

Camarocladia arborescens, new species.
Camarocladia fucoides, new species.
Camarocladia plana, new species.
Maclurites bigsbyi (Hall).

From the lower fossil horizon:

Stromatocerium regulatum, new species.
Maclurites bigsbyi (Hall).
Playfairia cf. *deltoidea* (Conrad).
Cycloceras (?) *manchuriense*, new species.
Cycloceras aokii, new species.
Sactoceras kobayashii, new species.
Sactoceras inaii, new species.
Armenoceras elegans, new species.
Armenoceras asiaticum, new species.
Armenoceras resseri, new species.
Armenoceras hatai, new species.
Armenoceras harioi (Kobayashi).
Armenoceras manchurense (Kobayashi).
Armenoceras nanum takayamai, new variety.
Armenoceras penhsiense, new species.
Armenoceras richthofeni (Frech).
Armenoceras suzukii, new species.
Ormoceras chinense, new species.
Isoteloides sp.

Camarocladia forms a characteristic bed about 3 m thick in the uppermost part of the Ssuyen and is directly overlain by the apparently conformable Carboniferous variegated siliceous shales. A fine *Stromatocerium* bed about 1.8 m thick occurs in the lower part of the lower fossil horizon.

2. Moderately thick-bedded, light-gray dolomitic limestone with beds averaging 10 cm in thickness, 40 m (131.2 feet).

Total Ssuyen formation, 160 m (524.8 feet).

The dark and grayish massive beds of the Ssuyen limestone form great cliffs just north of the Pen-hsi-hu colliery along the Antung-Mukden line and are here quarried for manufacture of natural cement. (See pl. 2, fig. 2.)

WUTING FORMATION:

Moderately thick-bedded, gray to dark limestone, interbedded with thin edgewise conglomerates and arenaceous limestone beds, varying in thickness from 1 to 30 m, 80 m (262.4 feet).

Fauna.—I have collected the following species from this formation in the vicinity of the second tunnel, 1 mile north of Pen-hsi-hu:

Orthis calligramma orthambonites von Buch.
Raphistoma cf. *aequilaterum* Koken?
Helicotoma sp.
Eccyliopterus sp.
Cycloceras (?) *marginale*, new species.
Plectoceras ohtakai, new species.
Nybyoceras foerstei Endo.
Armenoceras numatai, new species.
Ormoceras manchuriense, new species.
Bathyurus?? sp.

The Pen-hsi-hu cave is formed in the Wuting formation in this section. (See pl. 2, fig. 1.)

The Ordovician limestone breaks down and forms a broad, irregular rough slope from the cliff on the southwest side of the Huolien-chai Valley.

KANGYAO FORMATION:

Moderately thick-bedded, gray limestone with many irregular calcite veins.

Fauna.—Fragments of gastropod shells.

Canadian

SANTAO FORMATION:

Moderately thick-bedded, gray, arenaceous limestones with many irregular calcite veins, in layers 2 to 10 cm thick, 80 m (262.4 feet).

Fauna.—On the top of the second tunnel, 1 mile north of Pen-hsi-hu, a good fossil locality occurs from which I collected the following important, characteristic Canadian fossils:

Anthaspidella? planulata, new species.
Anthaspidella? radiata, new species.
Polytoechia? tapuensis, new species.
Cameroceras cf. *styliforme* Grabau.
Piloceras manchuriense, new species.
Penhsioceras fusiforme, new genus and species.

TAO-YUAN-KOU SECTION

In the vicinity of the Tao-yuan-kou coal field, the Ordovician strata are very well exposed, but, unfortunately, many comparatively strong faults have disturbed and scattered the outcrops, making necessary a generalized and somewhat arbitrary section. The strata that outcrop on the Lao-hu-ti-kou ridge have a synclinal structure, while those at Lung-wan-tien and near Huang-kan-kou are in a tilted block dipping 20° or 30° to the west. This section is essentially the same as that of Pen-hsi-hu, 5 miles southwest of this area, except that the Canadian Santao formation is lacking.

Ordovician

SSUYEN FORMATION:

1. Moderately thick-bedded, black to light gray limestone, in layers 5 to 20 cm thick, with interbedded thin edgewise conglomerate and dolomitic layers, 40–150 m (131.2–492 feet).

Fauna.—A good fossil locality occurs in the valley of Yao-tzu-ku-pan-kou, where I collected *Maclurites bigsbyi* (Hall) and *Armenoceras shimizui*, new species.

2. Moderately thick-bedded, light gray, buff-weathering, arenaceous, dolomitic limestone in layers 4 to 20 cm thick. These beds become thinner as compared with those of the Pen-hsi-hu and Shan-ping-chou sections, about 20 m (65.6 feet).

Total Ssuyen formation, 170 m (557.6 feet).

WUTING FORMATION:

Moderately thick-bedded, gray to dark limestone, interbedded with thin edgewise conglomerate and arenaceous limestone beds varying in thickness from 1 to 30 cm, about 120 m (393.6 feet).

Fauna.—From the arenaceous beds comparatively well-preserved fossils have been obtained near Ku-chia-tsu: *Raphistoma* cf. *aequilaterum* Koken? and undetermined brachiopods.

Although I have not yet collected any Kangyao or Santao fossils in the Tao-yuan-kou section, I have the impression of having seen some fragments of these on the limestone surfaces, and consequently it is probable that future field work may develop these formations in this area.

NIU-HSIN-TAI SECTION

Ordovician strata outcrop extensively all the way around the Niu-hsin-tai coal basin, except on its northwestern sector. The following section is a prolongation of the Cambrian and Sinian and was measured on the eastern rim of this structural basin along the line between Hung-lien-kou and Ta-wan-kou. All the strata outcropping here dip 20° to 30° to the southwest.

Ordovician

SSUYEN FORMATION:

1. Moderately thick-bedded, gray to black limestone with many calcite veins, with interbedded thin edgewise conglomerates and dolomitic limestones at some horizons; the limestone beds average 7 cm in thickness, 160 m (524.8 feet).

Fauna.—The contained fossils are found at two horizons from which I collected the following species:

From upper fossil horizon:

Maclurites bigsbyi (Hall).
Cycloceras (?) *peitoutzense* Grabau.
Armenoceras elongatum, new species.
Ormoceras orientale, new species.

From lower fossil horizon:

Stromatocerium regulatum, new species.
Sactoceras niuhsinense, new species.
Armenoceras sondai, new species.
Ormoceras kimurai, new species.

A good many fine specimens, listed on page 14, were found south of Hsiao-nan-kou, on the southern rim of the structural basin. Moreover, I have collected a number of black limestone bowlders believed to have come from the Ssuyen formation, in the river drift at the Niu-hsin-tai colliery, in which the following characteristic Ssuyen fossils occur:

Orthoceras toyamai, new species.
Orthoceras sp.
Cycloceras (?) *manchuriense*, new species.
Armenoceras hayasakai, new species.
Armenoceras marginale, new species.
Armenoceras nanum (Grabau).
Armenoceras nudum, new species.
Armenoceras yabei, new species.
Ormoceras nagaoi, new species.

2. Moderately thick-bedded, light-gray, dolomitic limestone in layers 1 to 15 cm in thickness, 40 m (131.2 feet).

Total Ssuyen formation, 200 m (656 feet).

WUTING FORMATION:

Moderately thick-bedded, gray to dark limestones, with thin edgewise conglomerate and arenaceous limestone beds; varying in thickness from 1 to 30 cm, 8 m (26.24 feet).

Fauna.—*Orthoceras rectiseptatum*, new species.

KANGYAO FORMATION:

Moderately thick-bedded, black limestone with fragments of gastropods.

Canadian

SANTAO FORMATION:

Moderately thick-bedded, grayish, dark, somewhat arenaceous limestone, the beds averaging 3 cm in thickness.

Fauna.—This formation furnished a specimen of *Penhsioceras fusiforme* from a locality in the valley of Ta-wan-kou, 1.5 miles northeast of the Niu-hsin-tai colliery.

HSIAOSHIH-TIENSHIHFUKOU SUBDISTRICT

This area, which embraces the Hsiao-shih and Tien-shih-fu-kou coal fields, lies about 18 miles east of the Niu-hsin-tai district. The Ordovician strata outcrop rather extensively, and I planned a close study of the lower Palaeozoic and Sinian beds in the summer of 1928, but unfortunately strong antiforeign feeling among the Chinese developed at that time, which drove me out of the area after only a rapid reconnaissance in the vicinity of Hsiao-shih. Since then there has been no opportunity to revisit the area, but I am planning as soon as I return to Manchuria to visit particularly Tien-shih-fu-kou and more eastern parts of the Tai-tzu-ho district.

HSIAO-SHIH SECTION

Notwithstanding my rapid reconnaissance, I fortunately found a continuous section from the Ordovician to the Sinian along the Hsiao-shih River, a tributary of the Tai-tzu.

Ordovician

SSUYEN FORMATION:

1. Moderately thick-bedded, gray to light-gray limestone in layers 2 to 30 cm thick, with interbedded thin edgewise conglomerate and dolomitic limestone beds at irregular intervals, 200 m (656 feet).

Fauna.—Fragments of cephalopods and gastropods; annelid trails and borings.

From other localities in this area, I collected *Armenoceras sondai*, new species, and *Ormoceras proximum*, new species. Therefore, I feel sure more complete specimens can be found.

2. Moderately thick-bedded, light-gray, buff-weathering arenaceous dolomitic limestone, and beds averaging 7 cm in thickness, 80 m (262.4 feet).

Total thickness of the Ssuyen, 100 m (328 feet).

WUTING FORMATION:

Moderately thick-bedded gray to black limestone with a few edgewise conglomerate and some arenaceous limestones. The limestone beds vary in thickness from 2 to 20 cm, 200 m (656 feet).

Fauna.—Although I have not collected any Wuting fossils in this immediate section, I found a specimen of *Rafinesquina* sp. near Hsiao-shih. In my rapid reconnaissance, nothing was seen of the Kangyao and Santao formations, but they are probably present; this can be settled, however, only by future field work.

COMMENTS ON THE GEOGRAPHIC DISTRIBUTION OF THE ORDOVICIAN

The distribution of the Canadian and Ordovician formations in the Kuantung, Pechili, and Tai-tzu-ho districts, described in the preceding pages, is shown graphically in the accompanying chart (p. 31). Several significant facts are apparent from a brief perusal of it. In the first place the Canadian Santao formation is lacking in the Kuantung and Pechili districts, at least so far as a fairly careful survey indicates. On the other hand, the Kangyao may have a wider distribution than my own collecting indicates, for while I found no characteristic fossils nor beds with the typical lithology, except in the Hsia-kang-yao and Wu-hu-tsui sections, T. Kobayashi reports the following species from three other areas:

From near Pen-hsi-hu:

Lophospira trochiformis Grabau.
Lophospira gerardi Grabau.
Pagodispira derwiduii Grabau.

From near Niu-hsin-tai:

Lophospira acuta Grabau.
Lophospira trochiformis Grabau.
Lophospira morrisi Grabau.

From Wu-hu-tsui (Actinoceras zone):

Lophospira morrisi Grabau.
Lophospira gerardi Grabau.
Pagodispira derwiduii Grabau.

These fossils belong to Kobayashi's Toufangkou fauna, which he correlates with Grabau's Machiakou limestone and which both of these authors consider typical North American Black River fauna. Even though only one species is common to Kobayashi's Toufangkou and my Kangyao faunas, it is apparent from a brief study that the Kangyao is to be regarded as equivalent to the lower part of Kobayashi's Toufangkou formation. It is reasonable, therefore, to

assume that the Kangyao is likely also present in the Pen-hsi-hu and Niu-hsin-tai areas. The fact that I also found a number of gastropods belonging to *Lophospira* or *Eotomaria* in the lower part of the Ordovician strata in these two areas may at least support the opinion that the Kangyao is represented in other areas of the Taitzu district.

Furthermore, in my opinion the fossil that Kobayashi identifies as *Pagodispira derwiduii* Grabau is *Lophospira producta pagodai.*

		Kuantung district	Pechili district	Tai-tzu-ho district	
		Kan-tao-tzu subdistrict	Wu-hu-tsui subdistrict	Liaoyang-Yentai subdistrict	Penhsihu-Niuhsintai subdistrict
Ordovician	Middle	Ssuyen.	Ssuyen.	Ssuyen.	Ssuyen.
	Lower	Wuting.	Wuting.	Wuting.	Wuting.
		Absent.	Kangyao.	Kangyao.	Kangyao.
Canadian		*Absent.*	*Absent.*	Santao.	Santao.
Ozarkian		Pingchou.	Pingchou.	Pingchou.	Pingchou.

STRATIGRAPHIC CORRELATIONS

When the Canadian and Ordovician strata of South Manchuria are compared with those of North China, there is no doubt that the upper and middle parts of the Machiakou limestone, in the Kaiping Basin, Chihli, are the equivalent of the Ssuyen formation, and in general both faunas have quite intimate relations with the Black River formation of North America. The following five species are common to both the Machiakou and Ssuyen faunas:

Armenoceras coulingi (Grabau).
Armenoceras nanum (Grabau).
Armenocerus richthofeni (Frech).
Armenoceras tani (Grabau).
Cycloceras? peitoutzense Grabau.

And the following paired species resemble one another closely:

Ssuyen Formation	Machiakou Limestone
Armenoceras asiaticum, new species.	*Armenoceras tani* (Grabau).
Armenoceras elongatum, new species.	*Armenoceras submarginale* (Grabau).
Armenoceras hatai, new species.	*Armenoceras coulingi* (Grabau).
Armenoceras hayasakai, new species.	*Armenoceras suanpanoides* (Grabau).
Armenoceras magnitubulatum, new species.	
Ormoceras orientale, new species.	

Grabau has described *Lophospira* and *Liospira*, together with characteristic Black River fossils, from the Machiakou formation, while Kobayashi identifies the same forms in the Toufangkou. The vertical range of these genera is very great, extending from the Canadian to the Richmond, but, since the gastropods found in the Ordovician strata of North China and South Manchuria, as well as North Korea, are more like those of the Mosheim stage of the Stones River, and, furthermore, since I have possibly the identical species in the Kangyao formation, my conclusion is that Grabau included some Stones River in the base of his Black River Machiakou formation. Such a mistake is easily made, since all outcrops of Canadian and Ordovician strata in both North China and South Manchuria are deeply weathered limestones much obscured by talus, deep-cultivated soils, or grassy slopes. Consequently the fossils are usually collected from the talus or bowlders, which are liable to lead one into serious error. This condition may therefore explain the inclusion of the two faunas in the Machiakou of the Kaiping Basin and further strengthen the view that the lower portion of that formation may be equivalent to the Kangyao formation of Manchuria.

In Grabau's descriptions I have been unable to find any fossils that may be referred to the Wuting fauna; consequently, according to the evidence now available, it seems that rocks equivalent to the Wuting are not developed in North China. This question, however, needs further investigation in the field. On the other hand, part of the Lingchiashan limestone and the Peilintze formation as developed in the Shih-men-chai region, northeastern Chihli, apparently correlate with the Santao as indicated in the following list of the identified species:

PEILINTZE LIMESTONE:

Archaeocyathus chihliense Grabau.
Fusispira sp.
Piloceras platyventrum Grabau.

LINGCHIASHAN LIMESTONE:

Cameroceras styliforme Grabau.
Piloceras platyventrum Grabau.

SANTAO FORMATION:

Anthaspidella? radiata, new species.
Anthaspidella? planulata, new species.
Hormotoma sp.
Cameroceras styliforme Grabau.
Piloceras manchuriense, new species.

At first glance most of the fossils listed above seem to belong to different species, genera, or families, with little or no real identity. I believe, however, that a comparison of my specimens with Grabau's, which are not too well illustrated, will show that his *Archaeocyathus*, *Fusispira*, and *Piloceras* species are the same or very closely related to those described by me under the genera *Anthaspidella*, *Hormotoma*, and *Piloceras*.

Examination of the foregoing list indicates that the Peilintze formation has more forms in common with the Santao than has the Lingchiashan. I might add that considerable doubt exists as to the correlation of the Canadian strata in North China. For example, how can such a late Canadian form as *Piloceras* be found at two horizons so widely separated vertically as 416 m (from horizon F_3 of the Lingchiashan formation to F_1 of the Peilintze formation)?

The major characteristics of the Ordovician strata in Korea have been described by T. Kobayashi (1927); according to him, the faunal characters of the Bantatsu formation, which occurs 5 kilometers east of Heijo, and the Chikunsan fossil beds, about 180 kilometers east-southeast of Keijo (Seul), show remarkable differences, the former having intimate connection with the Ordovician strata in Manchuria. The same author later (1930) expresses his views as follows:

The fauna of group II [Unkaku bed] consists of a total of 30 species and 1 variety, of which 15 species and 1 variety are quite new to science, all the remainder being found in either the Machiakou or the Toufangkou fauna, or in both, so that the present fauna can readily be compared to that of Toufangkou and Machiakou.

Specific names	Toufangkou fauna	Machiakou fauna
Lophospira morrisi	×	×
Lophospira gerardi	×	×
Lophospira trochiformis	×	×
Pagodispira tetracarina	×	
Liospira barbouri		×
Eccyliopterus kushanensis		×
Maclurea tofangoense	×	
Cycloceras mantalense		×
Stereoplasmoceras pseudoseptum	×	×
Stereoplasmoceras submarginale	×	
Actinoceras richthofeni	×	×
Actinoceras submarginale	×	×
Actinoceras manchurense	×	
Actinoceras nanum	×	×
Ormoceras [*Actinoceras*] *suampanoides*	×	×
Ormoceras [*Actinoceras*] *tani*	×	×
Ormoceras [*Actinoceras*] *harioi*	×	×

Among the cephalopods in the fauna of Group II [Unkaku bed], the actinoceroids predominate as is usually the case with the Black River and Trenton series in the Arcto-American province. * * *

Among the gastropods, there are many species which more or less resemble those of the Stone River, Black River, and the Trenton fauna of North America, while a few species bear some resemblance to the Cincinnatian and Canadian species. * * *

Fossils from Group III [Bantatsuan bed].—Among the fragmentary fossils obtained from Group III is one specimen which belongs undoubtedly to *Stereoplasmoceras* sp. All the others are imperfect specimens of brachiopods.

Stereoplasmoceras is usually considered to be a characteristic genus of the Toufangkou-Machiakou limestone. Therefore Group III containing *Stereoplasmoceras* sp. appears paleontologically to be more closely related to the Toufangkou-Machiakou series than to the Lianchiashan series containing Piloceras fauna.

It is quite clear from this that the Unkaku fauna includes forms typical of the Ssuyen and Kangyao faunas. At the present time, however, the question remains as to whether the Wuting fauna is not also included in Kobayashi's Unkaku or Bantatsuan fauna.

Finally, the relationships of the Canadian and Ordovician faunas in South Manchuria and North America should be discussed. Most of the species described in this monograph are new, but are usually closely allied to North American species. Only a very few are common to the two continents. The few identical forms and the large number of allied species in these two widely separated regions, however, leave little chance for doubt as to at least the general correlation.

The Manchurian Ssuyen fauna contains many cephalopods, such as *Armenoceras*, *Ormoceras*, and *Sactoceras*, which have the very characteristic features of Black River forms, in that they have comparatively broad actinoceroid siphuncles, and, of course, *Maclurites bigsbyi* (Hall) and *Maclurites nitida* (Ulrich and Scofield) are exactly the same as North American Black River species. *Camarocladia arborescens*, *C. fucoides*, and *C. plana*, which have been collected from the top of the Ssuyen formation, are closely similar to *Camarocladia dichotoma* Ulrich and Everett and *C. rugosa* Ulrich from typical Black River beds. Since the uppermost horizon of the Ssuyen formation, which has yielded *Camarocladia*, is overlain by Carboniferous variegated siliceous shales, and, furthermore, since *Stromatocerium regulatum*, which makes up thick limestone beds near the base of the Ssuyen formation, near Pen-hsi-hu, shows very intimate relationships with *Stromatocerium rugosum* Hall, Kobayashi insists that the Tofango-Machiakou formations represent both the Black River and Trenton groups of North America. According to the evidence discussed above, however, it is quite apparent that the Ssuyen is equivalent to the Black River and does not include any Trenton.

As most of the species from the Manchurian Wuting formation are new or too imperfect for exact determination, it seems undesirable to fix the age of the Wuting formation too definitely; but the general characters of the fauna are similar to those of the Athens group of the Upper Chazyan in North America. Moreover, further evidence for an Athens age of the Wuting lies in the fact that it is always directly overlain by the Ssuyen.

The Kangyao fauna of Manchuria is particularly characterized by the abundance and variety of gastropods, chiefly *Lophospira*, which, of course, features the Mosheim group of the Stones River

in North America. If the illustrations of the Kangyao fossils in the accompanying plates are compared with those from the Mosheim limestone figured by Butts, the great similarity of the two faunas is at once apparent.[2]

The following four species are very characteristic of the Manchurian Santao formation:

Anthaspidella ? radiata, new species.
Anthaspidella ? planulata, new species.
Calathium frechi, new species.
Piloceras manchuriense, new species.

Even though all these are new, the *Anthaspidella*-like species and the genus *Piloceras* are very characteristic of the uppermost Canadian in North America. Therefore, it may be assumed that the Santao formation is likely contemporaneous.

As stated in the introductory chapters, I was permitted to study some new Ordovician fossils from central China. From this study it is clear that the Ordovician strata of southern Shensi and northern Szechwan Provinces have quite different faunal successions as compared with Chihli and South Manchuria. No fossils from strata referable to the Black River group have yet been collected in Szechwan and Shensi. On the contrary, it is remarkable that the Upper Ordovician *Cryptolithus* zone (*Trinucleus*) occurs in both Provinces. As far as known, this Upper Ordovician zone is absent in North China and South Manchuria.

To sum up and clarify the discussion in the preceding pages, a generalized correlation table showing the Canadian and Ordovician strata in North China, South Manchuria, North Korea, and North America follows:

		North America	North China (Kaiping Basin)	North China (Shihmenchai)	South Manchuria	North Korea
Ordovician	Middle	Black River.	Machiakou.		Ssuyen.	Nanso (?)
	Lower	Blount (Athens).			Wuting.	Unkaku.
		Stones River (Mosheim).			Kangyao.	Bantatsuan (?)
Canadian		Uppermost Canadian.		Lingchiashan. Shihmenchai. Peilintze.	Santao.	(Maruyama zone)? Shorin zone ?
Ozarkian					Pingchou.	Kogen fossil zone ? (Tokusen fossil zone).

[2] Butts, Charles, Geology of Alabama, p. 102, pl. 19, 1926.

PART 2: PALEONTOLOGY

INTRODUCTION

In the following pages will be found descriptions of the identifiable fossils obtained from the Canadian and Ordovician beds in South Manchuria, together with some Ordovician fossils from central China. With much more adequate stratigraphic data and with a greater quantity of carefully collected material, this more intensive study quite naturally finds certain previous determinations inadequate or erroneous. I had to make many changes of generic names, especially for the actinoceroid cephalopods.

The fossil descriptions are arranged in the accepted biologic order, but the illustrations are in a strictly stratigraphic sequence. This unorthodox arrangement is believed to be more convenient for reference by field workers.

SPONGIAE

Genus ANTHASPIDELLA Ulrich and Everett, 1890

ANTHASPIDELLA? RADIATA, new species

PLATE 30, FIGURES 7, 8

Description.—The entire specimen is funnel-shaped, the stem comparatively strong, subcylindrical, and narrowed below. It is penetrated by the more or less confluent and comparatively regularly distributed small canals, rarely more than 0.2 mm in diameter. On the top of the specimen, these small canal series generally radiate from the interior margin of the cup to the outer margin of the specimen and are spaced about 10 in 2 mm of the length of each transverse row. A vertical section of the specimen shows that the central portion of the stem is traversed by vertical canals opening into the base of the cup. These canals continue into the walls forming the cup, where the terminal parts of the canals curve gradually inward, opening into the cup cavity, and outward where they open on the outerside. In the vertical section, ciliated chamberlike cavities seem to occur here and there. The cup wall appears to consist of but one layer.

Height of specimen, 25 mm; diameter of stem, 24 mm; approximate diameter of the specimen at the top, 59 mm; approximate diameter at cup margin, 23 mm; depth of cup, about 14 mm; average thickness of cup wall, 14 mm.

Comparison.—This specimen may be compared with *Anthaspidella*(?) *magnifica* Ulrich and Everett from the Trenton group,

North America, but the Manchurian species usually has smaller dimensions, shallower cup, and a shorter stem.

Formation and locality.—Upper Canadian, Santao formation: In the dark-gray banded limestones above the second tunnel, 1 mile north, of Pen-hsi-hu, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83617.

ANTHASPIDELLA DISCOIDALIS, new species

PLATE 27, FIGURES 3, 4

Description.—Sponge moderately large, discoidal, flat, with a short stem. Outer margin subacute or rounded. The entire upper surface is marked by rather irregular but more or less radially arranged furrows, averaging 1.2 mm in diameter. Oscula rather few and indistinct. A vertical section shows that the tubes in the walls are continuous, running diagonally upward from the cup wall to the outer margin of the specimen.

Diameter of the specimen, 75 mm; height, about 12 mm; diameter of the cup, about 15.5 mm.

Comparison.—The discoidal shape, smaller cup, and rather irregularly radiating, comparatively wider canal system, serve readily to distinguish this from any of the known species.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestones west of Shang-kang-yao, 3 miles southeast of the Yen-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83618.

ANTHASPIDELLA? PLANULATA, new species

PLATE 31, FIGURES 7, 8

Description.—The entire specimen is disk-shaped with a very shallow and rather wide cup. The specimen is penetrated by more or less confluent and comparatively regularly distributed small canals, rarely more than 0.2 mm in diameter. At the top these small canals are arranged radially, extending from the interior margin of the cup to the outer margin of the specimen, and are spaced about eight in 2 mm of the length of each transverse row. A vertical section shows that the part beneath the cup and cup walls is traversed by vertical canals opening into the base as well as the sides of the cup. Comparatively few ciliated chamberlike cavities are found in the cup walls.

Height of specimen, 8.5 mm; diameter at the top, 74 mm; diameter of cup at cup margin, 27 mm; depth of cup, 4 mm; average vertical thickness of cup wall, 5.5 mm.

This specimen is characterized by its disk shape and wide, shallow cup.

Formation and locality.—Upper Canadian, Santao formation: A grayish limestone bowlder believed to have come from the Santao formation, in river drift at the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83619.

Genus CALATHIUM Billings, 1865

CALATHIUM FRECHI, new species

PLATE 30, FIGURE 9; PLATE 31, FIGURES 5, 6

Description.—Holotype specimen 40 mm long, rather cylindrical; its shorter and longer axes 21 and 26 mm, respectively. The cup is estimated at 14 mm in diameter at the top and 21 mm in depth; it gradually narrows downward and extends nearly to the middle of the specimen. A line divides the sponge wall into two layers, an inner one that has approximately an even thickness throughout the cup wall, and the outer one, which is on the whole thicker. Its greatest thickness is near the base, diminishing toward the top.

Both layers are interpenetrated by the pores, and the penetration extends farther into the inner than into the outer layer. The pores, or canal apertures, are round and arranged quite regularly, about six in 22 mm of the length of each vertical row, and five in 2 mm in the transverse rows.

A second specimen is 14.5 mm long, cylindrical; the diameters of the sponge wall and cup are estimated as 13 and 5.5 mm, respectively, at the base of the cup. The pores are round and are spaced about 5.5 in 2 mm of the length of each vertical row, and 5 in 2 mm in the transverse rows.

Comparison.—The general features of this species recall *Calathium canadense* Billings from the Chazy limestone, Mingan Island of North America, but the smaller pores and comparatively wider cup serve readily to distinguish it.

Formation and localities.—Upper Canadian, Santao formation: In the gray banded limestone above the second tunnel, 1 mile north of Pen-hsi-hu and in the black banded limestone, near Shang-kang-yao, 3 miles southeast of the Yen-tai colliery, Liao-tung, Manchuria.

Holotype and paratype.—U.S.N.M. Nos. 83620 and 83621.

Genus CAMAROCLADIA Ulrich and Everett, 1890

CAMAROCLADIA ARBORESCENS, new species

PLATE 10, FIGURES 3, 4

Description.—This sponge has a rather large subcylindrical stem with a diameter of about 11.5 mm along which large clusters of

smaller stems arise. The small stems are also subcylindrical, varying in diameter from 1.5 mm to 4.5 mm and in turn branching dichotomously many times at intervals of approximately 10 mm. The surface of the stems is apparently somewhat roughened, for when the preservation is good the surface is seen to be covered by very minute pores, which Ulrich and Everett regard as the interstices of the reticulate skeleton. Among these minute pores, a small number of comparatively larger ones may be detected, which I think are the openings of the canal system.

Sections show that the interior of the branches is mainly occupied by rather thick walls, which are now crystalline calcite and which preserve only very faint traces of the interwoven fiber skeleton. From Plate 10, Figure 3, it is clear that this species belongs to *Camarocladia*, having dichotomously branching stems, a minutely pored surface, and a faintly preserved interwoven fiber skeleton with a confluent canal system.

Comparison.—The Manchurian species is readily distinguished from the described American species by its general outline and the more complicated branching system of the stems, and from the other Manchurian forms in such fashion as described in each case.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the uppermost horizon of the black-banded limestone near the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83622.

CAMAROCLADIA FUCOIDES, new species

PLATE 10, FIGURES 1, 2

Description.—Sponge ramose, branching dichotomously at intervals of 7 mm, on an average. Branches subcylindrical with diameters varying from 1.3 and 2.5 mm. Parts of the surface of the stems are smooth, while others are somewhat roughened and irregularly porous. Among these minute pores larger ones may be detected.

Sections show that the interior of the branches is occupied by more or less confluent subcylindrical cavities and the separating partitions, which are composed of crystalline calcite, preserve only faint traces of the fiber skeleton. These cavities appear to be arranged rather regularly.

Formation and locality.—Same as preceding.

Holotype.—U.S.N.M. No. 83623.

CAMAROCLADIA PLANA, new species

PLATE 11, FIGURES 7, 8

Description.—Sponge flat and rather broad, branching dichotomously, the diameter of the stems varying from 2 to 6 mm. The surface of the stems is fairly smooth and is covered irregularly by countless microscopic pores with a few rather large ones. The general features of the section are identical with those in *C. fucoides.* Ulrich and Everett originally defined *Camarocladia* as "sponges consisting of small subcylindrical branching stems. * * *[3] This flattened specimen might, therefore, belong to another genus, but since both external and internal features, except only the flatness of the stems, practically coincide with like characters in the genotype, *C. dichotoma*, I have placed it in *Camarocladia.*

Formation and locality.—Same as preceding.

Holotype—U.S.N.M. No. 83624.

Genus STROMATOCERIUM Hall, 1847

STROMATOCERIUM REGULATUM, new species

PLATE 11, FIGURES 1–3

Description.—The specimens referred to this species form large hemispherical or subglobular masses, frequently 25 cm or more in diameter with a comparatively smooth surface on which the mamillary elevations are not so well marked. Under an ordinary magnifier the structure in vertical section is seen to consist of a succession of thin concentric layers resting on varying thicknesses of intermediate vesiculose tissue, and both structures are penetrated by vertical pillars. The pillars appear as rather short and narrow lines and are not continuous throughout the entire height of the coralline growth, but appear and disappear at irregular intervals. The pillars grow in fascicles, those of the same fascicle spreading upward and outward from the center of the fascicle toward the surface of the specimen. The tangential section exhibits rather irregularly arranged pores and shallow stellate furrows (astrorhizae), which radiate outward from several centers.

Comparisons.—In general, this species appears very much like *S. rugosum* Hall from the Black River formation of North America, but the comparatively more regular concentric layers, the rather more closely spaced intermediate vesiculose tissue, and the more pronounced pillars serve to distinguish it. On the other hand, this

[3] Ulrich and Everett, Geological survey of Illinois, vol. 8, p. 20, 1890.

species appears very much like *Stromatopora* (?) *manchuriensis* Yabe and Sugiyama, but differs from it in having comparatively more regular concentric and vertical layers while *S.* (*?*) *manchuriensis* presents a general vermicular aspect.

Formation and locality.—Middle Ordovician, Ssuyen formation: At the base of the lower fossil horizon of the black banded limestone, near Pen-hsi-hu, Niu-hsin-tai, and on the Fu-chin-kou ridge, Liao-tung, Manchuria.

Cotypes.—U.S.N.M. Nos. 83625 to 83627.

ECHINODERMATA

Genus CARABOCRINUS Billings, 1853–1856

CARABOCRINUS species undetermined

PLATE 33, FIGURE 13

Louderback's collection from central China contains one large, strongly marked plate of a crinoid, which bears the characteristic markings of the genus *Carabocrinus.* Even though this specimen (U.S.N.M. No. 83628) is only a single plate, I have illustrated it, as, so far as I know, this is the first discovery of this crinoid in the Orient.

Formation and locality.—Upper Ordovician: Near Chao-tien, Szechwan, China.

BRACHIOPODA

Genus ORTHIS Dalman, 1828

ORTHIS CHINENSIS, new species

PLATE 33, FIGURES 1–8

Description.—Shell subcircular to subquadrate in outline; length of hinge line about equal to width of shell; cardinal angles obtuse or subrectangular. Pedicle valve strongly convex, swollen; beak rather high, incurved; hinge area rather large, triangular. Brachial valve slightly convex, with a weak median depression widening anteriorly; beak small, inconspicuous, not raised; hinge area narrow, nearly at right angles to valve. Interior of brachial valve unknown.

The external surface of both valves is ornamented with a variable number of rounded, rather strong ribs, which increase in number from about the middle of the margin by both regular and occasional interpolation of one or two smaller ribs between each pair of the larger ones. Ribs curve back slightly on both sides toward cardinal angles. Ribs and interspaces crossed by some irregular concentric striae and usually marked with a number of longitudinal striae.

The dimensions of a nearly complete, medium-sized specimen (pl. 33, figs. 4, 8) are: Height of pedicle valve, 16 mm; height of brachial

valve, 13.5 mm; width of pedicle valve at hinge area, 19 mm; width of brachial valve at hinge area, 17.5 mm.

Comparison.—The general form of this species may be compared to *Orthis calligramma* Dalman, a well-known European form, but it is distinguished by the interpolation of the smaller ribs between each pair of the larger ones. In its surface ornamentation it resembles *O. intercostata* Portlock, a British species, but its general shape is different.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Cotypes.—U.S.N.M. No. 83629.

ORTHIS CHINENSIS MULTISTRIATA, new variety

PLATE 33, FIGURES 9–12

Several smaller shells associated with *Orthis chinensis* possess the same general characters, particularly the shape, contour, and type of ribbing, but the number of ribs is greater than in *O. chinensis*, and the interspaces are much narrower. Moreover, the size of this variety in general is smaller than *O. chinensis*, varying from 3 to 10 mm in length and from 4 to 12 mm in width.

Formation and locality.—Same as preceding.

Cotypes.—U.S.N.M. No. 83630.

ORTHIS SHENSIENSIS, new species

PLATE 34, FIGURES 1–8

Description.—Shell plano-convex, subquadrate, rounded to semi-elliptical; hinge line rather longer than or equal to width of shell; cardinal angle rectangular. Pedicle valve convex, swollen; beak rather high, incurved. Brachial valve flattened or slightly convex with comparatively weak median depression widening anteriorly; beak small, inconspicuous, not raised.

Interior of pedicle valve with isosceles triangle muscle scar, less clearly defined, composed of two narrow diductors inclosing adductors of about one-half the width of the scar.

Surface of valves ornamented with about 40 rounded and comparatively weak ribs of equal strength, which are spaced equidistant along the margin; about half the number of primaries, the others being intercalated in the interspaces or branching off the primaries at about one-fifth to one-half their length. Interspaces about the same as the width of ribs. Ribs and interspaces crossed by comparatively strong concentric lines. Ribs curve back slightly on both sides toward cardinal angles.

The dimensions of nearly complete, medium-sized specimen (pl. 34, figs. 2 and 6) are: Height of pedicle valve, 7.5 mm; height of

brachial valve, 6 mm; width of pedicle valve at hinge area, 9.5 mm; width of brachial valve at hinge area, 8.5 mm.

Comparison.—This species should be compared with Weller's *Dalmanella testudinaria* (Dalman) from the Ki-sin-ling limestone, Szechwan, China, but it is distinguished by the less swollen pedicle valve and the comparatively longer hinge line.

Formation and locality.—Ordovician: Huang-pa-yi, Shensi, China.

Cotypes.—U.S.N.M. No. 83631.

ORTHIS CALLIGRAMMA ORTHAMBONITES von Buch

PLATE 23, FIGURES 1, 2; PLATE 27, FIGURES 7–10

1828. *Orthis calligramma* DALMAN, Kongl. Vet.-Acad. Handl., for 1827, p. 114, pl. 2, fig. 3.

1845. *Orthis calligramma* DE VERNEUIL, *in* Murchison, de Verneuil, and de Keyserling, Géologie de la Russie d'Europe et des montagnes de l'Oural, vol. 2, pt. 3, p. 207, pl. 13, figs. 7 *a–f*, and var. *orthambonites* VON BUCH, ibid., figs. 8 *a–g*.

1868. *Orthis calligramma* DAVIDSON, British Fossil Brachiopoda—Silurian, vol. 3, p. 240, pl. 35, figs. 18a, 19.

1883. *Orthis calligramma* KAYSER, *in* von Richthofen's China, vol. 4, p. 40, pl. 3, figs. 10–13.

1901. *Orthis calligramma* var. *serica* MARTELLI, Boll. Soc. Geol. Ital., vol. 20, p. 297, pl. 4, figs. 1–4; var. *davisoni* Martelli, idem, p. 301, pl. 45, figs. 5, 6.

1913. *Orthis calligramma* WELLER, Research in China, vol. 3, Carnegie Inst., Washington Publ. 54, p. 282, pl. 25, figs. 3–6.

1922. *Orthis calligramma* var. *orthambonites* VON BUCH, Grabau, Pal. Sinica, ser. B, vol. 1, fasc. 1, p. 15, pl. 1, figs. 6 *a–d*, 4 *a–c*.

Grabau recently gave a detailed description and discussion of this variety. The Manchurian specimens, though the majority are broken, agree in all essentials with his figures.

Surface of the shell is marked by about 19 strong regular rounded ribs, the interspaces between ribs not occupied by longitudinal ribs; very obscure, fine, concentric growth lines cross the radiating ribs and interspaces.

The dimensions of two nearly complete specimens, which are illustrated in this paper, are as follows: Height of pedicle valve, 9 mm; width, 10.5 mm; height of brachial valve, 6 mm; width, 9 mm.

Formation and locality.—Lower Ordovician, Kangyao and Wuting formations: In the black banded limestones vicinity of Shang-kang-yao, 3 miles south of the Yen-tai colliery, Liao-tung. In the sandy limestone beds of the Wuting formation on the top of Wu-ting hill, 3 miles south of the Yen-tai colliery, and in the same beds in the vicinity of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Plesiotypes.—U.S.N.M. Nos. 83632–83634.

Genus DALMANELLA Hall and Clarke, 1889

DALMANELLA TESTUDINARIA (Dalman)

PLATE 34, FIGURES 9–12

1828. *Orthis testudinaria* DALMAN, Kongl. Vet.-Acad. Handl., for 1827, p. 115, pl. 2, fig. 4.
1847. *Orthis testudinaria* HALL, Palaeontology of New York, vol. 1, p. 117, pl. 32, fig. 1; p. 288, pl. 79, fig. 4.
1863. *Orthis testudinaria* BILLINGS, Geology of Canada, p. 165, fig. 144.
1869. *Orthis testudinaria* DAVIDSON, British Fossil Brachiopoda-Silurian, vol. 3, p. 226, pl. 28, figs. 13–24.
1882. *Orthis testudinaria* WHITFIELD, Geology of Wisconsin, vol. 4, p. 258, pl. 12, figs. 5–7.
1884. *Orthis testudinaria* WALCOTT, Mon. U. S. Geol. Surv., vol. 8, p. 72, pl. 11, fig. 10.
1892. *Dalmanella testudinaria* HALL and CLARKE, Palaeontology of New York, vol. 8, pt. 1, pp. 190, 206, 218, 224, pl. 5B, figs. 27–39.
1893. *Orthis* (*Dalmanella*) *testudinaria* WINCHELL and SCHUCHERT, Minnesota Geological Survey, vol. 3, pt. 3, pp. 177, 241.
1897. *Orthis testudinaria* SARDESON, Amer. Geol., vol. 19, p. 92.
1903. *Dalmanella testudinaria* WELLER, Paleontology of New Jersey, vol. 3, p. 155, pl. 10, figs. 1, 2.
1913. *Dalmanella testudinaria* WELLER, Research in China, vol. 3, Carnegie Inst. Washington Publ. 54, p. 283, pl. 25, figs. 12–16.

The general characters and internal features of the several small shells collected by Louderback from Szechwan, agree quite well with representatives of the same species from North America.

When Weller's specimens from the Ki-sin-ling limestone, Szechwan, are compared with authentic specimens of *D. testudinaria*, the only Asiatic species thus far described, they appear on the average smaller, shorter, and more compressed. Consequently, I believe Weller's specimens may belong to another species or variety of *Dalmanella*.

Formation and locality.—Ordovician: Near Chao-tien, Szechwan, China.

Plesiotypes.—U.S.N.M. No. 83635.

DALMANELLA (?) species undetermined

PLATE 22, FIGURES 11–13; PLATE 23, FIGURES 3–7

A number of small brachiopod shells are in my Manchurian collection, the generic characters of which closely coincide with *Dalmanella*, but they are too poor to identify specifically.

Shells small, subequally biconvex, semicircular in outline. There is a more or less conspicuous, undefined median fold and sinus on the pedicle and brachial valves, respectively. Surface covered with fine, radiated bifurcating striae. U.S.N.M. No. 83636.

Formation and locality.—Lower Ordovician, Wuting formation: In gray banded limestone near Ta-pu, just north of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Genus RAFINESQUINA Hall and Clarke, 1892

RAFINESQUINA PUTEATA, new species

PLATE 34, FIGURES 22–24

Description.—This species is represented by two pedicle valves, both more or less incomplete. Shell semielliptical, gently convex; hinge line equal to width of shell; cardinal angle rectangular or slightly obtuse; hinge line not denticulate; beak small, scarcely rising above hinge line. Surface of valve covered with numerous subequidistant regular, straight, threadlike, primary radii of equal strength, some continuous from beak to margin, others originating at half or less than half their length; interspaces with 2 to 4 very fine, threadlike lines; whole surface of shell crossed by very delicate concentric lines. Substance of shell finely and densely pitted.

Comparisons.—The general outline of this species resembles *Rafinesquina alternata* (Emmons), an American species from the Trenton–Richmond groups, but the pitted surface and the finer radiating lines between the primary riblets serve to distinguish it readily. Also the English variety *Rafinesquina expansa marcallumi* Reed, from the Stinchar limestone group, bears a close resemblance but differs from the new species in having punctated instead of the pitted surface.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Cotypes.—U.S.N.M. No. 83637.

RAFINESQUINA species undetermined

PLATE 23, FIGURES 8, 9

Several poorly preserved specimens of *Rafinesquina* (U. S. N. M. Nos. 83638 and 83639), in size, outline, convexity, degree of geniculation anteriorly, and manner of striation appear to be closely allied to *R. alternata* (Emmons), from the Ordovician strata of North America. One of the most complete specimens from the Hsiao-shih district is a pedicle valve, 21.5 mm long and 25 mm wide with a convexity of 4 mm. The surface of the shell is marked by numerous radiating striae, alternating in size, with from one to four finer striae lying between the coarser ones. These radiating striae are crossed by finer concentric lines.

The outlines of the specimen from Hsiao-shih (pl. 23, fig. 9) and the one from Wu-hu-tsui (pl. 23, fig. 8) differ somewhat, and it is possible that they may represent different species or varieties.

Formation and locality.—Lower Ordovician, Wuting formation: In the black banded limestone in the vicinity of Hsiao-shih and the Wu-hu-tsui coal field, Liao-tung, Manchuria.

Genus PLAYFAIRIA Reed, 1917

PLAYFAIRIA cf. DELTOIDEA (Conrad)

PLATE 11, FIGURE 4–6.

1839. *Strophomena deltoidea* CONRAD, 3d Ann. Rep. New York Geol. Surv., p. 64.
1892. *Rafinesquina deltoidea* HALL and CLARKE, Palaeontology of New York, vol. 8, pt. 1, pl. 9A, figs. 1, 2, 4.
1917. *Rafinesquina* (*Playfairia*) *deltoidea* REED, Trans. Roy. Soc. Edinburgh, vol. 51, pt. 4, p. 866, pl. 11, figs. 21–30.
1920. *Rafinesquina deltoidea* FOERSTE, Bull. Sci. Lab. Denison Univ., vol. 19, no. 3, p. 200, pl. 21, figs. 2, 3; pl. 22, figs. 2, 3.

A single pedicle valve of a brachiopod, which I collected in Manchuria, is closely related to *Playfairia deltoidea* from the Trenton formation at Jacksonburg, N. Y., as may be seen from Figures 4 and 5 of Plate 11. The Manchurian specimen is 23 mm wide and about 27 mm long, and has a convexity of 8 mm.

In comparing the Manchurian specimen (U.S.N.M. No. 83640) with one figured by Foerste in 1920, I find no differences, and I therefore assume that the Manchurian form may be the same species. I hesitate, however, to say definitely that they are identical, because the Manchurian specimen is the only one found and occurs at a locality so very remote from North America. In view of this fact, I tentatively refer it to Conrad's species, hoping to get better specimens later.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon in the black banded limestones just north of the Pen-hsi-hu colliery, Liao-tung.

Genus PTYCHOGLYPTUS Willard, 1928

PTYCHOGLYPTUS ULRICHI, new species

PLATE 35, FIGURES 1–6

Among the material collected by George D. Louderback from Shensi, China, are a number of very fine brachiopods, which, from the general form of the shell and very fine and numerous transverse rugae, are referable to the genus *Ptychoglyptus*.

Description.—Shell comparatively small, semicircular to subsemicircular, almost flat, widest at the hinge, nearly two-thirds as long as wide. Surface of valves marked with 11 to 15 fine straight primary radii, equidistant and of equal strength, separated by wide flat interspaces. At half or four-fifths the length and midway between the primaries an almost equally strong but shorter secondary

radius is intercalated. These principal striations are not so distinct near the cardinal angles. The interspaces between principal striations are crossed by wavelike wrinkles, the crests about as wide as the troughs. There are about 20 crests in 5 mm on the anterior part of the shell. Each wave is steeper on the front than on the back slope. A wrinkle sometimes includes two adjacent interspaces between the ribs but usually alternate so that one interspace is a crest, while the next is the trough of the wrinkle. Near the cardinal angles, each wrinkle is more apt to involve several interspaces.

The pedicle valve is very convex on the umbo, becoming flattened toward the anterior margin or sometimes slightly concave near the front. Brachial valve flat, beak of both valves inconspicuous. Interior of valves unknown.

Average length, 11 mm; average width at hinge line, 15 mm.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Holotype and paratypes.—U.S.N.M. No. 83641.

Genus CLITAMBONITES Pander, 1830

CLITAMBONITES HEMISTRIATUS, new species

PLATE 35, FIGURES 7–12; PLATE 36, FIGURE 1

Description.—Shell semicircular; hinge line straight, almost equal to maximum width of shell; cardinal angles usually right angles. Pedicle valve moderately elevated at the beak, the surface sloping from the umbo to the anterior and antero-lateral margins with a slightly convex curve, sometimes becoming a little concave as it approaches the anterior margin; the slope to the cardinal extremities somewhat more abrupt; hinge area moderately large and triangular with a comparatively large triangular delthyrium. Brachial valve moderately convex; beak small, inconspicuous, not elevated; hinge area very narrow.

Ornamentation of valves is very characteristic; outer surface of each valve marked by many fine radiating costae, five or six of which occupy the space of 1 mm; inner surface of both valves, on the contrary, marked with comparatively lesser, fine straight primary radii, equidistant and of equal strength, separated by rather wide interspaces. These primary striations are separated by interspaces 0.5 mm to 1 mm wide, which are occupied by a number of minute, but very fine, longitudinal striations.

The dimensions of a pedicle valve are: Length, 12 mm; width, 14 mm. The dimensions of a brachial valve are: Length, 10.5 mm; width, 13.5 mm.

Comparison.—In its general outline this shell may be compared to *Clitambonites chinensis* Weller from the Ki-sin-ling limestone, Sze-

chwan, central China, but its peculiar ornamentation easily distinguishes it.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Cotypes.—U.S.N.M. No. 83642.

Genus PIONODEMA Foerste, 1909

PIONODEMA PUNCTOSTRIATA, new species

PLATE 36, FIGURES 2–8, 15

Four pedicle and three brachial valves constitute the material on which this new species is based.

Description.—Shell subcircular or subelliptical, unequally biconvex; hinge line equal to or slightly less than width of shell; cardinal angles rectangular or obtuse. Pedicle valve strongly convex, swollen; beak rather high, incurved, hinge area rather large. Brachial valve gently convex, with very shallow median sinus; beak small, low, inconspicuous; hinge area narrow. Interior of both valves not clearly observed.

Surface of valves ornamented with numerous ribs, which are very regular, close, filiform, and rounded, increasing by unequal bifurcation or by occasional intercalation at one-fourth to one-half their length. Ribs curve back slightly on both sides toward cardinal angles. Ribs, or sometimes interspaces between the ribs, are covered by rows of very beautiful circular superficial punctae.

The dimensions of two pedicle valves are: Length, 14 and 13 mm; width, 15 and 14 mm at hinge area. The dimensions of two brachial valves are: Length, 9.5 and 8 mm; width, 11 and about 9.5 mm at hinge area.

Comparison.—The general shape of the shell is much like that of *Pionodema* [*Dalmanella*] *subaequata* (Conrad) from the Ki-sin-ling limestone, central China, described by Weller, but it is easily distinguished by its peculiar ornamentation and by the beautiful circular superficial punctae. This characteristic ornamentation also serves to distinguish this species from the others of the genus.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Cotypes.—U.S.N.M. No. 83643.

Genus POLYTOECHIA Hall and Clarke, 1892

POLYTOECHIA CHINENSIS, new species

PLATE 34, FIGURES 13–21

Four pedicle valves and one brachial valve constitute the material on which this new species is based.

Description.—Shell small, broader than long, subelliptical to quadrilateral, the hinge line about one-half as long as the width of the shell, the cardinal extremities rounded. Pedicle valve moderately convex on the umbo, with a broad and profound mesial sinus toward the front, the surface of the valve anteriorly, which slopes toward the sinus, being about one-third the total width of the shell; the beak is rather small and slightly incurved. Brachial valve rather convex, most prominent along the median line, mesial fold broad and scarcely differentiated from the lateral slopes; beak small, slightly incurved.

As is seen in Plate 34, Figures 17 and 18, this species is characterized by having a spondylium supported by a stout median septum and two smaller lateral septae.

External surface of both valves ornamented by rather broad, concentric undulations and very fine radiating striae; very fine concentric striae occur on the interspaces between the raised undulating lines.

The dimensions of a pedicle valve are: Length, 8 mm; width, about 10 mm.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Cotypes.—U.S.N.M. No. 83644.

POLYTOECHIA? TAPUENSIS, new species

PLATE 31, FIGURE 1

Of this species only a single, somewhat imperfect, pedicle valve is known, which, because it has the characteristic spondylium, may be identified as a member of the genus *Polytoechia.*

Description.—Shell transversely semicircular in outline, wider than long, the hinge line straight, shorter than the width of shell; cardinal angle obtuse.

The umbonal cavity of this valve is somewhat broken, so that the features can not be clearly seen, but the spondylium appears to be supported by a number of septae, and the umbonal cavity of the valve may be divided into several chambers.

Valve moderately convex, surface covered with fine radiating striae and undulating, concentric growth lines, without evidence of a median sinus.

The dimensions of a single specimen are: Length, about 9 mm; width, 11.5 mm.

Formation and locality.—Upper Canadian, Santao formation: In the gray banded limestones near Ta-pu, just north of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83645.

Genus YANGTZEELLA Kolarova, 1925

YANGTZEELLA RETICULATA, new species

PLATE 36, FIGURE 9

One good pedicle valve and a cast of another occur in Louderback's collection from central China.

Description.—Shell medium, semicircular; hinge line perhaps straight, about equaling the diameter of the shell. Pedicle valve convex, smaller, rather prominent along the median line, mesial fold being about one-half of the total width of the shell and scarcely differentiated from the lateral slopes; beak comparatively small, slightly incurved. The spondylium is supported by a median and two lateral septae.

External surface of valve ornamented by very fine radiating and concentric striae, which make a very fine netlike reticulation.

The dimensions of a pedicle valve are: Length, 22 mm; width, 27 mm.

Comparisons.—This species may be compared with *Yangtzeella poloi* (Martelli) from central China, but it is distinguished from it by the rounded and more convex shell and the fine surface ornamentation.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Holotype.—U.S.N.M. No. 83646.

GASTROPODA

Genus PHRAGMOLITES Conrad, 1838

PHRAGMOLITES, species undetermined

PLATE 23, FIGURE 10

A single small specimen of gastropod (U.S.N.M. No. 8347) was collected from the Wuting formation. Even though this specimen is small, it shows characteristic features of the genus *Phragmolites* and appears to belong to a new species. Though it is too fragmentary to deserve a specific name, I shall describe it as far as possible.

Description.—Shell small, 5.5 mm in diameter, laterally compressed, consisting of two and a half volutions; whorls slightly wider than the height, somewhat depressed, rounded in sections, gently convex on the sides. Surface very rough and strongly undulated, about nine lamellae crossing the last whorl almost directly, about 1 mm apart. Between lamellae the whorls are marked by very fine lines of growth, which run parallel to the lamellae.

Formation and locality.—Lower Ordovician, Wuting formation: Black banded limestones near Tai-chia-pu-tzu, 2 miles west of Chiao-tou station, Liao-tung, Manchuria, China.

Genus OXYDISCUS Koken, 1889

OXYDISCUS PLANULATUS, new species

PLATE 23, FIGURES 11, 12

A single rather good specimen constitutes the material on which this new species is based.

Description.—Shell flat; dorsum acutely carinated; greatest diameter 25 mm; greatest thickness or width about 5 mm. Volutions four and one-half, thickest near umbilicus, from which the surface descends by a rather flat slope to the sharp periphery, each volution embracing one-third of the preceding one; umbilicus exposing all the whorls, its width about one-half of the diameter of the shell; edge of umbilicus very obtuse. Aperture not observed. Surface marked by fine and distinct lines of growth which curve strongly backward toward the peripheral carina.

This species is distinguished quite easily from the other species of *Oxydiscus* by its very flat shell and large shallow umbilicus.

Formation and locality.—Lower Ordovician, Wuting formation: In the black banded limestomes just north of Tai-chia-pu-tzu, 2 miles west of Chiao-tou station, Liao-tung.

Holotype.—U.S.N.M. No. 83648.

Genus RAPHISTOMA Hall, 1847

RAPHISTOMA cf. AEQUILATERUM Koken?

PLATE 23, FIGURES 14–18; PLATE 27, FIGURES 1, 2

1911. *Raphistoma* cf. *aequilaterum* KOKEN, Frech, *in* von Richthofen's China, vol. 5, p. 12, pl. 3, figs. 6a–8b.

Von Richthofen, on his well-known Chinese expedition, collected two specimens of *Raphistoma* at Hsiau-sorr (Hsiao-shih?) along the Tai-tzu-ho River, which were later identified by Frech as *Raphistoma* cf. *aequilaterum* Koken. I collected a number of specimens of *Raphistoma* (U.S.N.M. Nos. 83649–83651), which, judging from the published figures and description, are close to this form.

Description.—Shell of medium size, consisting of about four volutions which at first enlarge gradually then rapidly in the last whorl. Whorls very gently convex; umbilicus wide with depressed side; section of whorl lenticular and with such a sharp peripheral angle that the marginal carina is scarcely perceptible. The successive whorls embrace the lower half of each inner one. A medium-sized

specimen attains a largest diameter on the upper suface of 35 mm; the width of the aperture is 12 mm, that of the next adjoining whorl 6 mm, while the specimen is 11 mm high at the aperture.

Formation and localities.—Lower Ordovician, Wuting formation: In the sandy limestones on the top of Wu-ting hill, 3 miles south of the Yen-tai colliery, Liao-tung. In the same beds in the vicinity of the Pen-hsi-hu colliery and Yung-ning-cheng, 4 miles east of Pen-hsi-hu, Liao-tung. It also occurs in the black banded limestone near Hsia-kang-yao, 3.5 miles southeast of the Yen-tai colliery, Liao-tung.

Genus LOPHOSPIRA Whitfield, 1886

LOPHOSPIRA AOJII, new species

PLATE 28, FIGURES 1–3, 12, 13; PLATE 29, FIGURE 1

Description.—Height, 12.5 to 20.5 mm; apical angle, about 55°. Volutions about five (uppermost parts of specimens are somewhat broken); periphery trilineate, very prominent; upper slope, without carina, nearly flat or very gently concave, lower side decidedly concave; lower carina distinct although not prominent. Surface markings are well preserved and curve strongly backward to the peripheral band. Aperture quadrilateral, diagonally elongated, umbilicus apparently closed.

The specific name is given in honor of O. Aoji, of the Tahoku Imperial University in Japan.

Comparisons.—This species may be closely allied to *L. pulchelliformis* Grabau, the Chinese species from the Machiakou limestone, but the narrower apical angle and more feeble lower carina serve in distinguishing it.

Formation and locality.—Kangyao formation: In the black banded limestones in the vicinity of Shang-kang-yao, 3 miles south of the Yen-tai colliery, Liao-tung.

Cotypes.—U.S.N.M. No. 83652.

LOPHOSPIRA GRABAUI, new species

PLATE 28, FIGURES 4, 5

Description.—Height, 10 to 15 mm; apical angle, about 80°. Volutions five, the last very large, the whorls extending to the peripheral angulation; upper surface without carina, moderately concave; peripheral band comparatively thick, probably trilineate; lower carina not so distinct but clearly preserved; lower slope inclining inward, being first concave and then convex. Surface markings on the upper surface curve backward to the peripheral band; those of the lower slope, on the contrary, pass in a somewhat

vertical direction to the lower carina, from which they curve backward to the umbilicus. Aperture elongated, round; umbilicus small.

The specific name is given in honor of Dr. A. W. Grabau, of Peiping University in China.

Comparisons.—This species appears to be closely related to *L. trochiformis* Grabau, from the Machiakou limestone in Chihli, but it is distinguished by a wider apical angle, presence of a lower carina, and characteristic surface markings. It also resembles *L. tropidophora* (Meek), an American species from the Cincinnatian, but has a smaller umbilicus, and different surface markings, and the whorl is more strongly developed so as to cover entirely the preceding one.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestones in the vicinity of Shang-kang-yao, 3 miles south of the Yen-tai colliery, Liao-tung.

Holotype.—U.S.N.M. No. 83653.

LOPHOSPIRA KANGYAOENSIS, new species

PLATE 28, FIGURES 14–17

1930. *Lophospira morrisi* KOBAYASHI (not Grabau), Jap. Journ. Geol. and Geogr., vol. 7, nos. 3, 4, p. 87, pl. 9, fig. 6.

Description.—Height, 11 mm; apical angle, about 64°; volutions five, the last very large. Whorls inclosed to within a very short distance of the peripheral carina; upper surface concave; lower slope inclining inward; upper carina somewhat thick, close to the suture. Peripheral band prominent, trilineate. The surface markings, which are well preserved, turn backward to the peripheral band.

Comparisons.—This species is closely related to *L. grabaui* but is distinguished by its smaller apical angle, the presence of an upper carina, and comparatively lesser inclosing of the preceding whorl. It is also closely allied to *L. sumnerensis* Safford, an American species from the upper Trenton, but has a lesser convexity of the upper slope, and the upper carina and surface markings are less distinct.

Although the picture of Kobayashi's *L. morrisi* Grabau is too poor to permit a complete understanding of its characteristics, it seems to me it is completely different from Grabau's type, as it has a larger apical angle and thus agrees with *L. kangyaoensis.*

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestones near Shang-kang-yao, 3 miles south of Yen-tai, Liao-tung, Manchuria.

Holotype.—U. S. N. M. No. 83654.

LOPHOSPIRA MANCHURIENSIS, new species

PLATE 28, FIGURES 6–11

Three well-preserved specimens of this new species occur in my Manchurian collection.

Description.—Height, 7 to 15 mm; apical angle, about 60°; volutions about six, angular; periphery trilineate, moderately prominent; upper or subsutural carina small and very close to the suture; lower carina comparatively sharp and strong. The upper slope is a little concave, while the lower side slopes inward, and the basal part of the shell is somewhat ventricose. Surface markings are very fine and consist of transverse and revolving lines, the former curving strongly backward toward the peripheral band, while the latter are inclined to be irregular and more delicate. Aperture is rather round, and inner lip is reflected and covers the umbilicus.

Comparisons.—This species is undoubtedly closely related to *L. spironema* Ulrich and Scofield, an American species from the Black River, but the nearness of the upper carina to the suture and greater irregularities of the revolving lines serve readily to distinguish it. It is also closely allied to *L. tenuistriata* Ulrich and Scofield, another American species from the Utica group, but differs in having a more prominent lower carina, finer spiral lines, and sharper peripheral band.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestones in the vicinity of Shang-kang-yao, 3 miles south of the Yen-tai colliery, Liao-tung.

Cotypes.—U.S.N.M. No. 83655.

LOPHOSPIRA cf. OWENI Ulrich and Scofield

PLATE 29, FIGURES 2, 3

1897. *Lophospira oweni* ULRICH and SCOFIELD, Geology of Minnesota, Paleontology, vol. 3, pt. 2, p. 980, pl. 73, figs. 41–45.

I collected a single, but comparatively good, specimen (U.S.N.M. No. 83656) from the Kangyao formation that is very similar to *Lophospira oweni* Ulrich and Scofield.

Description.—Height, 21.5 mm; apical angle, 60°; volutions about five. Peripheral band prominent, thick and rounded. Upper slope slightly concave, except near the suture where there is a rather low, rounded ridge. Lower side sloping inward, and moderately ventricose. Surface markings, which are clearly retained in parts of the specimen, consist of rather fine lines of growth, all curving backward to the peripheral band. Aperture is rounded oval, the inner lip reflected and covering the umbilicus.

Comparisons.—As is seen from the above description, my specimen is nearly identical with *Lophospira oweni* Ulrich and Scofield.

Nevertheless, the Manchurian specimen differs in one or two minor details, namely, in having finer surface markings and a more feeble ridge near the suture. If in the future I am able to get more and better specimens, a more detailed comparison with the American species may prove whether this species is identical with *L. oweni*. At present, it does not appear wise to attempt to identify them as the same. I have therefore described this as an allied species.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestones in the vicinity of Shang-kang-yao, 3 miles southeast of the Yen-tai colliery, Liao-tung.

LOPHOSPIRA PRODUCTA PAGODAI, new variety

PLATE 29, FIGURES 8–11

A single rather good specimen and several fragments constitute the material on which this new variety is based.

Description.—Height, about 24 mm; largest diameter about 10 mm; apical angle, 32°; volutions, about seven.

This variety agrees in all respects with *Lophospira producta* Ulrich, from the Upper Trenton group in North America, except that the peripheral band has a little higher position and there is a closed umbilicus.

Comparison.—This variety is related to *Pagodispira derwiduii* Grabau from the Machiakou limestone in Chihli, being distinguished by a wider upper slope and comparatively deeper inclosing of the whorls.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestones in the vicinity of Shang-kang-yao, 3 miles south of the Yen-tai colliery, Liao-tung.

Holotype and paratype.—U.S.N.M. No. 83657.

LOPHOSPIRA TURRITIFORMIS, new species

PLATE 29, FIGURES 12, 13

Description.—Height, 14 mm; apical angle, 51°; volutions, about seven, angular; the peripheral band trilineate, prominent; upper and lower carinae both distinct; upper carina very close to the suture; both upper and lower slopes moderately concave. Surface markings very fine, sweeping strongly backward to the peripheral band. Aperture not observed; umbilicus apparently closed.

Comparisons.—This species is allied to *L. saffordi* Ulrich, an American species from the Upper Trenton, but the narrower apical angle and position of upper carina serve readily in distinguishing it.

Formation and locality.—Same as preceding.

Holotype.—U.S.N.M. No. 83658.

LOPHOSPIRA YENTAIENSIS, new species

PLATE 29, FIGURES 4–6

Description.—Height, 19 mm; apical angle, 57°; volutions, seven, the first very minute and decidedly angular. Peripheral band prominent, thick, and rounded. Upper slope flat or very slightly concave; lower slope concave and sloping inward. Upper carina very feeble and very close to the suture; lower carina moderately sharp and strong. Surface markings comparatively well preserved, curving strongly backward toward the peripheral band; these transverse lines may be closed by the very feeble, irregular, revolving lines. Aperture round, the inner lip reflected. Umbilicus appears as a very small slit in a comparatively better specimen, while it is covered by the reflected inner lip in a fragmentary one.

Comparisons.—The general appearance of this species might be considered to indicate close affinities with *L. oweni* Ulrich and Scofield, an American species, and *L.* cf. *oweni* Ulrich and Scofield, the Manchurian species from the same locality, but the comparatively small base and the fine lower carina prove that it is different.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestones near Shang-kang-yao, 3 miles south of the Yen-tai colliery, Manchuria.

Holotype.—U.S.N.M. No. 83659.

LOPHOSPIRA species undetermined

PLATE 30, FIGURE 10

A small fragment of a *Lophospira* (U.S.N.M. No. 83660), while in general shell features is somewhat similar to *L. aojii* from the same locality, differs from it in having more concave upper and lower slopes and more prominent and much more strongly curved surface markings. Even though this fragment seems to represent a new species, it is too poor to warrant a new specific name.

Formation and locality.—Same as preceding.

Genus EOTOMARIA Ulrich and Scofield, 1908

EOTOMARIA BARBOURI (Grabau)

PLATE 29, FIGURES 14–17

1922. *Liospira barbouri* GRABAU, Pal. Sinica, ser. B, vol. 1, fasc. 1, p. 33, pl. 3, figs. 14, 15.

Every character of the two figured specimens from the Kangyao formation, Manchuria, coincides exactly with the corresponding feature of Grabau's North Chinese species *Liospira barbouri.* The comparatively depressed conical shell, lines of growth strongly de-

flected backward, and comparatively large umbilicus, are features that may be pointed out as common to the specimens from both regions.

This species, however, is not a *Liospira*, since it has the concave band situated entirely upon the sloping upper side of the volutions, which is a characteristic feature and the prominent generic character of *Eotomaria*.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestones near Shang-kang-yao, 3 miles south of the Yen-tai colliery, Liao-tung.

Plesiotypes.—U.S.N.M. No. 83661.

EOTOMARIA ULRICHI, new species

PLATE 30, FIGURES 1–6

Description.—Shell rather small, about 13 mm wide, 12 mm high, depressed conical above the angular periphery, lower part being first slightly concave, next ventricose; apical angle about 115°. Volutions four or five, the outer two-thirds or three-fourths of the upper slope of whorls being decidedly concave, the remaining fourth next the suture convex.

Upper carina of the last whorl has a prominent supraperipheral position to the band of the preceding whorl. Umbilicus equaling nearly one-third the width of the shell. Lines of growth are very fine on the upper surface and curve moderately backward to the peripheral band, while beneath it they first curve slightly forward then turn backward and finally forward again as they descend into the umbilicus.

Comparison.—This species differs from the other species of *Eotomaria* in its larger apical angle, more ventricose condition of the last whorl and the supraperipheral position of the upper carina of the last whorl compared to the band of the preceding whorl.

Formation and locality.—Same as preceding species.

Holotype.—U.S.N.M. No. 83662.

Genus HORMOTOMA Salter, 1859

HORMOTOMA PAGODAI, new species

PLATE 12, FIGURES 1, 2

Description.—Only three casts of the interior are known. As a whole this gastropod is elongate and slender. In the incomplete holotype seven whorls are left after the apical end was broken away. Height of the type, which is a medium-sized specimen, 33 mm; apical angle, about 25°. Surface marked by a feeble angulation suggesting

a peripheral band. The whorls are about two times greater than their length, uniformly rounded, and enlarge gradually. In a fragment of a larger specimen the largest well-preserved whorl, next the body wall, has a width of 20 mm, and a vertical height of 10 mm. The extent of embracing is slight, producing a loose-coiled shell with a deep suture, which is oblique and forms an angle of about 70° with the axis of the shell. Aperture subovate; umbilicus comparatively small.

Comparisons.—This species appears to be relatively close to *Hormotoma terebriformis* Foerste, an American species from the Trenton group, Rogers Gap, Ky., but it is readily distinguished by the feeble angulation on the surface and the deep suture.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestones, 1.5 miles north of the Pen-hsi-hu colliery, Liao-tung.

Holotype.—U.S.N.M. No. 83663.

HORMOTOMA species undetermined

PLATE 32, FIGURES 1–4

Several casts of a gastropod (U.S.N.M. No. 83664), which from the general form of the spire and the contour of the whorls is referable to the genus *Hormotoma*, were obtained from the Santao formation in Manchuria.

Description.—Height averages 30 mm, apical angle about 12°. Specimens comparatively small, slender; whorls are somewhat depressed ventricose. Volutions eight in a specimen 36 mm long; other specimens consist of six whorls. The apical portion of all my specimens is imperfect. The extent of embracing is slight, producing a loose-coiled shell, with deep suture, which is very oblique and forms an angle of 65° with the axis of the shell.

On the surface of some casts a suggestion of a rounded peripheral band may be seen, but it is not very distinct. Aperture round; umbilicus closed.

Comparisons.—This species may be related to the *Hormotoma artemesia* type from the Canadian strata of North America, but as my specimens are too poor to identify with this or any other species, they are simply referred to *Hormotoma* with the hope that better specimens may be obtained in the future, when a specific name can be assigned.

Formation and locality.—Upper Canadian, Santao formation: In the banded limestones near Shang-kang-yao, 3 miles southeast of the Yen-tai colliery, Liao-tung, Manchuria.

Genus SOLENOSPIRA Ulrich, 1908

SOLENOSPIRA species undetermined

PLATE 29, FIGURE 7

Among the material collected from the Kangyao formation is one fragmentary specimen of a gastropod (U.S.N.M. No. 83665) that has depressed volutions and a somewhat channel-like spiral band with two salient thin ridges, therefore being safely referable to *Solenospira.*

This fragmental shell has the general form and characters of *Solenospira prisca* (Billings), from the Stones River of the United States, but it is too fragmentary to identify exactly as that species.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black-banded limestones near Shang-kang-yao, 3 miles south of Yen-tai colliery, Liao-tung, Manchuria.

Genus ECCYLIOPTERUS Remele, 1888

ECCYLIOPTERUS LOUDERBACKI, new species

PLATE 36, FIGURES 10–13

Description.—Width, 23 mm; greatest height, nearly two-thirds of the width; whorls, three in number, enlarging rather rapidly, coiled very nearly in the same plane; upper side of shell broadly concave; umbilicus comparatively large, about one-third the diameter of the shell; under side of whorls strongly convex, outer side sloping slightly inward; suture deep, collar somewhat prominent, well indicated; mouth somewhat acuminate quadrilateral, very oblique. Lines of growth curving strongly backward toward the marginal collar.

Comparison.—This species is related to *E. beloitensis* Ulrich and Scofield, from the Stones River, but is distinguished by a more acute collar, narrower umbilicus, acuminate quadrilateral aperture, and growth lines that are curved strongly backward. Another allied species is *Eccyliopterus sinensis* (Frech) (=*Raphistoma sinense* Frech) from southern China. The last, however, usually has a broader umbilicus and more pronounced embracing, so that each outer whorl rises, on its inner margin, above the collar of the preceding whorl.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Holotype.—U.S.N.M. No. 83666.

ECCYLIOPTERUS species undetermined

PLATE 23, FIGURE 13

My field work in Manchuria yielded two rather poor specimens of a gastropod (U.S.N.M. No. 83667) that, from the loosely coiled whorl with the "collar," is referable to *Eccyliopterus*.

Description.—Width of larger specimen, 30 mm; whorls very flattened, enlarging rather rapidly, coiled very nearly in the same plane; umbilicus comparatively large; collar rather low, but well indicated on the upper surface of the whorl. Character of aperture and nature of surface markings not ascertained.

Formation and locality.—Lower Ordovician, Wuting formation: In black banded limestones near the second tunnel, 1 mile north of the Pen-hsi-hu colliery, Liao-tung.

Genus HELICOTOMA Salter, 1859

HELICOTOMA species undetermined

PLATE 26, FIGURES 7, 8; PLATE 23, FIGURES 19, 20

A rather poor specimen (U.S.N.M. No. 83668) of a *Helicotoma* is, as may be seen in Plate 26, Figures 7 and 8, closely similar to *Helicotoma declivis* Safford, from the Stones River, in its wide umbilical cavity and the relative depression of the inner whorls as compared with the outer one. But in detail the Manchurian specimen differs in one or two minor features from the American species, namely, in having coarser surface markings and a higher revolving line on the upper surface of the whorl. Since it is so poor, however, no new specific name is assigned.

Another poor specimen (U.S.N.M. No. 83669) (pl. 23, figs. 19, 20) quite different specifically, seems to me also to belong to *Helicotoma*, since it has a wide umbilical depression and a nearly flat spire.

Formation and localities.—Lower Ordovician, Wuting formation: In the black banded limestones on Wu-ting hill 2 miles south of the Yen-tai colliery and near Pen-hsi-hu colliery, Liao-tung, Manchuria.

Genus MACLURITES Leseur, 1818

MACLURITES BIGSBYI (Hall)

PLATE 12, FIGURES 3–8

1861. *Maclurea bigsbyi* HALL, Report of the Geological Survey of the State of Wisconsin, p. 37.

1882. *Maclurea bigsbyi* WHITFIELD, Geology of Wisconsin, vol. 4, p. 222, pl. 6, figs. 17, 18; 1895, Mem. Amer. Mus. Nat. Hist. vol. 1, p. 62, pl. 8, figs. 14, 15.

1897. *Maclurea bigsbyi* ULRICH and SCOFIELD, Geology of Minnesota, Paleontology, vol. 3, pt. 2, p. 1039, pl. 75, figs. 5–10.

1909. *Maclurea bigsbyi* GRABAU and SHIMER, North Amer. Index Fossils, vol. 1, p. 664, fig. 919.
1930. *Maclurea tofangoense* KOBAYASHI, Jap. Journ. Geol. and Geogr., vol. 7, pts. 3, 4, p. 96, pl. 9, figs. 1a–c, 2, 3; pl. 10, fig. 2, pl. 11, fig. 7.

This species occurs abundantly at several horizons wherever the Middle Ordovician beds outcrop in Manchuria. Since a number of nearly entire specimens are in hand, even though most are casts, the major characters of the species are readily determined.

Description.—Sinistral shell with flat spire, convex and widely umblicated base, deep umbilicus, three or four whorls. The rapidly enlarging whorls and other features seem to indicate that this species is identical with *Maclurites bigsbyi* (Hall) from North America.

The dimensions of the best Manchurian specimen are as follows: The largest diameter of the upper surface is 50 mm; the corresponding width of the aperture, 18 mm; and height near the aperture, 18 mm.

Formation and locality.—Middle Ordovician, Ssuyen formation: Upper and lower fossil horizon of the black banded limestones near Pen-hsi-hu, Niu-hsin-tai, and Tao-yuan-kou collieries, Liao-tung, Manchuria.

Plesiotypes.—U.S.N.M. Nos. 83671, 83672, and 83673.

MACLURITES NITIDA (Ulrich and Scofield)?

PLATE 12, FIGURE 9; PLATE 13, FIGURES 1–3

1897. *Maclurea nitida* ULRICH and SCOFIELD, Geology of Minnesota, Paleontology, vol. 3, pt. 2, p. 1040, pl. 75, fig. 11.
1930. *Maclurea niuhsintaiense* KOBAYASHI, Jap. Journ. Geol. and Geogr., vol. 7, nos. 3, 4, p. 97, pl. 10, figs. 5a–c.

A well-preserved cast, a section of a shell, and one fragment constitute the material on which this specific reference is based.

As shown in Plate 13, Figures 1 and 2, the rather small shell, comparatively narrow, deep, and rather abrupt umbilicus, rather high and convex whorls, and other features cause me to think this species quite similar to *Maclurites nitida* (Ulrich and Scofield) from the Stones River. The Manchurian specimens may differ slightly in having a comparatively round outer angle and a somewhat more angular margin of umbilicus; nevertheless it seems to me that these differences may originate from differences of preservation; viz, the Manchurian specimens found up to the present time are casts only, while the American specimens retain some parts of the shells.

The Manchurian form is also related to *Maclurea neritoides* Eichwald from No-lu-ping, Tung-hu-hsien, Hu-pei, South China, but is distinguished by its comparatively round outer angle, narrower, abrupt umbilicus and the rather angular margin of umbilicus.

Formation and locality.—Middle Ordovician, Ssuyen formation: The lower fossil horizon of the black banded limestones near Hsiao-nan-kou, 2 miles south of the Niu-hsin-tai colliery, Liao-tung; and in the same beds near Shuang-chuan-ssu, 2 miles southwest of Miyanohara station on the Antung-Mukden line, Manchuria.

Plesiotypes.—U.S.N.M. Nos. 83674 and 83675.

CEPHALOPODA

Genus ENDOCERAS Hall, 1844

ENDOCERAS CENTROTUBULATUM, new species

PLATE 37, FIGURES 1–3

Description.—Specimen 125 mm long, enlarging laterally from 29 mm at the base to 42 mm at the top, the apical angle being about 8°. The cross sections of the conch and siphuncle are depressed dorsoventrally. Siphuncle is about centrally located. In the cross section of the siphuncle near the top three endocones are found, laid in rows dorsoventrally; 4.5 camerae occupy a length equal to the lateral diameter of the conch. Where the lateral diameter of the conch is 32 mm, the concavity of the septa equals 8.5 mm, and height of its camerae varies from 5.6 to 8.5 mm at the apical part of the specimen. When the septae approach the siphuncle the septal funnels become almost cylindrical in form. The lower part of the septal funnels contracts slightly in order to invaginate the septal funnels beneath, the length of this invagination averaging about 3.5 mm. The middle part of the septal funnels does not enlarge so distinctly. The surface of the shell may be smooth so far as determinable from the cast.

This species is very characteristic in having a central siphuncle and a comparatively septal concavity.

Formation and locality.—Upper Ordovician. This specimen is believed to have come from a part of lower Ordovician strata; collected near Han-chung-fu, Shensi, China, by George D. Louderback.

Holotype.—U.S.N.M. No. 83676.

Genus CAMEROCERAS Conrad, 1842

CAMEROCERAS cf. STYLIFORME Grabau

PLATE 31, FIGURES 2–4

1922. *Cameroceras styliforme* GRABAU, Ordovician fossils from North China, p. 39, pl. 4, figs. 4–6.

I collected two fragmental specimens of *Cameroceras* (U.S.N.M. No. 83677), the general outlines of which are nearly identical with those of *Cameroceras styliforme* Grabau from the Liangchiashan

limestone, North China. As both Grabau's and my specimens are too poor to allow any exact determination of details, I have described my specimen as allied to *Cameroceras styliforme* Grabau. The Manchurian specimen, however, differs in at least one or two minor details, namely, in having comparatively larger dimensions and from the North Chinese specimen, a more acute angle of the annulations compared with the ventral line of the siphuncle. If in the future I am able to obtain more and better specimens, this possible identity with *C. styliforme* may be definitely determined. The Manchurian specimens may be described as follows:

Description.—One of the specimens is 42.5 mm in length, consisting of part of a siphuncle showing endocone, which enlarges slightly from the base to the top. The surface of the siphuncle shows broad, ill-defined annulations, and the angles between these and the ventral line of the siphuncle are about 55°, the annulations being 2.5 in a space of 10 mm. At the base of the specimen the section is suboval, and here the dorsoventral and lateral diameters of the siphuncle are 10 and 11.5 mm, respectively. The corresponding diameters of the endocone are 7.5 and 9 mm, respectively. In the same section the endocone is in contact with the ventral wall of the siphuncle, while the space between the dorsal surface of the endocone and the corresponding surface of the siphuncle is estimated as 2.5 mm. Not only the siphuncle but also the endocone is distinctly flattened ventrally. The interiors of both the siphuncle and the endocone are filled by a calcareous matrix, and show no traces of the endosiphosheaths.

Formation and locality.—Upper Canadian, Santao formation: In the light gray limestone above the second tunnel, 1 mile north of Pen-hsi-hu, Liao-tung, Manchuria.

Genus PILOCERAS, Salter, 1859

PILOCERAS MANCHURIENSE, new species

PLATE 32, FIGURES 5–7; PLATE 33, FIGURES 14, 15

Description.—The holotype is 75 mm long, enlarging dorsoventrally very rapidly from the base to a point 22 mm farther up, in its angle of enlargement being about 60° where it has reached a diameter of 25.5 mm. From this point upward it enlarges more gradually, attaining 32 mm at the top of the specimen. The surface of the siphuncle is apparently annulated, the rings being transverse and not showing any traces of oblique angles. These annulations are four in a space of 10 mm. Where the dorsoventral diameter of the siphuncle is 26 mm, the corresponding diameter of the endosiphuncle is 8 mm, and here the space between it and the ventral surface of the

siphuncle is 11 mm, while that between its dorsal surface and the corresponding surface of the siphuncle is 7 mm. This point is about 34 mm above the base of the specimen, and here the situation of endosiphuncle is somewhat excentric. Since the interiors of both the endosiphuncle and of the siphuncle are completely filled with calcareous matrix, the internal structure can not be determined.

A second specimen 59 mm long has a 32 mm diameter of the siphuncle at the top of the specimen. A lateral view of this second specimen and two transverse sections, one of which is at the top of the specimen and the other 27 mm below, are also figured. The lower transverse section shows two, or possibly more, of the older endosyphosheaths.

Comparisons.—This species is closely related to *Piloceras platyventrum* Grabau, which has four transverse annulations in a space of 10 mm, while my species has 2.5 annulations in the same space. Grabau's third specimen (not figured), from which he took the sections printed on page 48 of his paper (Grabau, 1922), probably belongs to this new species.

Formation and locality.—Upper Canadian, Santao formation: Light gray limestones above the second tunnel, 1 mile north of Pen-hsi-hu; and in the black banded limestone near Tai-chia-pu-tzu, 2 miles west of Chiao-tou station, Liao-tung, Manchuria.

Holotype and paratype.—U. S. N. M. Nos. 83678 and 83679.

Family PILOCERATIDAE

PENHSIOCERAS, new genus

Diagnosis.—Breviconic orthoceracones with large, stout, spindle-shaped siphuncle, which is surrounded by a definite wall or siphuncular shell; with conical apical end. Siphuncle filled with endosiphosheaths and calcareous matrix, so the detailed structure of the interior is not shown. The cross sections of the siphuncle and endosiphocone are apparently circular. The endosiphocone is long, conical, alveolar toward the apex and it rapidly tapers into the endosiphotube at the comparatively younger part.

In none of the specimens so far obtained is the camerate portion preserved. The surface of the siphuncle is apparently annulated.

Comparisons.—Comparing the structure of *Penhsioceras* with that of other cephalopods, I am at once reminded of *Chilioceras* and *Piloceras*. But the new genus differs from *Chilioceras* in having no trace of a triploid endocone (no traces of lateral and main cavities). *Penhsioceras* is also readily distinguished from *Piloceras* in having a narrower endosiphocone and a spindle-shaped siphuncle.

Genotype.—*Penhsioceras fusiforme*, new species.

PENHSIOCERAS FUSIFORME, new species

PLATE 32, FIGURES 8–10

Description.—The holotype specimen is 107 mm long, enlarging very rapidly dorsoventrally from the base to a point 24 mm farther up, its enlargement angle being 55° where it has reached a diameter of 22 mm. From this point upward it decreases in diameter very gradually to 16.5 mm near the top of the specimen and thus acquires a general spindle shape. The cross sections of the siphuncle and endosiphocone are apparently circular. The endosiphocone is rather long, conical, alveolar toward the apex. At a point 11 mm below the top, the dorsoventral diameter of the siphuncle is 17 mm, and the corresponding diameter of the endosiphocone 8 mm. Here the space between it and the ventral surface of the siphuncle is 2.5 mm, while that between its dorsal surface and the corresponding surface of the siphuncle is 6.5 mm, and in this section the endosiphocone is situated very slightly ventrally. The endosiphocone tapers rapidly into the endosiphotube at a point 34.5 mm below the top, and here the diameter of the endosiphotube is estimated as 2 mm. The same diameter of the endosiphotube obtains throughout the specimen from this point to the apex. Unfortunately, as the interiors of the endosiphocone and siphuncle are filled entirely with calcareous matrix, no internal structures can be determined, but some remains of endosiphosheaths are clearly retained. The surface of the siphuncle is apparently annulated, these annulations being three in a space of 7 mm.

A fragmental specimen of the apical part, which may belong to the present species, was collected near Niu-hsin-tai. The interior part of the siphuncle of this specimen, though filled by a calcareous matrix, retains some relics of endosiphosheaths.

Formation and localities.—Upper Canadian, Santao formation: In the light gray limestone above the second tunnel, 1 mile north of Pen-hsi-hu and at the same horizon near Ta-wan-kou, 1.5 miles northeast of Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype and paratype.—U.S.N.M. Nos. 83680 and 83681.

Genus ORTHOCERAS Breynius, 1832

ORTHOCERAS MAGNICHINENSE, new species

PLATE 38, FIGURES 1, 2

Description.—Specimen 131 mm long, enlarging from a diameter of 41 mm at the base to 77 mm at the top, the apical angle being about 10°. The cross sections of the conch and siphuncle are circular. The siphuncle is located centrally. Number of camerae in a length equal to a diameter of conch is 1.8. The concavity of the septa

equals 22 mm. The rings of the siphuncle are tubular. Interior surface of the siphuncle is slightly thickened by the deposition of calcareous matrix. The interiors of the camerae toward the apical end are filled with calcareous matrix, while the younger part remains empty. The surface of the shell is smooth.

Comparisons.—This specimen may be compared to *Orthoceras chinense* Foord, but the larger apical angle, the greater septal distance, and the larger diameter of the conch serve readily in distinguishing it.

Formation and locality.—Upper (?) Ordovician: Near Hanchung-fu, Shensi, China.

Holotype.—U.S.N.M. No. 83682.

ORTHOCERAS LIAOTUNGENSE, new species

PLATE 13, FIGURE 6

Description.—The single specimen collected is 55.5 mm long, enlarging from a diameter of 14 mm at the base to 19.7 mm at the top, the apical angle being 5°. The cross sections of the conch and the siphuncle apparently are circular, but only half of the specimen remains, the other half having weathered away. The siphuncle has a central position. The number of camerae in a length equal to the diameter of the conch is three. The concavity of the septa equals 7.5 mm. The rings of the siphuncle are approximately tubular or widened but slightly within the camerae. The outer side of the siphuncle and the anterior sides of the septae are moderately thickened with the calcareous matrix, having comparatively large spaces in each camerae. The surface of the shell is smooth.

Comparisons.—The comparatively narrow camerae and the great concavity of the septae serve readily in distinguishing this species from any American or European *Orthoceras.*

Formation and locality.—Middle Ordovician, Ssuyen formation: A black limestone bowlder believed to have come from a part of the Ssuyen formation; in river drift at the Pen-hsi-hu colliery, Liaotung, Manchuria.

Holotype.—U.S.N.M. No. 83683.

ORTHOCERAS RECTISEPTATUM, new species

PLATE 25, FIGURE 1

Although this single specimen is almost too poor to receive a new specific name, characteristic features are well shown.

Description.—Specimen 31.7 mm long, consisting of about 6 camerae, enlarging from 6 mm at the base to 11.7 mm at the top, the apical angle being 11°. The siphuncle is central in position and 1.8

camerae occupy a length equal to the diameter of the conch. Where the diameter of the conch is 11.6 mm, the diameter of the siphuncle is estimated at 1.4 mm. The septae are straight transversally or slightly convex toward the apical part, which is a very characteristic feature. Septal distance is very great, being estimated as between 3 mm and 7.5 mm. Surface of the shell is slightly annulated. Interiors of the siphuncle and camerae are filled almost entirely with a calcareous matrix.

This species is characterized by having straight septae, large septal distances, and a slightly annulated surface.

Formation and locality.—Lower Ordovician, Wuting formation: In the gray limestone, near Ta-wan-kou, 1.5 miles northeast of the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83684.

ORTHOCERAS TOYAMAI, new species

PLATE 13, FIGURES 4, 5, 13; PLATE 40, FIGURE 17

Description.—The holotype is 74 mm long, enlarging slightly from a diameter of 11 mm at the base to 17 mm at the top. The number of camerae in a length equal to the diameter of the conch equals three at the middle part. The cross sections of the conch and the siphuncle are almost circular, or slightly depressed, but the dorsal part of the shell has been weathered away, leaving some doubt on this point. The siphuncle is central in location, rather tubular, but slightly enlarged within the camerae. Where the diameter of the specimen is 13 mm, and where the septae are 4.5 mm apart, one of the segments of the siphuncle has a diameter of 2.5 mm at mid height, and the passage of siphuncle through the septum is 1.5 mm. The concavity of the septae is relatively small. The deposition of the calcareous matrix in the siphuncle and camerae is very irregular; in some parts it fills completely the whole space of the siphuncle and the camerae while in other places these are rather empty. The surface of the shell is very slightly annulated so far as seen in the polished longitudinal section.

A second specimen, 61 mm long, enlarges from a diameter of 13 mm at the base to 17 mm at a point 36 mm farther up. The concavity of the septae is 2.5 mm and the septae average 4.5 mm apart. The cross section of the conch is somewhat depressed.

A third specimen from Pen-hsi-hu is 46 mm long. The concavity of the septae is 2.5 mm, and they average 6 mm apart. The enlarging of the segments of the siphuncle within the camerae is rather clear, but, on the contrary, the annulation of the surface of the shell is very faint.

The specific name is given in honor of S. Toyama, a prominent Manchurian paleontologist.

Comparisons.—This species may be related to *Tofangoceras pauciannulatum* Kobayashi, but differs from it in having rather longer camerae and slighter annulation of the surface of the shell.

Even though my specimens have characteristics of *Tofangoceras* in possessing surface annulations and a slightly nummuloidal siphuncle, these characters are very poorly developed as compared with that of the genotype of *Tofangoceras*. On the contrary, the generic characters of my specimens are comparable rather with *Orthoceras* in showing straight and comparatively smooth longicones with simple septae and sutures. Therefore at present I place this species in *Orthoceras*. If in my future field work, however, I shall have the good fortune to find a whole specimen that is not embedded in the rock matrix, I can then examine the surface annulation in more detail, and it may happen that its generic reference will have to be changed.

Formation and localities.—Middle Ordovician, Ssuyen formation: A grayish black limestone bowlder believed to have come from the Ssuyen formation in river drift at the Niu-hsin-tai colliery; also in drift near the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype and paratype.—U.S.N.M. Nos. 83685 and 83686.

ORTHOCERAS species undetermined

PLATE 13, FIGURES 8, 9

Specimen (U.S.N.M. No. 83687), 46 mm long, 23 mm in diameter at its top, cross section circular, rate of enlargement very small. The siphuncle is located in a central position. The average length of the camerae is 4.5 mm. Concavity of septa about 4 mm. Diameter of siphuncle 2.5 mm at mid height, diminishing slightly at the septal necks. The latter are about 0.7 mm long. The surface of the shell is smooth; living chamber unknown.

Formation and locality.—Middle Ordovician, Ssuyen formation: A grayish black limestone bowlder supposed to belong to the Ssuyen formation, in river drift at the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Genus CYCLOCERAS McCoy, 1844

CYCLOCERAS (?) MANCHURIENSE, new species

PLATE 13, FIGURES 10–12; PLATE 14, FIGURES 8, 9, 12; PLATE 17, FIGURE 7

Description.—The holotype specimen (pl. 13, figs. 10–12) is 55.5 mm long, enlarging from a diameter of 14.5 mm at the base to 18.5 mm at the top, the apical angle being rather small. The cross sections of the conch and siphuncle are circular. Four and a half

annulations occur in a length equal to the diameter of the conch, the number of camerae in the same length being 8.5. The concavity of the septa equals almost 3.6 mm. The center of the siphuncle is located 5.5 mm from the ventral wall of the conch. At a point near the base, the diameter of the siphuncle at its passage through the septa appears to have been 2 mm, enlarging to 3.2 mm within the camerae. The septal neck is very short. The annulations are 3 mm wide, about 1 mm high, and 5 mm apart from crest to crest. These annulations are nearly transverse along the dorsal side of the specimen and along the median part of the opposite side, but they run obliquely along the lateral sides at a 5° to 6° angle.

A second specimen (pl. 14, figs. 8, 9), 54 mm long, has an apical angle of 8°. The diameter of the conch is 13.5 mm and that of the siphuncle 2.5 mm near the base. A vertical section has been cut in a lateral direction through the center of the siphuncle. Six camerae occupy a length equal to the diameter of the conch, four annulations occurring in the same length. The obliquity of the annulation of the calcareous material in the camerae is comparatively irregular; the posterior camerae are filled entirely with the calcareous matrix, while in the younger camerae the deposit is only small.

A third specimen (pl. 14, fig. 12) is 66 mm long, the diameter of the conch being 18.5 mm and that of the siphuncle 2.5 mm near the top. The number of camerae and annulations in a length equal to the diameter of the conch is 8.2 and 5 mm, respectively.

Since the surface of the shell of this species is not well preserved, I can not decide exactly whether it belongs to *Spyroceras* or *Cycloceras*, and therefore it is assigned to *Cycloceras* only tentatively.

Comparison.—I am not acquainted with any American or European species with which this species is likely to be confounded. But it may have some characters in common with *Cycloceras undulostriatum* (Hall) from the Trenton limestone of New York, although the different obliquity of the annulations, the comparatively larger distance between the crests of the annulations, and other details serve easily to distinguish it.

Formation and locality.—Middle Ordovician, Ssuyen formation: The lower fossil horizon of the black banded limestone beds, just north of the Pen-hsi-hu colliery, also in river drift at the Niu-hsin-tai colliery, Manchuria.

Holotype and paratypes.—U.S.N.M. Nos. 83688 and 83689.

CYCLOCERAS LOUDERBACKI, new species

PLATE 36, FIGURE 16

Description.—Specimen is 40 mm long and enlarges dorsoventrally from 9 mm at the base to 13.2 mm at the top, the apical angle being

8°. The cross section of the conch has been somewhat compressed laterally by rock pressure. The siphuncle is located ventrally, its center being 5.2 mm from the wall of the conch near the top. Five and five-tenths annulations occur in a length equal to the diameter of the conch. Where the dorsoventral diameter of the conch is 13 mm, that at its passage through the septa appears to have been 2.7 mm, but seems not to enlarge within the camerae. The concavity of the septa equals 2.2 mm, and height of its camerae is 3.2 mm. The septal neck is rather short, about 1 mm or less in length. The annulations are 2 mm wide, rather low, and 3.1 mm apart from crest to crest. These annulations are nearly transverse along the dorsal side of the specimen and along the median part of the opposite side, but run obliquely along the lateral sides at a rather low angle.

The specific name is given in honor of Dr. George D. Louderback, of the University of California, who collected this and many other fine specimens in central China.

Comparisons.—This species may be compared with *Cycloceras arcuoliratum* (Hall) from the Trenton and Black River formations of the United States, but has more rounded and broader annulations and less obliquity of those on the lateral sides of the specimen.

Formation and locality.—Upper Ordovician: Near Han-chung-fu, Shensi, China.

Holotype.—U.S.N.M. No. 83690.

CYCLOCERAS AOKII, new species

PLATE 14, FIGURE 7

Description.—The specimen is 60 mm long and has a rather low apical angle. The cross section of the conch may be slightly depressed, while that of the siphuncle is circular. Four annulations occur in a length equal to the diameter of the conch. The number of camerae in an equal length is six. The concavity of the septa is estimated at 3 mm. The center of the siphuncle is located 5.5 mm from the ventral wall of the conch. At the middle of the specimen, the diameter of the siphuncle at its passage through the septa is 1.2 mm, enlarging to 1.8 mm within the camerae. The annulations are 3 mm wide, about 1 mm in height, and 5 mm apart from crest to crest. The annulations run obliquely along the lateral sides at an angle of about 5°. The interior of the camerae is entirely filled with calcareous matrix, while that of the siphuncle is rather empty.

The specific name is given in honor of Prof. R. Aoki, of the Tohoku Imperial University in Japan.

Comparisons.—As is seen from the above description, this species is very closely allied to *Cycloceras manchuriense*, but differs in having a comparatively slender and rather unnummuloidal siphuncle in con-

trast to the latter, which shows many nummuloidal segments of the siphuncle.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the lower fossil horizon of the black banded limestone just north of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83691.

CYCLOCERAS (?) MARGINALE, new species

PLATE 27, FIGURE 5; PLATE 40, FIGURE 11

Description.—This single specimen is 105 mm long, enlarging dorsoventrally from a diameter of 18 mm at the base to 26 mm at a point 71 mm farther up; the apical angle is comparatively low. The cross section of the conch is slightly compressed. The siphuncle is excentric in position, its center located 8 mm from the ventral wall of the conch. The number of camerae in a length equal to the diameter of the conch is eight. The surface of the conch is fairly annulated, and five of these annulations occupy a length equal to the diameter of the conch. When the diameter of the conch is 26 mm, the concavity of the septa is 5.5 mm; the maximum diameter of the siphuncle here is estimated at 4.5 mm, and the height of its camerae averages 3.2 mm. The inner margins of the septa form a short septal neck. These inner margins are in contact with only the lower sides of the preceding connecting rings. The interior of the siphuncle has no trace of the deposition of calcareous matrix. The camerae of the older part of the shell are densely filled with the calcareous matrix, which becomes gradually less toward the younger part. Since the surface of the shell of this species is not exposed, I can not decide exactly whether it belongs to *Spyroceras* or *Cycloceras*, and therefore it is tentatively assigned to *Cycloceras*.

Comparisons.—Comparatively large shell, the larger septal concavity, the form of the segments of the siphuncle and excentric position of the siphuncle serve to differentiate this species from others found in the Ordovician beds of the Orient. I am not acquainted with any American or European species with which this one is likely to be confounded.

Formation and locality.—Lower Ordovician. Wuting formation: In the black banded limestone beds, near the second tunnel, 1 mile north of Pen-hsi-hu, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83692.

CYCLOCERAS (?) SHENSIENSE, new species

PLATE 37, FIGURES 4, 5; PLATE 38, FIGURE 4

Description.—Louderback's collection contains another specimen, 50 mm long, that enlarges slightly from the base to the top. The

cross sections of the conch and siphuncle apparently were originally circular, but have been more or less compressed laterally by pressure. The siphuncle is located somewhat ventrally. About six annulations occur in a length equal to the diameter of the conch. The number of camerae in an equal length is 7.2. Where the lateral diameter of the conch is 22.2 mm, the concavity of the septa equals 4.6 mm, and the height of its camerae averages 3.2 mm. The siphuncle is tubular and does not enlarge within the camerae. The septal neck is very short, about 0.6 mm or less in length. The annulations are rather indistinct, are 4 mm apart from crest to crest, and run obliquely along the lateral sides of the specimen.

Since the surface of the shell of this specimen is not preserved, I can not decide definitely whether it belongs to *Spyroceras* or to *Cycloceras*, and it is therefore assigned tentatively to *Cycloceras*.

Comparisons.—In general this species may be compared with *Cycloceras* (*?*) *manchuriense*, but differs in having the tubular siphuncle, indistinct annulations, and a comparatively large number of annulations in a length equal to the diameter of the conch.

Formation and locality.—Upper Ordovician: Near Han-chung-fu, Shensi, China.

Holotype.—U.S.N.M. No. 83693.

CYCLOCERAS (?) PEITOUTZENSE Grabau

PLATE 14, FIGURES 3, 4

1922. *Cycloceras* (?) *peitoutzense* GRABAU, Pal. Sinica, ser. B, vol. 1, fasc. 1, p. 63, pl. 6, fig. 2 (not. pl. 6, figs. 1, 3, 4).

1927. *Cycloceras* (?) *peitoutzense* KOBAYASHI, Jap. Journ. Geol. and Geogr., vol. 5, no. 4, p. 184, pl. 21, fig. 1.

It is quite likely that two or three species belonging to *Cycloceras* and *Spyroceras* are included in Grabau's *Cycloceras* (?) *peitoutzense*, because, according to his description, the shells of his second to fifth specimens have fine concentric striae between the interspaces of the annulations; his first specimen, on the contrary (pl. 6, fig. 1), has very faint longitudinal lines upon the early portion of the fragment. Therefore, it is clear that the four specimens with concentric striae belong to *Cycloceras* but that the other specimen belongs to *Spyroceras*. Morever, I have some doubt whether his second (pl. 6, fig. 2), third, fourth (pl. 6, fig. 3), and fifth (pl. 6, fig. 4) specimens are the same species. Two of my specimens are also too incomplete to settle the question whether they belong to *Cycloceras* or *Spyroceras*. It seems to me, however, that my specimens may coincide with Grabau's second specimen, so I am describing them tentatively as a species of *Cycloceras* (?).

Since Grabau's first specimen may belong to *Spyroceras*, I shall designate his second specimen as the lectotype of *Cycloceras* (?)

peitoutzense Grabau. Kobayashi's specimen may agree with Grabau's second specimen. One of my specimens is 30 mm long and is very slightly enlarged from the base to the top. The cross section of the conch apparently was circular. The siphuncle is located somewhat excentrically. Three camerae occupy a length equal to the diameter of the conch, and three annulations occur in the same length. Where the diameter of the conch is 7 mm, the concavity of the septa equals 1.5 mm. The maximum diameter of the siphuncle here is estimated as 1.5 mm, and the height of camerae averages 2.2 mm. The deposition of the calcareous matrix in the camerae is rather unusual.

Formation and locality.—Middle Ordovician, Ssuyen formation: Upper and lower fossil horizons of the black banded limestone beds, near the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Plesiotype.—U.S.N.M. No. 83694.

Genus SPYROCERAS Hyatt, 1879

SPYROCERAS species undetermined

PLATE 38, FIGURE 5

One specimen of *Spyroceras* (U.S.N.M. No. 83695) occurs in Louderback's collection from central China. It is 67 mm long and consists of the living chamber only, no trace of the camerae being left. It enlarges from a diameter 22.5 mm at the base to 26.5 mm at a point 47 mm farther up; thus an apical angle is very low. The cross section of the conch is circular. The crests of five annulations occur in a length equal to the diameter of the conch. They show some sigmoid curvature on the lateral surfaces of the conch. These annulations are about two-thirds of a millimeter in height, are rather broadly rounded, and are separated by intermediate grooves of about the same width. The surface of the conch is ornamented by very faint vertical striae which cross the annulations. This specimen seems to belong to a new species, but as no trace of the camerae is preserved I hesitate to give a new specific name to the fragment.

Formation and locality.—Upper Ordovician, near Han-chung-fu, Shensi, China.

Genus PLECTOCERAS Hyatt, 1884

PLECTOCERAS OHTAKAI, new species

PLATE 24

One of my students, the late Chujiro Ohtaka, collected near Penhsi-hu, during a geological excursion of the Manchurian Teachers' College, a large but broken cast of a coiled cephalopod. Though this specimen is rather fragmentary and only a mold, it became clear, after making a plaster cast and carefully examining it, that it

is a *Plectoceras*, since it has the characteristic coiling of the transverse riblike folds on the surface of the shell and the large umbilical perforation, and agrees in other details. The Manchurian specimen may be described as follows:

Description.—Volutions of conch apparently in contact with one another, consisting of about four and one-half volutions, of which the living chamber probably occupied a length of about one-third of a volution, though the actual length of the part here preserved is only 125 mm, and the maximum diameter of the conch across its umbilical part is about 240 mm.

At the larger end of the specimen its dorsoventral diameter is estimated as 46 mm. One volution back from this larger end, the dorsoventral diameter is about the same as that of the former one. Two volutions back from larger end, the dorsoventral diameter diminishes to about 25 mm. The earlier volutions of the conch probably are in contact with one another, and the dorsal side may be finely impressed, but toward the aperture the living chamber may not be in actual contact with the preceding volution, though closely contiguous. The maximum prominence of the lateral sides is much nearer to the dorsal side. The dorsolateral angles are very prominent, and are estimated at about 70°, but the ventrolateral angles may be broadly rounded.

The surface of the shell is crossed obliquely by very remarkable transverse riblike folds, which curve backward along the lateral sides of the conch. About four of the folds occupy a length equal to the dorsoventral diameter of the shell. In addition to these oblique riblike folds the surface of the conch is crossed by fine, minute, transverse striae, parallel to the folds.

This species is characterized by its remarkable dorsolateral angle, very sharp and well-defined riblike folds, and about the same dorsoventral diameters of the living chamber and the preceding volution as compared with other species of *Plectoceras*.

Formation and locality—Lower Ordovician, Wuting formation: In loose limestone bowlder, apparently from the Wuting formation near San-tao-kang-tzu, 1.5 miles north of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83696.

Genus SACTOCERAS Hyatt, 1884

SACTOCERAS KOBAYASHII, new species

PLATE 14, FIGURE 6; PLATE 40, FIGURE 8

Description.—The holotype is 54 mm long, enlarging laterally from a diameter of 21.5 mm at its base to 28 mm at a point 44 mm

farther up, the apical angle being 9°. The cross sections of the conch and the siphuncle are apparently circular, but only the lateral half of the shell remains, the other half being weathered away. The number of camerae in a length equal to the diameter of the conch is about 4.5. Septa regularly concave; their concavity is not so conspicuous, and is rather shallow, being 4.5 mm in depth. The siphuncle is excentric, its center located 10.5 mm from the ventral side of the conch at a point near the top. Where the diameter of the conch is 27.5 mm, and where the septa are 6 mm apart, one of the segments of the siphuncle has a maximum diameter of 5 mm at mid height, constricting to 2.5 mm at its passage through the septum. The resultant form of segments of the siphuncle is almost globular, slightly depressed anteriorly. Almost all the interior of the camerae is filled with calcareous deposits, leaving very narrow strips here and there, while the inner side of the siphuncle is empty except for a slight deposit just inside its passage through the septum.

The specific name is given in honor of T. Kobayashi, of the Tokyo Imperial University in Japan.

Comparisons.—This species may be closely allied to *Sactoceras decipiens* (Barrande), and *Sactoceras improbus* (Barrande) from stage E, Bohemia, but the shallower concavity of the septa serves readily in distinguishing it.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone beds near Penhsi-hu, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83697.

SACTOCERAS NIUHSINENSE, new species

PLATE 14, FIGURE 13; PLATE 40; FIGURE 18

Description.—The holotype is 74 mm long, enlarging very slightly from base to top. The cross sections of the conch and siphuncle apparently are circular, but only the ventral half of the conch remains, the dorsal half being weathered away. The siphuncle is centrally located. The number of camerae in a length equal to the diameter of conch is about 10. Where the diameter of the specimen is 37.5 mm and where the septa are 3.5 mm apart, one of the segments of the siphuncle has a maximum diameter of 5 mm at mid height, constricting to 2.6 mm at its passage through the septum. The resultant form of the siphuncle segments is somewhat depressed globular. The average concavity of the septa is 6.5 mm. The interior of the siphuncle and the conch are almost empty, but a very small quantity of the lunate calcareous matrix is found on the interior of the siphuncle at its passage through the septa; also the septa are thickened slightly here and there by deposits of calcareous matrix.

The smaller apical angle, lower concavity of the septa, and smaller ratio between the diameter of the siphuncle and that of the conch serve to differentiate this species from others found in the Ordovician.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, 1 mile east of the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83698.

SACTOCERAS LIAOTUNGENSE, new species

PLATE 14, FIGURE 10

Description.—The holotype is 33.5 mm long, enlarging from 7.5 mm at the base to 15 mm at the top, the apical angle being 9°. The cross sections of the conch and siphuncle apparently were circular, but only the lateral half of the conch remains. The siphuncle is located somewhat ventrally. Five camerae occupy a length equal to the diameter of the conch. Where the diameter of the specimen is 13.5 mm and where the septa are 3 mm apart, one of the segments of the siphuncle has a maximum diameter of 2.5 mm at mid height, constricting to 1.2 mm at its passage through the septum. The resultant form of segments of the siphuncle is almost globular. The concavity of the septa averages 3 mm. The interior of the siphuncle is moderately filled with calcareous matrix, and that of the camerae is almost entirely filled with the same deposition, leaving a diagonal narrow space at its center.

Comparisons.—The comparatively small conch and rather large apical angle serve to differentiate this species from others found in the Ordovician beds in the Orient. Moreover, I am not acquainted with any American or European forms with which this species is likely to be confounded.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestones, on the Fu-chin-kou ridge, 2.5 miles southwest of Miyanohara station, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83699.

SACTOCERAS INAII, new species

PLATE 14, FIGURE 1

Description.—The holotype is 47 mm long, 17.5 mm in diameter at the base, and 19.5 mm near the top, the apical angle being very small. The cross section of the conch, apparently, was laterally depressed, but the comparatively large part of the dorsal side has weathered away. The location of the siphuncle is very excentric, its distance from the ventral wall of the conch being 2.5 mm. The number of

camerae in a length equal to the diameter of the conch is nine. Where the diameter of specimen is 19 mm and where the septa are 2 mm apart, one of the siphuncle segments has a maximum diameter of 3 mm at mid height, constricting to 1.2 mm at its passage through the septum. The resultant form of the siphuncle segments is globular. Septal necks very short; envelope on the interior of the siphuncle by lunate calcareous deposits, leaving rather a large endosiphuncular passage. The septa are thickened rather slightly with the deposition of calcareous matrix at both the upper and lower sides.

Living chamber and surface of the conch unknown.

The specific name is given in honor of Y. Inai, a prominent paleontologist in Manchuria.

Comparisons—This species is closely allied to *Sactoceras manitoulinense* Foerste from the clay cliffs at Meaford, Canada, but it is distinguished by the much more excentric siphuncle and its more depressed segments. Moreover, in the Manchurian specimen, nine camerae occur in a length equal to the diameter of the conch, while in *S. manitoulinense* this number is six or seven.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone at Tou-fang-kou, 2.5 miles northwest of Pen-hsi-hu, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83700.

SACTOCERAS species undetermined

PLATE 13, FIGURE 7

A fragmental specimen (U.S.N.M. No. 83701) 29 mm long has a very low apical angle. Five camerae occur in a space equal to the diameter of the conch. The cross section of the conch apparently is depressed. Where the diameter of the conch is 8.5 mm, the concavity of the septa is 1.2 mm; the maximum diameter of the siphuncle here is estimated at 2.8 mm, and height of its camerae averages 2 mm. The interior of the siphuncle is densely filled with calcareous matrix. The septa are moderately thickened with the deposition of calcareous matrix on the anterior side of each septum.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, near the Pen-hsi-hu colliery, Liao-tung, Manchuria.

SACTOCERAS species undetermined

PLATE 14, FIGURE 11

A fragmental specimen (U.S.N.M. No. 83702) is 53 mm long, 18.5 mm in diameter near the base, and estimated to have been 25 mm in diameter at a point 32 mm farther up, thus indicating an apical

angle of about 14°. The cross section of the conch apparently was elliptical laterally, that of the siphuncle circular. The siphuncle is located excentric laterally. Seven camerae occupy a length equal to the diameter of the conch. Where the diameter of the specimen is 20 mm, the segment of the siphuncle has a maximum diameter of 3.6 mm at mid height, constricting to 2.5 mm at its passage through the septum. The resultant form of segments of siphuncle is almost globular. Septa are moderately concave. The interiors of the camerae and siphuncle are irregularly filled with calcareous matrix.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the lower fossil horizon of the gray banded limestones, near Pen-hsi-hu, Liao-tung, Manchuria.

Genus ACTINOCERAS Bronn, 1837

ACTINOCERAS CONCAVUM, new species

PLATE 16, FIGURE 10

Description.—A rather good specimen is 80 mm long, enlarging from a diameter of 26.5 mm near the base to 34 mm at the top, the apical angle being 6°. The cross sections of the conch and the siphuncle were apparently circular, but only the dorsal side of the shell remains. The number of camerae in a length equal to the diameter of the conch is about 6.7. Where the lateral diameter of the conch is 34 mm, the concavity of the septa is 10 mm, the length of the camerae is 5.2 mm, and the maximum diameter of the segments of the siphuncle is 13.2 mm. The septal necks descend slightly below the general concave curvature of the septa, and their length is usually 0.7 mm or less. The inner margin of the septa is in contact with the lower surface of the preceding connecting rings for a radial width of only 2 mm. The interior of the siphuncle is filled with typical actinoceroid materials, leaving a medium-sized endosiphuncular passage and its narrow diverticula, which bend forward somewhat. The septa are thickened considerably by the deposition of calcareous matrix, which occurs both on the upper and under sides of the septum, leaving very narrow, diagonal interspaces in the middle part of each camera.

Comparisons.—This species may be compared to *Armenoceras richthofeni* (Frech), but differs from it in having greater concavity of the septa and fewer camerae in a length equal to the diameter of the conch, and comparatively longer septal necks.

Formation and locality.—Middle Ordovician, Ssuyen formation: A black limestone bowlder believed to have come from a part of the Ssuyen formation; collected in river drift at the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83705.

Genus NYBYOCERAS Troedsson, 1926

NYBYOCERAS FOERSTEI Endo

PLATE 25, FIGURES 3–5; PLATE 26, FIGURES 9, 10

1930. *Nybyoceras foerstei* ENDO, Denison Univ. Bull., Journ. Sci. Lab., vol. 25, p. 298, pl. 60, figs. 1 a–c.

Description.—The holotype is 127 mm long, and its apical angle seems to be rather small. The cross section of the conch is somewhat depressed, while that of the siphuncle is circular, a part of the dorsal side of the conch having weathered away. The dorsoventral diameter of the conch at the top of the specimen is estimated as about 57 mm, while its lateral diameter is about 63 mm. The number of camerae in a length equal to the lateral diameter of the conch is seven. The diameter of siphuncle at the top of the specimen is 21 mm. The ratio between the diameter of the siphuncle and the dorsoventral diameter of the conch is 37 : 100. The distance of the siphuncle from the ventral wall of the conch at the top of specimen is 3 mm. Siphuncle is strongly nummuloidal, and its anterior is filled with actinoceroid deposits of calcareous material, leaving a central endosiphuncular passage. Septal neck rather conspicuous. On the dorsal side of the conch the septa are in contact with the segments of the siphuncle below instead of those above, but ventrally they are conspicuously in contact with the segments above, and laterally the same form of contact predominates. It was upon this very characteristic structure that Troedsson established the subgenus *Nybyoceras*, which I have raised to generic rank. Both sides of the septa on the dorsal side of the conch are covered by a deposit of calcareous material, and the interior of the camerae on its vertical side is almost filled by a similar deposit. The sutures of the septa are very oblique, the surface of the shell apparently smooth.

The specific name is given in honor of Dr. August F. Foerste, of Dayton, Ohio, from whom I have received valuable help and many suggestions in my study of the Manchurian Ordovician fossils.

Comparisons.—This species is readily distinguishable from *Nybyoceras bekkeri* Troedsson from the Lyckholm bed (F_1) at Nyby, Estonia, in having a siphuncle of relatively smaller diameter and shorter camerae.

Formation and locality.—Lower Ordovician, Wuting formation: In the black banded limestones near San-tao-kang-tzu, 1.5 miles north of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83455.

Genus ARMENOCERAS Foerste, 1924

ARMENOCERAS ORIENTALE, new species

PLATE 16, FIGURE 9; PLATE 40, FIGURE 14

Description.—A large, well-preserved specimen, retaining all the living chamber, becomes the holotype of another new species. It is 311 mm long, 124 mm of which belongs to the living chamber. Its lateral diameter enlarges from 31 mm near the base to 72.5 mm at a point 245 mm farther up, the apical angle being about 7°. The cross sections of the conch and the siphuncle apparently are depressed, but only the dorsal half of the specimen remains, the ventral half having weathered away. The siphuncle is located ventrally, its center being 14 mm from the dorsal wall of the conch at a point 50 mm above the base. The siphuncle is 12.2 mm in diameter near the base and 15.5 mm at a point 61 mm above, the ratio of its diameter to that of the conch being 8:25. The number of camerae in a length equal to the lateral diameter of the conch is 16.2. The concavity of the septa varies from 8.5 mm near the base of the specimen to 14.5 mm at the top of its camerae. The length of the camerae varies from 6.5 mm at the oldest to 4.1 mm at the youngest. Where the lateral diameter of the siphuncle is 13.2 mm that of the passage of the siphuncle through the septum is 7.5 mm. Between the connecting rings this septum is horizontal, and the inner margin of the septum extends about 3 mm inward from the vertical projection of the outer margin of the septal rings. These rings are in contact with the septa both above and below for a radial width of 2 mm. In the interior of the siphuncle nearly the whole space of the central part is filled with the calcareous matrix, leaving comparatively broad empty spaces in the portion of the marginal nummuloids. The shell and some septa are slightly and very irregularly thickened by calcareous matrix. Surface of the shell unknown.

Comparisons.—This very complete specimen differs from all other described oriental species in having a comparatively small apical angle and highly nummuloidal segments of the siphuncle, and the horizontal inner margin of the septa between the connecting rings. I am not acquainted with any American or European species with which this species is likely to be confounded.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the lower fossil horizon of the dark gray limestone beds, near Hsia-kang-yao, 3.5 miles southeast of the Yen-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83707.

ARMENOCERAS ASIATICUM, new species

PLATE 16. FIGURES 2–6

1927. *Actinoceras tani* KOBAYASHI (not Grabau), Jap. Journ. Geol. and Geogr., vol. 5, no. 4, p. 192, pl. 20, fig. 9; pl. 21, fig. 5; pl. 22, figs. 1 a–b.

This species has a rather wide distribution in Manchuria and I have obtained four fragmental but comparatively well-preserved specimens on which to base the following description:

Description.—The best specimen is 43 mm long (pl. 16, fig. 3), enlarging laterally from a diameter of 14 mm at the base to 21 mm near the top, the apical angle being 12°. The cross section apparently is elliptical laterally, but only the ventral half of the specimen remains. Eight camerae occupy a length equal to the diameter of the conch. The siphuncle is about central in its position, its diameter is 5.5 mm near the top, the ratio of its diameter to the lateral diameter of the conch being 7:25. The concavity of the septa is 3 mm. In this specimen only the overlying connecting ring is adnate to the intermediate septa for about 1 mm in width in the area immediately surrounding the passage of the siphuncle through the septa, but the underlying connecting rings are not adnate to the septa immediately above, as they meet the inner margin of these septa at a very acute angle, without a distinct septal neck intervening. The anterior parts of the segments of the siphuncle are somewhat depressed as compared with its posterior parts. The interior of the siphuncle is filled with calcareous deposits, except the endosiphuncular passage and its diverticula. The septa are thickened by the deposition of calcareous matrix on the anterior surfaces, which are comparatively thin at the margin, gradually thickening toward the siphuncle, and then abruptly thinning out, finally assuming a saucerlike shape before reaching the connecting rings.

Comparisons.—The general characters of this species closely coincide with those of *Armenoceras tani* (*Actinoceras tani* Grabau), but in this species only the overlying connecting ring is adnate to the intermediate septa for a short distance in the area immediately surrounding the passage of the siphuncle through the septa, while in the latter species both the overlying and the underlying connecting rings are adnate to the intermediate septa. Moreover, the former species has a smaller ratio between the diameter of the siphuncle and that of the conch as compared with that of the latter species.

The specimens described by Kobayashi as *Actinoceras tani* are exactly the same as my new species *Armenoceras asiaticum* in having the inner margins of the septa adnate to only the upper connecting

ring, which feature also distinguishes Kobayashi's specimen from Grabau's *Actinoceras tani*.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone beds, just north of and 4 to 5 miles southwest of the Pen-hsi-hu colliery Liao-tung, Manchuria.

Cotypes.—U.S.N.M. Nos. 83708 and 83709.

ARMENOCERAS BASSLERI, new species

PLATE 22, FIGURES 5, 6; PLATE 40, FIGURE 12

Description.—The holotype is 85 mm long, enlarging laterally from a diameter of 29 mm to 39 mm in a length of 46.5 mm, indicating an apical angle of about 16°. The cross section of the conch is somewhat depressed, while that of the siphuncle is circular. The siphuncle is about central in its position; its diameter is estimated at 13 mm at the middle and its center is located 8 mm from the ventral wall of the conch. Nine camerae occupy a length equal to the diameter of the conch. Where the lateral diameter of the conch is 36.5 mm the concavity of the conch equals 7 mm. Near the lateral margins of the conch the sutures of the septa are shown as having a very slight sigmoidal shape, and the septa come into contact with the lower side of the segments of the siphuncle near its inner margins, but the underlying connecting rings are not so distinctly adnate to the septa. The interior of the siphuncle is occupied by calcareous matrix, leaving a comparatively large endosiphuncular passage, and its narrow diverticula into the lateral margins of the segments of the siphuncle. The septa are thickened regularly by calcareous matrix, which occurs both on the upper and under sides of the septum, leaving narrow, diagonal, and saucerlike spaces in the middle of each camera but just outside of the segments of the siphuncle.

Living chamber and outer surface of the shell unknown.

The specific name is given in honor of Dr. R. S. Bassler, head curator of geology of the United States National Museum, from whom I have received much assistance in this work.

Comparison.—This species differs from all described oriental species of *Armenoceras* in having a very large ratio of the diameter of the siphuncle to that of the conch, and slightly sigmoidal shape of the sutures.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, near Hsia-kang-yao, 3.5 miles southeast of the Yen-tai colliery, Liao-tung Manchuria.

Holotype.—U.S.N.M. No. 83759.

ARMENOCERAS RESSERI, new species

PLATE 17, FIGURE 6

Description.—The holotype is 112 mm long, its lateral diameter increasing from 22.5 mm near the base to 41 mm near the top, the apical angle being 16°. The cross section apparently is circular, but only the ventral half of the specimen remains, the dorsal half having weathered away. The siphuncle is centrally located. Thirteen camerae occupy a length equal to the diameter of the conch. Where the diameter of the conch is 41 mm, the maximum diameter of the siphuncle is estimated as 11.5 mm. The concavity of the septa and the height of the camerae are estimated to average 7.5 and 3.5 mm, respectively. Where the lateral diameter of the siphuncle is 11.5 mm, that of the passage of the siphuncle through the septum is 8 mm. The inner margin of the septum extends about 3 mm inward from the vertical projection of the outer margin of the septal rings. These rings are in contact with the septa both above and below for a radial width of 2 mm. The interior of the siphuncle is filled with typical actinoceroid deposits, leaving an endosiphuncular passage 6 mm wide and its narrow, somewhat forward bending diverticula between the outer margin of the connecting rings. The camerae of the older part are almost filled with the calcareous matrix, which becomes gradually less toward the younger end.

This species is characteristic in having a rather large conch, a small ratio between the diameter of the siphuncle and that of the conch, and a large endosiphuncle. I am not acquainted with any American, European, or Oriental species with which this is likely to be confounded.

The specific name is given in honor of Dr. C. E. Resser, of the United States National Museum, from whom I have received valuable assistance in this work.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone beds, near Toufang-kou, 2.5 miles northwest of Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83710.

ARMENOCERAS COULINGI (Grabau)

PLATE 17, FIGURE 5

1903. *Actinoceras* (*Ormoceras*) aff. *tenuifilum* CRICK, Geol. Mag., new ser., vol. 10, p. 481, pl. 22, fig. C, Dec. 4.

1920. *Actinoceras* (*Ormoceras*) sp. indt. YABE, Palaeontology of southern China, p. 52, pl. 19, fig. 9.

1922. *Actinoceras coulingi* GRABAU, Pal. Sinica, ser. B, vol. 1, fasc. 1, p. 82, pl. 8, fig. 1, 2.

1927. *Actinoceras coulingi* KOBAYASHI, Jap. Journ. Geol. and Geogr., vol. 5, no. 4, p. 193, pl. 21, fig. 6.

Description.—This plesiotype is 86 mm long, its lateral diameter increasing slightly from the base to the top. As only the ventral half of the specimen remains, the shape of the cross section of the conch can not be exactly identified, but apparently is depressed laterally. Thirteen camerae occupy a length equal to the diameter of the conch. The siphuncle is 16 mm in diameter at the upper part of the specimen, the ratio of its diameter to that of the conch being 37:100. The siphuncle is located excentric in position. The concavity of the septa averages 7 mm. Where the lateral diameter of the siphuncle is 17.5 mm, that of the passage of the siphuncle through the septum is 9 mm. Between the connecting rings this septum curves gently downward but does not form a septal neck. This inner margin extends about 4 mm inward from the vertical projection of the outer margin of the septal rings. These rings are in contact both above and below with the septa for a radial width of 2.5 mm, which structures are characteristic features of *Armenoceras.* The interior of the siphuncle is almost filled with calcareous matrix. The septa are thickened very irregularly with the deposition of the calcareous matrix, which appears as if it were deposited on both sides of the septum.

Formation and locality.—Middle Ordovician, Ssuyen formation: The lower fossil horizon of the black banded limestones, just south of the Wu-hu-tsui colliery, Liao-tung, Manchuria.

Plesiotype.—U.S.N.M. No. 83711.

ARMENOCERAS ELEGANS, new species

PLATE 15, FIGURES 1–3

One fragment of the conch and two large siphuncles of an *Armenoceras* constitute the material on which this new species is based.

Description.—The first specimen (pl. 15, fig. 2), is 53 mm long and enlarges laterally from 25 mm at the base to 45 mm at the point 25 mm farther up, so that the apical angle is rather large. The cross section apparently is elliptical laterally, but only the ventral half of the specimen remains. About nine camerae occupy a length equal to the diameter of the conch when the counting is completed. The siphuncle is excentric in position, the distance between the siphuncle and ventral side of the conch is 5 mm at the base. The diameter of the siphuncle is about the same throughout the specimen. Where the diameter of the conch is 30 mm, that of the siphuncle at its passage through the septa is 12 mm, enlarging to 18.5 mm at mid height within the camerae. The septal necks appear to be about 1.5 mm in length. The interior of the siphuncle is filled with calcareous material, leaving a rather large endosiphuncular passage and its narrow lateral diverticula, which bend backward at first and then curve

forward. The septa of the lower part of the specimen are thickened by deposition of calareous matrix.

A second specimen (pl. 15, fig. 1), consisting of a siphuncle 177 mm long, enlarges from a lateral diameter of 27 mm at its base to 31 mm near the top. This specimen shows very distinctly the connecting portion between the septal necks and the rings, a characteristic feature of *Armenoceras*.

A third specimen (pl. 15, fig. 3), also a siphuncle, is 123 mm long. The enlargement of this specimen is peculiar; at its apical part it enlarges at an angle of 20° from the lateral diameter of 12 mm at the base to 29 mm at a point 41 mm farther up. From this point it enlarges in diameter very gradually to the top.

Formation and localities.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone beds near the Pen-hsi-hu and the Niu-hsin-tai collieries, Liao-tung, Manchuria.

Holotype and paratypes.—U.S.N.M. Nos. 83703 and 83704.

ARMENOCERAS ELONGATUM, new species

PLATE 17, FIGURES 1–4; PLATE 18, FIGURE 8

Description.—The holotype, 96 mm long, has a lateral diameter increasing from 15 mm near the base to 33 mm near the top, the apical angle being 8°. The cross section of the conch is apparently circular near the base and elliptical laterally near the top; that of the siphuncle is circular throughout, but only the dorsal half of the specimen remains, the ventral half having weathered away near the base, while almost the whole of the dorsal portion remains near the top. Ten camerae occupy a length equal to the lateral diameter of the conch. The siphuncle is 7.5 mm in diameter near the base of the specimen and 10.5 mm at its middle, the ratio of its diameter to that of the conch varying between 21:50 and 25:50 within the 43 mm length of the specimen. The distance between the siphuncle and the ventral side of the conch is about 4 mm near the base and 2.5 mm near the top. The concavity of the septa varies from 4.5 mm to 5 mm. Where the lateral diameter of the siphuncle is 10.5 mm, that of the passage of the siphuncle through the septum is 6 mm. The inner margin of the septa, at the passage of the siphuncle through the septa, curves faintly downward, but does not form a septal neck. The interior of the siphuncle and almost all the septal interspaces of the ventral side are filled with typical actinoceroid deposits of calcareous material, leaving the usual central endosiphuncular passage and its diverticula into the outer margin of the connecting rings.

Living chamber of the shell unknown. Outer surface apparently smooth. The cross section near the top of a second specimen is exactly the same as the first. The dorsoventral diameter of the conch

in this section is about 21 mm, while the lateral diameter is 25 mm. The number of camerae in a length equal to the lateral diameter of the conch equals nine. The diameter of the siphuncle in the same section is 10.5 mm, the ratio between the diameter of the siphuncle and the lateral diameter of the conch being 21:50. The distance of the siphuncle from the ventral wall in the same section is 3 mm. The dorsal part of the camerae in this second specimen is not filled with the calcareous matrix.

A vertical section of a third specimen has been cut in a dorsoventral direction through the center of the siphuncle; in this section, as seen in Plate 17, Figure 2, the concavity of the septa of the ventral side is very conspicuous as compared with that of the dorsal side.

Comparisons.—This species may be compared with *Armenoceras* (*Actinoceras*) *submarginale* (Grabau) from the Machiakou limestone of the Kaiping basin, North China, but the comparatively narrow siphuncle and its position serve readily to distinguish it. This species is also closely allied to *Armenoceras* (*Actinoceras*) *manchurense* (Kobayashi) but differs in having a faintly downward curving inner margin of the septum at the passage of the siphuncle through the septum, while that part of *A. manchurense* is more horizontal.

Formation and locality.—Middle Ordovician, Ssuyen formation (holotype from the lower fossil horizon): In the black banded limestone beds, which are widely distributed south of the Niu-hsin-tai colliery, Liao-tung, Manchuria. Paratype from the same beds on the small hill, just south of Kan-chia-tun in the Wu-hu-tsui coal basin, Manchuria. The third specimen was collected from the upper fossil horizon just north of the Niu-hsin-tai colliery.

Holotype and paratypes.—U.S.N.M. Nos. 83712–83714.

ARMENOCERAS HATAI, new species

PLATE 18, FIGURES 1–3

Description.—The holotype is 50 mm long, slightly enlarging laterally from the base to the top. The cross sections of the conch and siphuncle are circular. The siphuncle is excentric, its center being located 6 mm from the ventral wall of the conch. Seven and one-half camerae occupy a length equal to the diameter of the conch. Where the diameter of the conch is 22.5 mm, the maximum diameter of the siphuncle is estimated at 8.5 mm, making the ratio of the latter to the former 19:45. The concavity of the septa and the height of the camerae are estimated to average 4.5 mm and 2.7 mm, respectively. The segments of the siphuncle are strongly depressed vertically both above and below, and the connecting rings are in contact with the septa both above and below for a radial width of 1 mm. The interiors of the siphuncle and the camerae are filled

rather densely with the calcareous deposit, leaving only small spaces here and there.

The specific name is given in honor of G. Hata, a geologist of the geological institute of the South Manchuria Railway Co.

Comparisons.—This species is closely related to *Armenoceras tani* (Grabau), but differs in having a larger concavity of the septa and a more excentric siphuncle.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestones, just north of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83715.

ARMENOCERAS HARIOI (Kobayashi)

PLATE 16, FIGURE 1

1927. *Actinoceras harioi* KOBAYASHI, Jap. Journ. Geol. and Geogr., vol. 5, no. 4, p. 196, pl. 20, fig. 12; pl. 21, fig. 9.

Description.—A fragmental specimen, 25.5 mm long, enlarges slightly from the base to the top. The cross section of the conch, apparently, was laterally depressed, while that of the siphuncle was circular, but most of the dorsal side has weathered away. The siphuncle is located very excentrically. The number of camerae in a length equal to the diameter of the conch equals about 10. Where the lateral diameter of the conch is 15.5 mm, the concavity of the septa is 2 mm, the length of the camerae is 1.4 mm, and the maximum diameter of the segments of the siphuncle 3 mm. There are no traces of the septal necks at the inner margins of the septa, which are combined with both upper and lower connecting rings at acute angles. The calcareous matrix is slightly developed in the camerae of the apical part of the shell, while it fills very densely the camerae of the older part.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the lower fossil horizon of the gray banded limestone beds, on Fu-chin-kou ridge, southwest of Miyanohara station on the Antung-Mukden line, Manchuria.

Plesiotype.—U.S.N.M. No. 83716.

ARMENOCERAS HAYASAKAI, new species

PLATE 18, FIGURES 6, 7

Description.—The holotype is 97 mm long, enlarging from a lateral diameter of 13 mm near its base to 20.5 mm at a point 42 mm farther up, the apical angle being 10°. The cross sections of the conch and the siphuncle are somewhat depressed. A small portion of the ventral side is weathered away. Eight camerae occupy a length equal to the lateral diameter of the conch. Where the diameter of the

conch is 18 mm, the concavity of the septa is 3 mm, the length of the camerae is 2.5 mm, and the maximum diameter of the segments of the siphuncle is 9.5 mm. The inner margin of the septa, at the passage of the siphuncle through it, curves slightly downward. The overlying connecting rings are adnate to the intermediate septa for a short space in the area immediately surrounding the passage of the siphuncle through the septa, while the underlying connecting rings meet the inner margin of each septum at acute angles. The deposition of calcareous material in the camerae is rather pronounced in the earlier part of the shell but becomes less in the later. For the most part it is added to the anterior portion of the septa, but in some cases appears slightly on their posterior surfaces. The septa are sometimes undulating. The siphuncle, evidently, was located ventrally. Living chamber and the surface of the shell are unknown.

The specific name is given in honor of Prof. I. Hayasaka, of the Taihoku Imperial University in Japan.

Comparisons.—The general form of this species is rather like *Armenoceras* (*Actinoceras*) *tani* (Grabau), but the comparatively large diameter of the siphuncle, the deeper concavity of the septa, the rather undulating septa, and the smaller apical angle of the conch serve readily to distinguish it.

Formation and locality.—Middle Ordovicion, Ssuyen formation: A grayish black limestone bowlder believed to have come from the Ssuyen formation, river drift at the Niu-hsin-tai colliery; another fragmental specimen comes from the lower fossil horizon of the black banded limestone 5 miles west of Chiao-tou station, Liao-tung, Manchuria.

Holotype and paratype.—U.S.N.M. Nos. 83717 and 83718.

ARMENOCERAS KIDOI, new species

PLATE 18, FIGURE 9; PLATE 40, FIGURE 5

Description.—The holotype is 88 mm long, enlarging from a diameter of 26 mm near the base to 29 mm at a point 48 mm farther up. The cross section of the conch was apparently somewhat depressed, while that of the siphuncle was circular. The siphuncle is located in the center of the conch. The number of camerae in a length equal to the diameter of the conch is seven. Where the diameter of the conch is 27 mm, the concavity of the septa is 7 mm and the length of the camerae 3.5 mm. Where the lateral diameter of the siphuncle is 10 mm, that of the passage of the siphuncle through the septum is 4.5 mm. Between the connecting rings this septum is more nearly horizontal and its inner margin directed slightly downward. This inner margin extends about 3 mm inward from the ventral projection of the outer margin of the septal rings.

These rings are in contact with the septa both above and below for a radial width of 1.5 mm. The siphuncle is filled with typical actinoceroid deposits of calcareous material, leaving the rather large central endosiphuncular passage and its diverticula into the outer margin of the connecting rings. The septa are thickened irregularly with the deposition of calcareous matrix on both their upper and lower sides; this calcareous material almost entirely fills in the camerae of the one side and of the older part. Living chamber and surface of the shell unknown.

The specific name is given in honor of Doctor Kido, former director of the geological survey of the South Manchuria Railway Co.

Comparisons.—This species may be compared to *Armenoceras manchurense* (Kobayashi), but differs from it in having a smaller apical angle, a larger septal distance, and an almost circular shell.

Formation and locality.—Middle Ordovician, Ssuyen formation: A black limestone bowlder believed to have come from the Ssuyen formation, in river drift near the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83719.

ARMENOCERAS TEICHERTI, new species

PLATE 19, FIGURE 1; PLATE 40, FIGURE 6

Description.—The holotype specimen is 69 mm long, enlarging from a lateral diameter of 26 mm near its base to 33.5 mm at a point 38 mm farther up, indicating an apical angle of about 7°. It is estimated that about seven camerae occupied a length equal to the lateral diameter of the conch near the base. The cross sections of the conch and the siphuncle are apparently circular, but only the ventral half of the specimen remains, the dorsal half having weathered away. The concavity of the septa is about 6.5 mm. The distance of the siphuncle from the ventral wall of the conch is 4 mm. The diameter of the siphuncle is 10.2 mm; at a point where its lateral diameter is 10.5 mm, that of the passage of the siphuncle through the septum is 5 mm. Between the connecting rings this septum is horizontal and its inner margin curves slightly downward; the inner margin extends about 2.5 mm inward from the vertical projection of the outer margin of the septal rings. These rings are in contact with the septa both above and below for a radial width of 2 mm. The interior of the siphuncle is filled with typical actinoceroid calcareous materials, but the endosiphunclar passage and its diverticula into the outer margin of the connecting rings lack such deposits. The septa are thickened on both upper and lower marginal portions by nearly equal quantities of calcareous material, which leaves narrow spaces in the middle of each camera.

The specific name is given in honor of Dr. C. Teichert, of Germany, from whom I have received many suggestions in connection with this study.

Comparisons.—The general outline of this species reminds one of *Stereoplasmoceras pseudoseptatum* Grabau (*Armenoceras pseudoseptatum*) from the Machiakou limestone, North China, but shows a characteristic generic feature of *Armenoceras*, as seen in the preceding description, and moreover, the comparatively large diameter of its siphuncle serves readily in distinguishing it specifically.

Formation and locality.—Middle Ordovician, Ssuyen formation: From a limestone bowlder believed to have come from the Ssuyen formation; river drift at the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83720.

ARMENOCERAS MANCHURENSE (Kobayashi)

PLATE 19, FIGURES 6–8

1927. *Actinoceras manchurense* KOBAYASHI, Jap. Journ. Geol. and Geogr., vol. 5, no. 4, p. 194, pl. 20, fig. 10; pl. 21, fig. 7; pl. 22, figs. 2 a–b.

The better specimen in my collections is 61 mm long, enlarging from a lateral diameter of 16.5 mm at its base to 31 mm at a point 49 mm farther up, the apical angle being 15°. The cross section of the conch, apparently, was depressed, while that of the siphuncle was probably circular. The number of camerae in a length equal to the lateral diameter of the conch is 10. Septa regularly concave, the concavity averaging 6 mm. The siphuncle is strongly annulated; where the diameter of the conch is 28.5 mm, the maximum diameter of the segment of the siphuncle is 12.5 mm. The inner margin of the septa, at the passage of the siphuncle through it, curves very slightly downward, but does not form a septal neck. Septal rings are in contact with the septa both above and below for a radial width of 2 mm. This feature between the connecting rings and septa is very characteristic of *Armenoceras*. The inner margin of the siphuncle and the anterior surface of the septa are covered with calcareous deposits. The distance between the siphuncle and the ventral side of the conch is 3 mm at the base and near the top, but the siphuncle is excentric near the top while it is found rather centrally located at the base.

A second specimen (pl. 19, fig. 8) from near the Pen-hsi-hu colliery is 70 mm long, its cross section being somewhat crushed laterally and dorsoventrally. The siphuncle is very excentric in location, 10 camerae occupying a length equal to the lateral diameter of the conch.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, near Tou-fang-

kou, 2.5 miles northwest of the Pen-hsi-hu colliery; and also from the same horizon just east of the same colliery, Liao-tung, Manchuria.

Plesiotypes.—U.S.N.M. Nos. 83721 and 83722.

ARMENOCERAS MAGNITUBULATUM, new species

PLATE 19, FIGURES 5, 10

Description.—The holotype, 90 mm long, enlarges from 26.5 mm at the base to 39 mm at a point 39 mm farther up, the apical angle being about 20°. The cross sections of the conch and the siphuncle are circular. The siphuncle is central. Where the diameter of the conch is 29 mm, the concavity of the septa equals 6 mm; the maximum diameter of the siphuncle here is estimated at 17 mm, and the height of its camerae averages 4 mm; the ratio of the diameter of the siphuncle to that of the conch is 29 : 50. There are 6.5 camarae in a length equal to the diameter of the conch. The inner margin of the septa, at the passage of the siphuncle through the septa, curves slightly downward, the connecting ring beneath each septum meets with this inner margin at an acute angle; a similar acute angle is shown where the immediately overlying connecting ring meets the same septum. The interior of the siphuncle is filled with calcareous matrix, leaving a comparatively narrow endosiphuncular passage and its lateral diverticula. The septa are thickened with the deposition of calcareous matrix, which is deposited only on the anterior sides of the septa in some places, but is found on both sides in others. Living chamber and the surface of the shell unknown.

Comparisons.—This species may be compared with *Armenoceras coulingi* (Grabau) and *Armenoceras manchurense* (Kobayashi). It is easily distinguished by the larger ratio between the diameter of its siphuncle and that of the conch, and the larger apical angle of the shell.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, in the vicinity of Hsiao-nan-kou, 2 miles south of the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83723.

ARMENOCERAS MURAKAMII (Kobayashi)?

PLATE 19, FIGURES 2–4

1927. *Actinoceras murakamii* KOBAYSHI, Jap. Journ. Geol. and Geogr., vol. 5, no. 4, p. 198, pl. 22, fig. 6.

Two of my specimens, as is seen in Plate 19, Figures 2–4, seem to agree closely with Kobayashi's *Actinoceras murakamii*, but unfortunately I had no opportunity to compare specimens directly, and

Kobayashi's illustrations are too poor to be relied on; consequently I can not be certain that my specimen is the same. To judge from his description, however, it is possible that both represent the same species.

Description.—One of my best specimens is 32 mm long, enlarging from 10.2 mm near the base to 14 mm at a point 20 mm farther up, the apical angle being 10°. The cross sections of the conch and siphuncle were apparently circular, but only the lateral half of the specimen remains. The siphuncle is very excentric, its center being located 4.5 mm from the ventral wall of the conch; 4.5 camerae occupy a length equal to the diameter of the conch. Where the diameter of the conch is 13.7 mm, the concavity of the septa is 2.4 mm; height of camerae averages 2.5 mm. Where the lateral diameter of the siphuncle is 5.2 mm, that of the passage of the siphuncle through the septum is 1.5 mm. Between the connecting rings the septum is nearly horizontal. Connecting rings are in contact with the septa both above and below for a radial width of 1 mm. The interior of the siphuncle is filled completely with deposits of calcareous matrix, but that of a second specimen leaves a narrow endosiphuncular passage and its lateral diverticula. The camerae of the ventral side of the shell are nearly filled with the calcareous matrix, while the septa of the dorsal side are thickened very slightly with the deposits of calcareous matrix on the anterior surfaces.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, just south of the Wu-hu-tsui colliery, and on the Fu-chin-kou ridge, 2.5 miles southwest of Miyanohara station, Liao-tung, Manchuria.

Plesiotypes.—U.S.N.M. Nos. 83724 and 83725.

ARMENOCERAS NANUM (Grabau)

PLATE 18, FIGURES 4, 5

1922. *Actinoceras nanum* GRABAU, Pal. Sinica, ser. B. vol. 1, fasc. 1, p. 87, pl. 7, fig. 7; pl. 9, fig. 2.

1927. *Actinoceras nanum* Kobayashi, Jap. Journ. Geogr. and Geol., vol. 5, no. 4, p. 196, pl. 20, fig. 11; pl. 21, fig. 8, pl. 22, fig. 5.

Description.—A specimen from Niu-hsin-tai (pl. 18, fig. 4), 32.5 mm long, enlarges from a lateral diameter of 7.5 mm at its base to 11.5 mm near the top, the apical angle being 9°. The cross section of the conch was apparently slightly depressed. The number of camerae in a length equal to the diameter of the conch is eight. Where the diameter of the conch is 11 mm, the concavity of the septa is 2.5 mm, the length of the camera is 1.3 mm, and the maximum diameter of the segments of the siphuncle is 3 mm. The connecting ring beneath each septum meets the inner margin of the

septum at an acute angle; a similar acute angle is shown where the immediately overlying connecting rings meet the same septum; this structure is characteristic of *Armenoceras*. The calcareous matrix is rather slightly developed on the anterior margin of the septa in the younger part of the shell, while comparatively much greater quantities are found in the camerae at the older part of the shell.

A second specimen from near the Pen-hsi-hu colliery (pl. 18. fig. 5) is 40 mm long. The ratio between the diameter of the siphuncle and that of the conch is 3 : 10.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, near the Niu-hsin-tai and the Pen-hsi-hu collieries, Liao-tung, Manchuria.

Plesiotypes.—U.S.N.M. Nos. 83726 and 83727.

ARMENOCERAS NANUM TAKAYAMAI, new variety

PLATE 16, FIGURES 7, 8

Description.—Another fragmentary specimen, 17.5 mm long, has a rather cylindrical conch, enlarging very slightly from the base to the top. The cross section of the conch apparently was slightly depressed; the siphuncle is practically central. The lateral diameter of the conch at the top is estimated as 8 mm, while that of the siphuncle is 2 mm. The number of camerae in a length equal to the diameter of the conch is 6.2. The convexity of the septa at the middle part of the specimen is 2 mm; the length of the camerae averages 1.5 mm. The inner margin of each septum is connected with both the upper and lower connecting rings at an acute angle. The interior of the siphuncle is filled with calcareous matrix, leaving a narrow endosiphuncular passage. The septa are somewhat thickened by the calcareous matrix which occurs on both the upper and lower sides of the septum.

A second specimen from Wu-hu-tsui district (pl. 16, fig. 7) is 51 mm long. Though the manner of depositing the calcareous matrix is very irregular, other general features closely agree with that of the first specimen. Six camerae occupy a length equal to the diameter of the conch. The height of the camerae is estimated to average 2 mm, and the concavity of the septa at the lower part of the specimen is 2.5 mm. This variety differs from the type species in having a rather cylindrical conch, shallower concavity of the septum, and comparatively longer septal distance.

The name of this variety is given in honor of Y. Takayama, who collected the holotype.

Formation and localities.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone at Tou-fang-kou,

2.5 miles northwest of Pen-hsi-hu, and from the same horizon, near Wu-hu-tsui, Liao-tung, Manchuria.

Holotype and paratype.—U.S.N.M. Nos. 83728 and 83729.

ARMENOCERAS NUDUM, new species

PLATE 20, FIGURE 1; PLATE 40, FIGURE, 13

Description.—The holotype, 84 mm long, enlarges from 13 mm near the base to 25 mm at a point 56 mm farther up, the apical angle being about 15°. The cross section on the conch apparently is laterally depressed, while that of the siphuncle is circular, but only the ventral part of the specimen remains, the dorsal half having been weathered away. The siphuncle is excentric, its center located 5.5 mm from the ventral wall of the conch. Where the diameter of the conch is 24.5 mm, the concavity of the septa equals 4.5 mm; the maximum of the siphuncle here is estimated as 7 mm, and height of its camerae averages 3.5 mm. Therefore, the ratio of the diameter of the siphuncle to that of the conch is 29 : 100. There are seven camerae in a length equal to the diameter of the conch. The inner margin of the septa, at the passage of the siphuncle through it, curves downward very slightly. Both the overlying and the underlying connecting rings are adnate to the intermediate septa for 1 mm in width, on the average, in the area immediately surrounding the passage of the siphuncle through the septa. The interior of the siphuncle is filled with typical actinoceroid calcareous matrix, but the narrow endosiphuncular passage and its diverticula into the outer margin of the connecting rings lack such deposits. The septa are slightly thickened with the deposition of the calcareous matrix chiefly on the anterior but in some cases, also slightly on the posterior sides of the septa. Most of the camerae, however, are empty. This emptiness of the camerae is the most marked feature of the species, and, together with the comparatively narrower siphuncle and other details, serves to differentiate it from the others.

Formation and locality.—Middle Ordovician, Ssuyen formation: A black limestone bowlder believed to have come from the Ssuyen formation, in river drift at the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83730.

ARMENOCERAS NUMATAI, new species

PLATE 26, FIGURE 11; PLATE 40, FIGURE 7

One rather good specimen of this new species was given me by H. Numata, a teacher at the Antung Middle School.

Description.—The holotype is 55 mm long, enlarging from a lateral diameter of 17.5 mm at the base to 26 mm at the top, the

apical angle being 14°. The cross section apparently is elliptical laterally, but only the ventral half of the specimen remains, the dorsal half having weathered away. Eight camerae occupy a length equal to the diameter of the conch. The siphuncle is excentric, the distance between the siphuncle and ventral side of the conch being 4.5 mm at the top. Where the diameter of the specimen is 24.5 mm, and the septa 3.5 mm apart, segments of the siphuncle have a maximum diameter of 10.1 mm at mid height, constricting to 4.5 mm at its passage through the septum, with the result that the siphuncular segments form depressed nummuli. The concavity of the septa averages 4.7 mm. Between the connecting rings the septa are horizontal, and there is no trace of a septal neck. The interior of the siphuncle is filled with typical actinoceroid deposit, leaving the comparatively large endosiphuncular passage with its narrow, lateral diverticula into the outer margin of the connecting rings. Septa are somewhat thickened by the deposition of the calcareous matrix which occurs on both the upper and under sides of the septum.

Comparisons.—This species may be compared with *Armenoceras richthofeni* (Frech), but the smaller apical angle, the shallower septal concavity, the comparatively narrower siphuncle, and the shorter septal neck serve readily to distinguish it.

Formation and locality.—Lower Ordovician, Wuting formation: In the black banded limestone beds, near the second tunnel, 1 mile north of Pen-hsi-hu, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83706.

ARMENOCERAS PENHSIENSE, new species

PLATE 20, FIGURE 6; PLATE 40, FIGURE 15

Description.—The holotype, 67 mm long, enlarges very slightly in a length of 39 mm at the upper part of the specimen. This specimen shows a dorsoventral longitudinal natural section. The cross section of the conch and siphuncle, however, apparently are circular. The siphuncle is very excentric, its center being located 8.5 mm from the ventral wall of the conch. Where the dorsoventral diameter of the conch is 29 mm, the concavity of the septa is 7.5 mm; the maximum diameter of the siphuncle here is estimated at 12 mm, and the average height of its camerae is 5.5 mm. There are about 5.1 camerae in a length equal to the dorsoventral diameter of 29 mm. Between the connecting rings the septa are horizontal, and there is no trace of a septal neck; the inner margin of the septa extends about 3.7 mm inward from the vertical projection of the outer margin of the septal rings. The interior of the siphuncle is filled with calcareous matrix, leaving an endosiphuncular passage 1.5 mm wide, with its lateral diverticula, into the outer margin of the connecting rings. The

camerae are also filled almost completely with calcareous matrix, leaving only narrow spaces near the outer side of the connecting ring and the middle part of each camera. The outer surface of the shell and living chamber are unknown.

Comparisons.—This species may be closely related to *Armenoceras marginale*, but the former differs in having a deeper concavity of the septa, a greater septal distance, a comparatively wider siphuncle, and endosiphuncular passage.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone beds, just north of the Pen-hsi-hu colliery, Manchuria.

Holotype.—U.S.N.M. No. 83731.

ARMENOCERAS RICHTHOFENI (Frech)

PLATE 20, FIGURE 10

1911. *Actinoceras richthofeni* FRECH, *in* von Richthofen's China, vol. 5, p. 8, pl. 11, fig. 4a.

1922. *Actinoceras richthofeni* GRABAU, Pal. Sinica, ser. B, vol. 1, fasc. 1, p. 75, pl. 7, figs. 1, 3; pl. 9, figs. 4, 6–8.

1927. *Actinoceras richthofeni* KOBAYASHI, Jap. Journ. Geol. and Geogr., vol. 5, no. 4, p. 191, pl. 20, fig. 8; pl. 21, figs. 3 a–b, and 4.

From an examination of the previously published figures, as well as Plate 20, Figure 10, it will be noted that the inner parts of the septa of this well-known species are in contact with both overlying and underlying connecting rings for a rather considerable width in the area immediately surrounding the passage of the siphuncle through the septa. Moreover, these pictures and my specimen do not show any traces of distinct septal necks, all of which are characteristic features of the genus *Armenoceras* and are the criteria by which Foerste separated this genus from *Actinoceras*. Therefore, I have changed the original generic name of this species.

Description.—The only specimen I have is figured on Plate 20, Figure 10. It is 81 mm long, enlarging at an apical angle of 15° from a lateral diameter of about 23 mm near the base to 40 mm at a point 61 mm farther up. The cross section apparently is elliptical laterally, but only the ventral half of the specimen remains. About 12 camerae occupy a length equal to the diameter of the conch. The diameter of the siphuncle is about the same throughout the specimen; it is 11.5 mm near the top where the lateral diameter of the conch is 40 mm. The siphuncle is subcentral; the distance between the siphuncle and ventral side of the conch is 5 mm near the top. The concavity of the septa averages 9.5 mm. Where the lateral diameter of the siphuncle is 14 mm, that of the passage of the siphuncle through the septum is 9 mm. Between the connecting rings this septum is more nearly horizontal, and its inner margin

extends about 2.5 mm inward from the vertical projection of the outer margin of the septal rings. These rings are in contact with the septa both above and below for a radial width of 1.5 mm. The interior of the siphuncle is filled with typical actinoceroid deposits of calcareous material, leaving the large endosiphuncular passage and its narrow diverticula, which show a more or less forward bending. The septa are thickened by the calcareous matrix, which occurs both on the upper and under sides of the septum, so that this matrix fills in the larger part of the camerae in the older part of the specimen. Some camerae, however, especially in the apical part, were empty. Surface of the conch fairly well annulated.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the lower fossil horizon of the black banded limestone near Toufang-kou, 2.5 miles northwest of Pen-hsi-hu, Liao-tung, Manchuria.

Plesiotype.—U.S.N.M. No. 83732.

ARMENOCERAS SHIMIZUI, new species

PLATE 20, FIGURE 5

Description.—The holotype is 43 mm long, enlarging very slightly from the base to the top. The cross section apparently is depressed but only the ventral half of the specimen remains. Siphuncle excentric in its position, the distance of the siphuncle from the ventral wall of the conch being 2 mm at the base. It is estimated that 7.2 camerae occupy a length equal to the lateral diameter of the conch. Where the lateral diameter of the conch is 17.5 mm, the concavity of the septa is 2.5 mm, the length of the camerae is 2.7 mm, and the maximum diameter of the segments of the siphuncle 6 mm. There are no traces of the septal necks at the inner margins of the septa, which are adnate with both the upper and lower connecting rings for 0.7 mm in radial width. The interior of the siphuncle is densely filled with calcareous matrix. The septa are thickened regularly by the calcareous matrix, which occurs both on the upper and lower sides of the septum, leaving rather narrow spaces in the mid height of each camera.

The specific name is given in honor of Dr. S. Shimizu, of the Tohoku Imperial University in Japan.

Comparisons.—The general features of this species recall *Armenoceras tani*, but the cylindrical conch and the calcareous deposits on both sides of the septa serve readily in distinguishing it from the latter species.

Formation and locality.—Middle Ordovician, Ssuyen formation: The lower fossil horizon of the black banded limestone bed, at a point 2 miles east of the Tao-yuan-kou colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83733.

ARMENOCERAS SONDAI, new species

PLATE 20, FIGURES 7, 8; PLATE 40, FIGURE 9

Description.—Holotype is 65 mm long, slightly enlarged laterally from the base to the top. The cross section of the conch was apparently laterally depressed, but the dorsal half is weathered away. The center of siphuncle is located 6 mm from the ventral wall of the conch. There are about seven camerae in a length equal to the diameter of the conch. Where the diameter of the conch is 32 mm, the concavity of the septa equals 5.5 mm; the maximum diameter of the siphuncle here is estimated as 8.5 mm, and height of its camerae averages 4.7 mm; thus the segments of siphuncle are strongly vertical both above and below. Between the segments of the siphuncle, the inner margin of the septa may be in contact with both the upper and lower connecting rings for some radial distance. In the interior of the siphuncle and on the anterior side of the septa some deposition of calcareous matrix is found.

Though this specimen is fragmentary, the comparatively smaller ratio between the diameter of the siphuncle and that of the conch, lesser enlargement laterally of the conch from the base to the top, and the manner of deposition of the calcareous matrix in the camerae are characteristic features.

The specific name is given in honor of T. Sonda, who collected the specimen.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, near the Tao-yuan-kou colliery, Liao-tung, Manchuria. A fragmental second specimen found in the same horizon, near the Hsiao-shih colliery, Manchuria.

Holotype and paratype.—U.S.N.M. Nos. 83734 and 73735.

ARMENOCERAS SUZUKII, new species

PLATE 21, FIGURES 5, 6

Description.—A single good specimen 73.5 mm long becomes the holotype of another new species enlarging from 13.5 mm near the base to 20 mm at a point 60 mm farther up, the apical angle being very small. The cross sections of the conch and the siphuncle apparently are circular, but only the lateral half of the specimen remains. The siphuncle is very excentric, its center being located 6.5 mm from the ventral wall of the conch. Where the diameter of the conch is 19 mm, the concavity of the septa equals 4.5 mm; the maximum of the siphuncle here is estimated as 7.5 mm, and the height of its camerae averages 2.5 mm. There are 7.5 camerae in a length equal to the diameter of the conch. Between the connecting rings each septum

is nearly horizontal or curves gently downward. The inner margin of the septum extends about 2 mm inward from the vertical projection of the outer margin of the septal rings. These rings are in contact both above and below with the septa for a radial width of 1 mm. The ventral sides of the siphuncle and the camerae are almost filled with calcareous matrix, which becomes less in the apical part, while the dorsal portion is almost empty. Some deposits of calcareous matrix, however, are found on the anterior surfaces of the septa which are thin at the margin, but gradually thicken toward the siphuncle and thin out abruptly, thus assuming a saucerlike shape before reaching the connecting rings. Living chamber and surface of the shell unknown.

The specific name is given in honor of Dr. J. Suzuki, of the Hokkaido Imperial University in Japan, from whom I have received much encouragement in this work.

Comparisons.—This species may be compared with *Armenoceras murakamii* (Kobayashi) but is easily distinguished by the larger ratio between the diameter of the conch and that of the siphuncle and the larger number of camerae in a length equal to the diameter of the conch.

Formation and locality—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, near the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83736.

ARMENOCERAS TANI (Grabau)

PLATE 21, FIGURE 7; PLATE 14, FIGURE 2; PLATE 40, FIGURE 3

1922. *Actinoceras tani* GRABAU, Pal. Sinica, ser. B, vol. 1, fasc. 1, p. 80, pl. 7, figs. 4–7.

This species shows a rather wide distribution in North China, Manchuria, and possibly Korea.

Description.—A rather good specimen 63 mm long has a lateral diameter increasing from 17 mm near its base to 25 mm at a point 39.5 mm farther up, the apical angle being 12°. The cross section apparently is a little depressed, but only the ventral half of the specimen remains. Eight and one-half camerae occupy a length equal to the diameter of the conch. The siphuncle is 8.5 mm in diameter at the top of the specimen, the ratio of its diameter to the lateral diameter of the conch being 1:3. The concavity of the septa averages 3 mm. Where the lateral diameter of the siphuncle is 8.5 mm, that of the passage of the siphuncle through the septum is 4.5 mm. As is seen in the illustration, both the overlying and underlying connecting rings are adnate to the immediate septa for a

rather considerable width in the area immediately surrounding the passage of the siphuncle through the septa; also the slightly downward curving of the margin of the septa and the absence of a distinct septal neck show that this species belongs distinctly to *Armenoceras*. The siphuncle is rather excentric. The inside of the siphuncle is filled with a calcareous deposit, leaving only the endosiphuncular passage and its diverticula. The calcareous deposits in the camerae are irregular.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone beds, 4 to 5 miles southwest of the Pen-hsi-hu colliery. Another fragmental specimen of this species came from the same horizon, near the Wu-hu-tsui colliery, Liao-tung, Manchuria.

Plesiotypes.—U.S.N.M. Nos. 83737 and 83738.

ARMENOCERAS YABEI, new species

PLATE 21, FIGURES 8, 9

Description.—The holotype is 70 mm long, enlarging slightly from the base to the top. The cross section of the siphuncle is circular, while that of the conch apparently is depressed a little, but only the lateral half of the conch remains; 6.3 and 5.5 camerae, respectively, occupy a length equal to the lateral and dorsoventral diameters of the conch. The siphuncle is 13.5 mm in diameter at the middle of the specimen, the ratio of its diameter to the dorsoventral diameter of the conch being 31 : 100. The siphuncle is located comparatively ventral of the center of the conch; the distance between the siphuncle and the ventral side of the conch is 12 mm at the middle of the specimen. The concavity of the septa averages 15.5 mm. The siphuncle is strongly annulated where the diameter of the siphuncle is 13.5 mm, that of the passage of the siphuncle through the septum is 6 mm. Between the connecting rings this septum is horizontal, and the rings are in contact with the septa both above and below for an average radial width of 3.5 mm. The interior of the siphuncle is filled with calcareous material, leaving the usual central endosiphuncular passage. Both sides of the septa also are thickened with calcareous deposits. The surface of the shell is apparently smooth. Living chamber unknown.

The specific name is given in honor of Prof. H. Yabe, of the Tohoku Imperial University in Japan.

Formation and locality.—Middle Ordovician, Ssuyen formation: a grayish black limestone bowlder believed to have come from the Ssuyen formation, collected in river drift at the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83739.

ARMENOCERAS species undetermined

PLATE 19, FIGURE 9; PLATE 20, FIGURE 2

Description.—First specimen (U.S.N.M. 83740) 29 mm long, enlarges at an apical angle of about 11° from a lateral diameter of 9.5 mm at its base to 12.5 mm at a point 13 mm farther up. It is estimated that six camerae occur in a length equal to the lateral diameter of the conch. The cross sections of the conch and the siphuncle, apparently, are circular, but only the ventral half remains. The siphuncle is located at the center of the conch. Where the diameter of the conch is 13 mm the concavity of the septa is 3 mm, the length of the camerae 2.5 mm, and the maximum diameter of the segments of the siphuncle 3.2 mm. The inner margins of the septa are connected with both upper and lower connecting rings at very acute angles. The interior of the siphuncle is almost entirely filled with calcareous matrix. The calcareous deposit in the camerae is irregular.

A second specimen (U.S.N.M. 83741) from Niu-hsin-tai (pl. 20, fig. 2) appears to have a somewhat excentric siphuncle, but otherwise agrees quite closely with the first.

Comparisons.—These specimens may be compared with *Armenoceras nanum* (Grabau), but the longer septical distance, comparatively larger siphuncle, and the larger apical angle of the conch serve readily in distinguishing this species. Therefore, these specimens may probably belong to a new species, but are too fragmentary to receive a specific name.

Formation and localities.—Middle Ordovician, Ssuyen formation: From both upper and lower fossil horizons of the black banded limestone beds, near the Niu-hsin-tai colliery and on the Fu-chin-kou ridge, southwest of Miyanohara station, Liao-tung, Manchuria.

ARMENOCERAS species undetermined

PLATE 25, FIGURE 2

I also collected a fragmentary specimen of *Armenoceras* (U.S.N.M. 83744) from the Wuting formation, near the Wu-hu-tsui colliery. As this is one of the rare specimens of *Armenoceras* from the Wuting formation in Manchuria, it is described despite its imperfect condition.

Description.—The specimen is 32 mm long, enlarging laterally at an apical angle of about 8° from a lateral diameter of 18.5 mm at the base to 24 mm at its top. About six camerae occupy a length equal to the lateral diameter of the conch. The cross section apparently is elliptical laterally. The siphuncle is located somewhat ventrally. As a small fault runs through the center of the siphuncle, the septa and segments of siphuncle are somewhat displaced vertically between the lateral sides of the longitudinal medial line

of the specimen, so that the ratio between the diameter of the siphuncle and that of the conch can not be determined exactly. Where the diameter of the conch is 23.5 mm, the concavity of the septa is 6 mm the length of the camerae 4 mm. The inner margins of the septa are in contact with both the upper and lower connecting rings for only a small radial width. The calcareous deposits in the siphuncle and camerae are very irregular.

Formation and locality.—Lower Ordovician, Wuting formation: Black banded limestone, just south of the Wu-hu-tsui colliery, Liao-tung, Manchuria.

Genus ORMOCERAS Stokes, 1838

ORMOCERAS CHINENSE, new species

PLATE 21, FIGURE 10

Description.—The holotype is a fairly good specimen 108 mm long and enlarges from a diameter of 32 mm near the base to 37.5 mm at a point 44 mm farther up, the apical angle being estimated at 8°. The cross sections of the conch and siphuncle, apparently, are circular or slightly depressed laterally, but only the ventral half of the conch remains. The siphuncle is central in position. It is estimated that 6.5 camerae occupy a length equal to the diameter of the conch. Where the diameter of the conch is 34.5 mm, the concavity of the septa equals 7.7 mm; the maximum diameter of the siphuncle here is estimated at 6.5 mm; and the height of its camerae averages 6 mm. From these dimensions of the siphuncle and camerae it is estimated that the form of the segments of the siphuncle was globular, but somewhat depressed vertically at the contacts between successive segments. The interiors of the siphuncle and the camerae are occupied by the deposition of the calcareous matrix, leaving a narrow endosiphuncular passage and the narrower diagonal spaces at the middle part of each camera. Living chamber and surface of the shell unknown.

Comparisons.—I am not acquainted with any American, European, or Oriental species with which this is likely to be confounded.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the dark-gray banded limestone, near Toufang-kou, 2.5 miles northwest of Pen-hsi-hu, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83745.

ORMOCERAS KIMURAI, new species

PLATE 20, FIGURE 9; PLATE 40, FIGURE 1

Description.—The holotype is 82 mm long, enlarging from a diameter 11 mm near the base to 19 mm at the top. The ventral

side of the conch has been weathered away, so as to expose the septa and the siphuncle. The siphuncle is somewhat ventral of the center of the conch. It is estimated that 7 camerae occupy a length equal to the diameter of the conch. Where the diameter of the conch is 19 mm, the concavity of the septa is 2.7 mm; the maximum diameter of the siphuncle here is estimated at 5.5 mm, and the height of its camerae averages 2.7 mm. The segments of the siphuncle are rather globular, but slightly depressed vertically at its anterior contacts with successive segments. The septal necks are short, usually 0.5 mm or less in length. The interiors of the siphuncle and the camerae of the lower part of the specimen are occupied by dense calcareous matrix, which becomes less toward the apical end. Living chamber and surface of the shell unknown.

The specific name is given in honor of R. Kimura, director of the geological institute, South Manchuria Railway Co.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone beds just east of the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83746.

ORMOCERAS MANCHURIENSE, new species

PLATE 27, FIGURE 6; PLATE 40, FIGURE 16

Description.—The holotype, 80 mm long, enlarges slightly laterally from the base to the top. The dorsoventral diameter of conch near the top of the specimen is estimated as about 44 mm, while the lateral diameter at the same place is about 32 mm. The cross section of the conch is apparently compressed, while that of the siphuncle is circular, but only the lateral half of the specimen remains. The siphuncle evidently was located rather ventral of the center of the conch. It is estimated that 3 camerae occupy a length equal to the dorsoventral diameter of the conch. Where this dorsoventral diameter is 43 mm, the concavity of the septa is 29.5 mm; the maximum diameter of the siphuncle here is estimated at 23 mm, and the height of its camerae varies from 13.5 to 15 mm. The siphuncle is rather nummuloidal. The septal necks are short, usually 1.5 mm or less in length, with their lower margins flaring widely where they unite with the connecting rings. Both sides of the septa and the interior of the siphuncle are filled with calcareous deposits, but the usual central endosiphuncular passage and its lateral deverticula into the outer margin of the annulation lack such deposits.

Comparison.—This form differs from other species of *Ormoceras* in having a larger siphuncle, a great concavity of the septa, and comparatively higher camerae.

Formation and locality.—Lower Ordovician, Wuting formation: In the black banded limestones near San-tao-kang-tzu, 1.5 miles north of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83747.

ORMOCERAS NAGAOI, new species

PLATE 21, FIGURE 11; PLATE 40, FIGURE 2

Description.—The holotype is 68 mm long, enlarging slightly from the base to the top. The cross sections of the conch and the siphuncle, apparently, are circular, but only the lateral half of the specimen remains. The siphuncle is located somewhat ventral of the center of the conch; 4.7 camerae occupy a length equal to the diameter of the conch. Where the diameter of the conch is 14.5 mm, the concavity of the septa is 4 mm; the maximum diameter of the siphuncle here is estimated at 6 mm, and the height of its camerae averages 3 mm. The segments of the siphuncle are rather depressed globular. The septal necks are short, usually 0.7 mm or less in length. The interior of the siphuncle is filled with actinoceroid materials, but the usual endosiphuncular passage 1.5 mm wide and its diverticula into the outer surface of the segments of the siphuncle lack such deposits. The ventral sides of the camerae are almost entirely filled with calcareous material, which become less in the younger part, while the dorsal part is almost empty. Some deposits of the calcareous matrix, however, are found on the anterior surface of the septa, which are thin at the margin but gradually thicken toward the siphuncle and abruptly thin out later, assuming a saucer-like shape before reaching the connecting rings. Living chamber and the surface of the shell unknown.

The specific name is given in honor of Dr. T. Nagao, a professor at the Hokkaido Imperial University in Japan.

Comparisons.—This species may be allied to *Ormoceras kimurai*, but it is easily distinguished by the larger concavity of the septa and the fewer camerae in a length equal to the diameter of the conch.

Formation and locality.—Middle Ordovician, Ssuyen formation: A black limestone bowlder believed to have come from a part of Ssuyen formation; collected in river drift at the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83748.

ORMOCERAS ORIENTALE, new species

PLATE 21, FIGURES 1–4

1927. *Actinoceras suampanoides* KOBAYASHI (not Grabau), Jap. Journ. Geogr. and Geol., vol. 5, no. 4, p. 196, pl. 20, fig. 13; pl. 21, figs. 10–12.

Description.—The holotype is 42 mm long, enlarging laterally from a diameter of 10.5 mm at the base to 12.5 mm at a point 32 mm

farther up, the apical angle being very low, estimated at 3° or 4°. The ventral side of the conch has been weathered away, so as to expose the septa and the siphuncle. The siphuncle, apparently, was located ventral of the center of the conch. It is estimated that 3.2 camerae occupy a length equal to the lateral diameter of the conch. Where this lateral diameter is 12 mm, the concavity of the septa equals 4.5 mm; the maximum diameter of the siphuncle here is estimated at 4.5 mm, and height of its camerae is 3.5 mm on the average. From these dimensions of the siphuncle and camerae it is estimated that the form of the segments of the siphuncle was globular, but somewhat flatter near the anterior margin than the posterior. Septal necks are short. The interior of the siphuncle is occupied by the calcareous matrix, showing very slight traces of an endosiphuncular passage. The septa are thickened irregularly by calcareous matrix, which occurs on both the upper and under sides of the septum, making rather large masses at the mid height of each camera.

Comparisons.—The general features of this species agree exactly with *Actinoceras suampanoides*, from To-fan-go (Tou-fang-kou) and Niu-hsin-tai, described by T. Kobayashi. Both Kobayashi's and my specimens, however, show the characteristic generic features of *Ormoceras* in having quite narrow and less nummuloid segments of the siphuncle and short septal necks. On the other hand, Grabau's *Actinoceras suampanoides* (which perhaps belongs to *Armenoceras*) shows broadly nummuloidal siphuncular segments, and, further, appears to lack entirely traces of the septal necks.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the black banded limestone, near the Niu-hsin-tai and the Wu-hu-tsui collieries, Liao-tung, Manchuria.

Holotype and paratype.—U.S.N.M. Nos. 83749 and 83750.

ORMOCERAS PROXIMUM, new species

PLATE 20, FIGURES 3, 4

Description.—The holotype is 41.5 mm long, enlarging very slightly from the base to the top. The cross sections of the conch and siphuncle are apparently circular, but only the lateral side of the conch remains. The siphuncle is very excentric in its position, its center estimated as only 2 mm from the ventral wall of the conch. Three camerae occupy a length equal to the dorsoventral diameter of the conch. Where the dorsoventral diameter is 7.5 mm, the concavity of the septa equals 2 mm, and the maximum diameter of the siphuncle here is estimated as 3.9 mm, the height of its camerae averaging 3 mm. The interior of the siphuncle and that of the camerae of the ventral side are densely filled with calcareous matrix. Near the siphuncle the upper side of the septa of the dorsal side

is thickened very conspicuously by the deposition of calcareous matrix, which thins gradually toward the outer surface of the shell.

Comparisons.—The general outline of this species appears to relate it to *Ormoceras orientale*, but the very excentric position of the siphuncle and the smaller septal concavity, as well as the different manner in which the calcareous matrix is deposited, serve readily in distinguishing it.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the lower fossil horizon of the black banded limestone, near Chang-tung-kou in the Hsiao-shih district, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83751.

ORMOCERAS TAII, new species

PLATE 22, FIGURE 8; PLATE 40, FIGURE 10

Description.—The holotype, 49 mm long, enlarges laterally from a diameter of 17.2 mm at the base to 25.5 mm near the top, the apical angle being estimated at 13°. The dorsal side of the conch has been so weathered away that the real cross section can not be examined, but apparently it is laterally elliptical. The siphuncle is located somewhat excentric laterally. It is estimated that eight camerae occupy a length equal to the lateral diameter of the conch. Where the lateral diameter is 25 mm, the concavity of the septa is 4.5 mm; the maximum diameter of the siphuncle here is estimated at 5.5 mm, and the height of its camerae averages 3.5 mm. From these diameters of the siphuncle and camerae it is estimated that the form of the segments of the siphuncle was nearly globular, being somewhat depressed vertically at the contacts between successive segments. The septal necks are very short. The interior of the siphuncle is occupied by calcareous materials, leaving a central endosiphuncular passage. The calcareous deposits in the camerae show irregular form; filling densely the basal camerae and becoming gradually less from the base toward the top where only a small quantity exists. Surface features of shell unknown.

The specific name is given in honor of W. Tai, a collector of fossils in Manchuria.

Comparisons.—At first glance this species appears to be close to *Armenoceras tani* (Grabau) from the Machiakou limestone, Chihli, and the Ssuyen formation, Manchuria, but further examination shows that it differs in having distinct generic characters—that is, it has a short septal neck, while *O. taii* entirely lacks this distinctive feature.

Formation and locality.—Middle Ordovician, Ssuyen formation: From the lower fossil horizon in the black banded limestone 2 miles south of the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83752.

ORMOCERAS TAITZUENSE, new species

PLATE 22, FIGURE 7; PLATE 40, FIGURE 4

Description.—The holotype is 48 mm long, enlarging laterally from a diameter of 15 mm near its base to 21.5 mm at its top, indicating an apical angle of 9°. The cross sections of the conch and the siphuncle are apparently circular, but only the ventral half of the specimen remains, the dorsal half having weathered away.

The siphuncle was somewhat excentric laterally. The number of camerae in a length equal to the diameter of the conch is about 4.5. Where the lateral diameter is 18 mm, the concavity of the septa equals 2.5 mm. The form of the segments of the siphuncle is globular, but is somewhat depressed vertically at the contacts between successive segments. Where the lateral diameter of the siphuncle is 5.5 mm, that of the passage of the siphuncle through the septa is 2 mm. The septal necks are short, usually 0.5 mm or less in length. The interior of the siphuncle is occupied by calcareous deposits, comparatively small in quantity, very irregularly distributed, while in the camerae they are found in rather large quantities.

Comparison.—This species differs from *Ormoceras taii* mainly in its circular cross section of the conch, shallower concavity of the septa, and the number of camerae in a length equal to the diameter of the conch.

Formation and locality.—Middle Ordovician, Ssuyen formation: A black limestone bowlder believed to have come from a part of the Ssuyen formation collected in a river drift at the Niu-hsin-tai colliery, Liao-tung, Manchuria.

Holotype.—U.S.N.M. No. 83753.

ORMOCERAS species undetermined

PLATE 22, FIGURE 1–3; PLATE 14, FIGURE 5; PLATE 16, FIGURE 11

The first of four specimens referred to *Ormoceras* (pl. 22, fig. 1) is 27.5 mm long, with a diameter of 8.5 mm (U.S.N.M. No. 83755). Five camerae occupy a length equal to a diameter of the conch. The apical angle is very low. The conch apparently was circular. The traces of the comparatively narrow siphuncle occur along the lower half of the natural longitudinal weathered section.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestone, just south of the Wu-hu-tsui colliery, Liao-tung, Manchuria.

The second specimen (U.S.N.M. No. 83756) (pl. 14, fig. 5; pl. 16, fig. 11), collected in the vicinity of the Pen-hsi-hu colliery, is a mere fragment. It appears to belong to the same species as the foregoing specimen. It is, however, too fragmentary to permit more definite identification.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of gray banded limestone beds, near the Pen-hsi-hu colliery, Manchuria.

A third specimen (U.S.N.M. No. 83757) (pl. 22, fig. 3) is 20 mm long, the cross section of the conch apparently somewhat depressed. The number of camerae in a length equal to the diameter of the conch is 3.5. Where the diameter of the conch is 6 mm that of the siphuncle is 1.2 mm. This specimen appears to belong to another species of *Ormoceras*, but it is too fragmentary to receive a new specific name.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestones, on the Fu-chin-kou ridge, 2.5 miles southwest of Miyanohara station, Liao-tung, Manchuria.

The general character of a fourth specimen (U.S.N.M. No. 83758) (pl. 22, fig. 2) agrees closely with that of the third but may be slightly different in having a somewhat larger concavity of the septa.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the black banded limestones, just south of the Wu-hu-tsui colliery, Liao-tung, Manchuria.

ORMOCERAS species undetermined

PLATE 22, FIGURE 9

This rather fragmentary specimen (U.S.N.M. No. 83754) is 72 mm long. Its apical angle seems to be very small. The cross sections of the siphuncle and the conch apparently are circular. The siphuncle is central. The number of camerae in a length equal to the lateral diameter of the conch is 3.5. The diameter of the conch at the base is 25 mm and that of siphuncle is estimated as 13.7 mm. Septal distance averages 7.5 mm. The siphuncle is strongly nummuloided, and its interior is filled with calcareous matrix, leaving the central endosiphuncular passage and its lateral diverticula which runs horizontally into the outer sides of the connecting rings. The septal concavity is rather low and its inner margin is in contact with only the lower side of the preceding segment of the siphuncle. Septal

necks are rather conspicuous, 1 mm or less in length. The interiors of the camerae are almost filled with calcareous matrix, leaving but narrow spaces in its middle parts.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the lower fossil horizon of the black banded limestone, near Pen-hsi-hu, Liao-tung, Manchuria.

Genus GONIOCERAS Hall, 1847

GONIOCERAS species undetermined

PLATE 22, FIGURE 4

I have a small fragment of a thin, straight shell (U.S.N.M. No. 83760), which is flat on one face and slightly convex on the other. Though my specimen does not show any part of a thin lateral edge, the outline of the shell suggests that it belongs to *Gonioceras*.

Description.—The fragment is 25 mm long, consisting of nine camerae in this length. Septal concavity is moderate and its distance averages 2.6 mm. In the vicinity of the siphuncle the septa curve moderately downward, and septal necks are absent. The segments of the siphuncle are strongly depressed vertically from both above and below. Interior of the siphuncle is filled with calcareous matrix, leaving a rather large endosiphuncular passage. Septa are somewhat thickened by the deposition of the calcareous matrix on its anterior surfaces. The surface of the shell is smooth.

Formation and locality.—Middle Ordovician, Ssuyen formation: Lower fossil horizon of the dark gray limestone, just north of the Pen-hsi-hu colliery, Liao-tung, Manchuria.

TRILOBITA

Genus ROBERGIA Wiman, 1902

ROBERGIA STRIATA, new species

PLATE 38, FIGURE 3

A cephalon, lacking the free cheeks, is present in Louderback's collection. It is somewhat rounded triangular in outline and rather strongly convex. The glabella is subtriangular, convex, the width somewhat greater than the length; dorsal and occipital furrows slightly impressed, three pairs of very shallow, narrow, fairly long glabellar furrows are traceable on the posterior half of the glabella; palpebral lobes small; frontal rim rather flat and narrow. Surface beautifully striated transversely.

This species is characterized by its rounded, triangular, convex cephalon and beautiful striations on the surface.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Holotype.—U.S.N.M. No. 83761.

Genus BATHYURUS Billings, 1859

BATHYURUS(?) species undetermined

PLATE 39, FIGURE 1

A single small cranidium (U.S.N.M. No. 83762) is found in Louderback's collection from near Huang-pa-yi, Shensi, that is apparently referable to *Bathyurus*, although I have some doubt as to the validity of this reference.

Description.—Cephalon semicircular, convex; glabella rounded triangular, strongly convex, without noticeable traces of glabellar furrows; dorsal and occipital furrows very distinct; palpebral lobes and eye lines distinct. Fixed cheeks are rather broad and the rim is narrow. Under a strong lens, the surface of the specimen is shown to be minutely pitted.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

BATHYURUS (?) species undetermined

PLATE 26, FIGURE 1

A single poorly preserved pygidium (U.S.N.M. No. 83763), found in the strata of the Wuting formation, has the general features of a *Bathyurus*. The specimen has a rather broad, convex axial lobe and gently convex pleural lobes which are divided by about five furrows into about five segments, exclusive of the terminal one.

Formation and locality.—Lower Ordovician, Wuting formation: In the black banded limestone, near the second tunnel, 1 mile north of Pen-hsi-hu, Liao-tung, Manchuria.

Genus CRYPTOLITHUS Green 1832

CRYPTOLITHUS MULTISERIATUS, new species

PLATE 39, FIGURE 2

Description.—Brim of cephalon with 6 or 7 rows of pits anterior to the fixed cheek of the cephalon, and with 11 or 12 rows antero-lateral to the lateral part of the fixed cheek. Pits enlarge very gradually from the center to the outer margin of the brim and about the half rows of the inner pits, tending to a radial arrangement, with the posterior end of the glabella at the center of the radii. The remaining outer pits alternate more or less definitely. Glabella obovate, strongly bulbous convex, especially anteriorly where it rises almost 1.2 mm above the rim. Posterior margin of the cephalon almost

directly transverse for about half of the distance from the dorsal furrow to the general angle, then curving backward. Surface of the glabella and of the fixed cheeks marked by minute pits as shown under the magnifying lens.

Comparisons.—In general this species may be compared with *Cryptolithus tessellatus* Green from the Trenton-Maysville group, North America, but differs from it in having many rows of rather even-sized, small pits on the brim.

Formation and locality.—Upper Ordovician: Near Huang-pa-yi, Shensi, China.

Holotype.—U.S.N.M. No. 83764.

CRYPTOLITHUS WELLERI, new species

PLATE 39, FIGURE 3–8

Louderback's central China material contains a number of heads representing another *Cryptolithus.*

Description.—Brim of cephalon with 2 rows of pits anterior to the middle of the cephalon, 6 rows at the anterolateral part and 8 rows at the lateral sides of the cheeks. Pits forming the 2 or 3 outer rows of the brim conspicuously larger, and the first 2 or 3 inner rows are arranged along radii centering at the posterior end of the glabella. The remaining pits alternate more or less distinctly. The general shape of the glabella and the cheeks of this species causes it to resemble *C. multiseriatus*, but it has three rather distinct glabellar furrows on the lateral sides of the glabella, while *C. multiseriatus* shows very slight traces of any. The surface of the glabella and cheeks is seen under magnifying lens to be pitted.

Formation and locality.—Upper Ordovician, near Chien-ko-hsien and Chao-hua, Szechwan, China.

Cotypes.—U.S.N.M. Nos. 83765 and 83766.

Genus MEGALASPIS Angelin, 1878

MEGALASPIS INSCULPTA, new species

PLATE 39, FIGURES 18–20

Description.—This species is based upon several pygidia, which are triangular in shape, with a rather convex axis. This axis is marked by 5 anterior and 4 or 5 very faint, shallow posterior furrows that divide the axis into 6 comparatively well-defined rings, and a rather long terminal section. The dorsal furrow is clearly defined.

Pleural lobes broad, rather convex, with a broad panulate margin. Seven well-marked anterior segments and two posterior fainter ones are outlined on the pleural lobes by furrows that curve backward and terminate on the inner margin of the doublure.

The surface is marked by very peculiar ripplelike striations.

Although this species is founded on pygidia alone, I give these remarkable specimens a new specific name, since the features are very characteristic.

Formation and locality.—Upper Ordovician: Near Chao-hua, Szechwan, China.

Cotypes.—U.S.N.M. No. 83767.

Genus ASAPHUS Brongniart, 1822

ASAPHUS ASIATICUS, new species

PLATE 39, FIGURES 11–17

A number of curious cephalia and rather well-preserved associated pygidia were included in Louderback's collection from central China. As I could not find a whole specimen or even a perfect cephalon in this collection, I am not sure to which genus these specimens really belong. The general features of the cephalia and pygidia, however, resemble characters of *Asaphus*, to which I am tentatively referring them.

Description.—Cephalon, exclusive of the free cheeks, somewhat elongated-circular in outline. Glabella circular, moderately convex, without perceptible traces of the glabellar furrows; dorsal furrow shallow but rather distinct; palpebral lobes very faint, scarcely noticeable; frontal rim broad and distinctly concave.

The associated pygidia are rounded, subtriangular in outline, and about two-thirds as long as the width of the anterior margin, moderately convex; axial lobe convex and tapering gradually posteriorly; it is very faintly divided by about 5 or 6 transverse furrows into 5 or 6 rings and a rather long terminal section; 3 or 4 ankylosed pleural segments are outlined on the pleural lobes by furrows.

Surface of the cephalia and pygidia is marked by very fine undulating striations with associated, sometimes small, pits, ornamentations which are naturally most conspicuous on the cephalia.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Cotypes.—U.S.N.M. No. 83768.

Genus ISOTELOIDES Raymond, 1910

ISOTELOIDES species undetermined

PLATE 22, FIGURE 10

A single distinct pygidium occurs in the lower fossil horizon of the Ssuyen formation. This specimen (U.S.N.M. No. 83769) is referable to *Isoteloides*, since it has a smooth surface with a slightly

concave border. It is moderately convex, rounded triangular in outline, and has a poorly defined, rather slender axis, which is wide at the anterior end, tapering rather rapidly to the posterior end. Pleural lobes rather convex and sloping gradually into the marginal border without any well-defined boundary. Axes and pleural lobes are marked very slightly by scarcely traceable slender ribs.

Formation and locality.—Middle Ordovician, Ssuyen formation: In the lower fossil horizon of the black-banded limestones, near Toufang-kou, 2.5 miles northwest of Pen-hsi-hu, Liao-tung, Manchuria.

Genus NILEUS Dalman, 1826

NILEUS WALCOTTI, new species

PLATE 39, FIGURE 10

A single but very remarkable cephalon to which is attached six thoracic segments occurs in Louderback's collection from Shensi, China.

Description.—Cephalon nearly semicircular, length a little less than half of the width, strongly and evenly convex, sloping gently to the sides without any depressed border. Eyes very large, closely covered with minute tubercles as shown under a low-power magnifying lens, their length about half the whole length of the cephalon. The distance between the posterior corner of the eye and the posterior margin of the cephalon is a little less than that between the eye and the frontal margin. The glabella is not differentiated from the remainder of the cephalon. The facial suture extending from the anterior corner of the eye first curves outward and then inward, closely encircling the front margin. Behind the eye it runs slightly outward, cutting the posterior margin at a point just back of the eye. The surface of the test is apparently smooth. Thoracic segments are strongly convex, and the axial furrows are slightly impressed.

The specific name is given in honor of Dr. Charles D. Walcott, former secretary of the Smithsonian Institution, who described a great number of the Chinese fossils.

Comparison.—I am not acquainted with any American or European species with which this form is likely to be confounded, but it may be compared with *Nileus perkinsi* Raymond from the upper Chazyan strata on Isle La Motte, Vt., North America. The comparatively anterior position of the eyes, the rather broad free cheek, and smooth surface of the test, however, serve readily in distinguishing it.

Formation and locality.—Ordovician: Near Ning-kiang, Shensi, China.

Holotype.—U.S.N.M. No. 83770.

Genus CALYMENE Brongniart, 1822

CALYMENE(?) species undetermined

PLATE 39, FIGURE 9

A single poorly preserved cranidium (U.S.N.M. No. 83771) is contained in Louderback's collection from central China. It may be referable to *Calymene* since it has a convex, conical glabella; three pairs of the glabellar furrows, the posterior one deep and prominent; and a well-defined occipital furrow. Even though this apparently represents an undescribed species, since the specimen is so poor I hesitate to assign an exact generic designation or to give a new specific name.

Cephalon convex, fixed cheeks, occipital ring, and posterior border rather broad; facial sutures curving strongly outward. The surface of the specimen under the strong lens is shown to be marked by rather scanty pustules.

Formation and locality.—Upper Ordovician, near Chao-hua, Szechwan, China.

Undetermined Trilobite

PLATE 36, FIGURE 14

A single pygidium (U.S.N.M. No. 83772) has a rather convex axial lobe divided by about six transverse furrows into about six segments and a terminal section. The axial segments continue out on the pleural lobes to where they merge into the border.

Formation and locality.—Ordovician: Near Huang-pa-yi, Shensi, China.

Undetermined Trilobites

PLATE 30, FIGURE 11; PLATE 26, FIGURES 2–6

Several small and poorly preserved pygidia belonging to different genera occur in the limestones of the Wuting formation. Since all these specimens are too poor to be given any special names, I describe them here as undetermined species, hoping to get more and better specimens in future field work.

The specimen illustrated in Plate 30, Figure 11 (U.S.N.M. No. 83773), is convex, subsemicircular in outline, and strongly trilobed, without a planulated margin. Axial lobe convex, divided by four transverse furrows into four rings and a small terminal section. Pleural lobes convex; furrows and segments of the axis extended into the margin toward the back on the surfaces of the pleural lobes. Under a strong lens the surface is seen to be densely marked by the pustules.

Formation and locality.—Lower Ordovician, Kangyao formation: In the black banded limestone west of Shang-kang-yao, 3 miles southeast of Yen-tai colliery, Liao-tung, Manchuria.

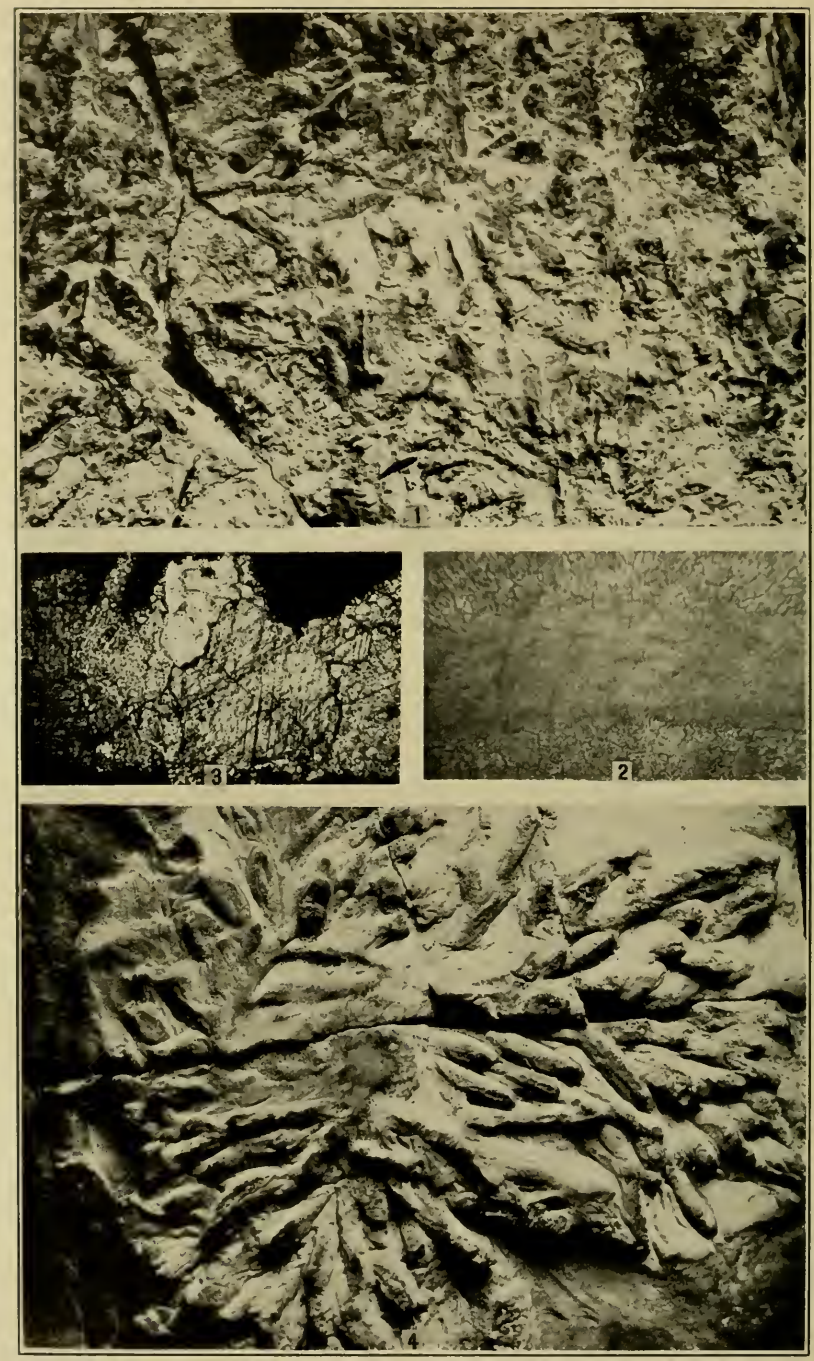
The specimens illustrated on Plate 26, Figures 2–5, are apparently the same species. They are convex and subsemicircular in outline, with rather slender axes and moderately wider planulated margin. The anterior parts of the axes and pleural lobes are faintly marked by the same furrows, nearly fading away at the inner margin of the doubler.

The specimen illustrated in Plate 26, Figure 6 (U.S.N.M. No. 83774), is moderately convex, transversely subsemicircular in outline with a convex, broad axial lobe and rather narrow planulated margin. The axis is marked by the three anterior transverse furrows and a very shallow posterior furrow that divides the axis into four rings and a terminal section. The pleural lobes are rather convex and are marked by furrows.

Formation and locality.—Lower Ordovician, Wuting formation: In the sandy limestone beds on the top of Wu-ting hill, 3 miles south of the Yen-tai colliery, Liao-tung, Manchuria.

EXPLANATION OF PLATES

(All illustrations of fossils are arranged first in stratigraphic order, then in the usual biologic sequence. This arrangement is adopted with a view to making this report more useful in the field. All figures of specimens are natural size unless otherwise indicated)



SSUYEN FORMATION

PLATE 10

Page

FIGURES 1, 2. *Camarocladia fucoides*, new species 39

A rock composed almost entirely of the branches of this organism and a thin section (×80) exhibiting the internal structure.

Middle Ordovician, Ssuyen formation: Black banded limestone in the vicinity of Pen-hsi-hu, Liao-tung, Manchuria.

3, 4. *Camarocladia arborescens*, new species 38

Section (×20) exhibiting the internal structure and a portion of a rock composed almost entirely of the branches of this organism.

Locality same as preceding.

Plate 11

Page

Figures 1–3. *Stromatocerium regulatum*, new species 40

1, 2. Weathered specimen showing the characteristic concentric laminae of the horizontal and vertical sections.

3. Polished vertical section of another specimen, showing the radiating pillars.

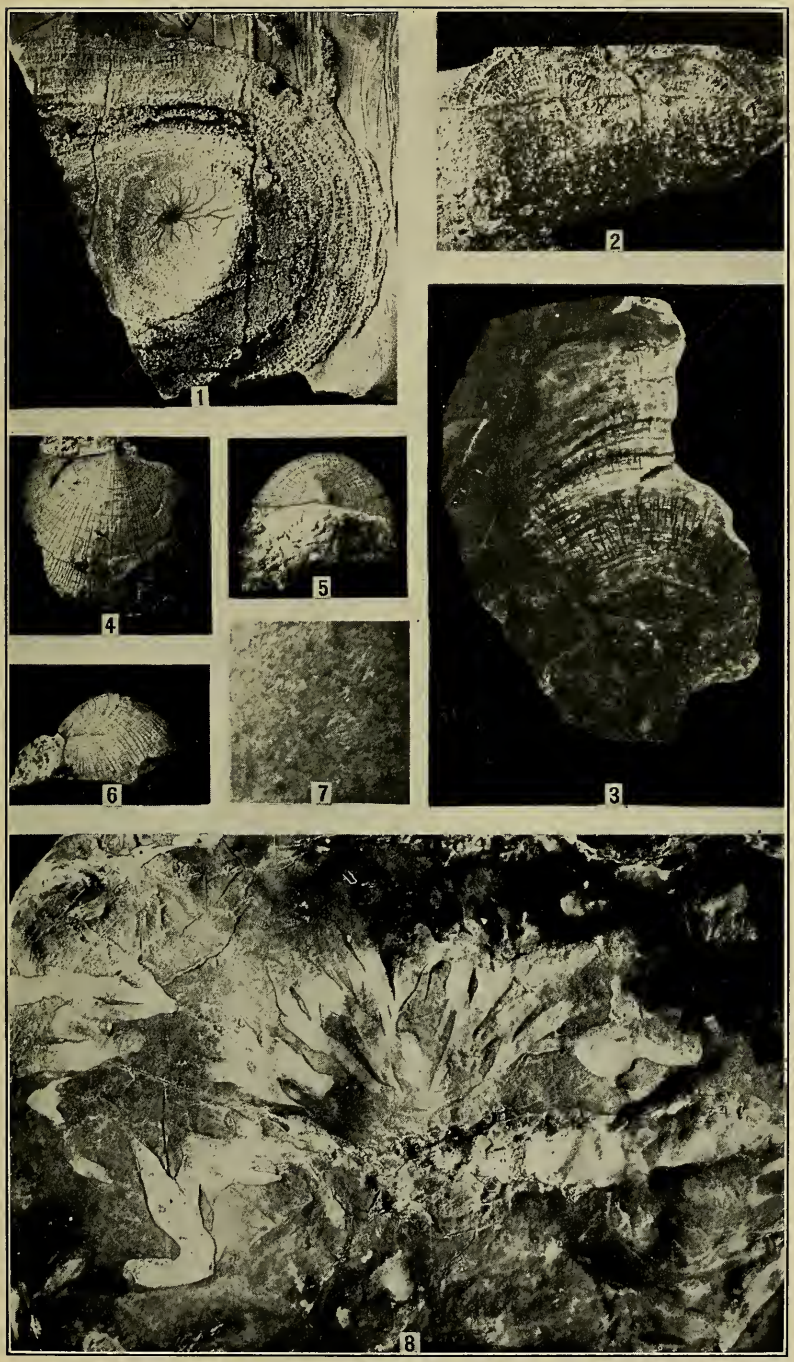
4–6. *Playfairia* cf. *dettoidea* (Conrad) 46

Dorsal, anterior, and lateral views of a pedicle valve.

7, 8. *Camarocladia plana*, new species 40

Rock fragments composed almost entirely of the branches of this sponge and a section (× 80) exhibiting the internal structure.

Middle Ordovician, Ssuyen formation: Black banded limestone, in the vicinity of Pen-hsi-hu, Liao-tung, Manchuria.



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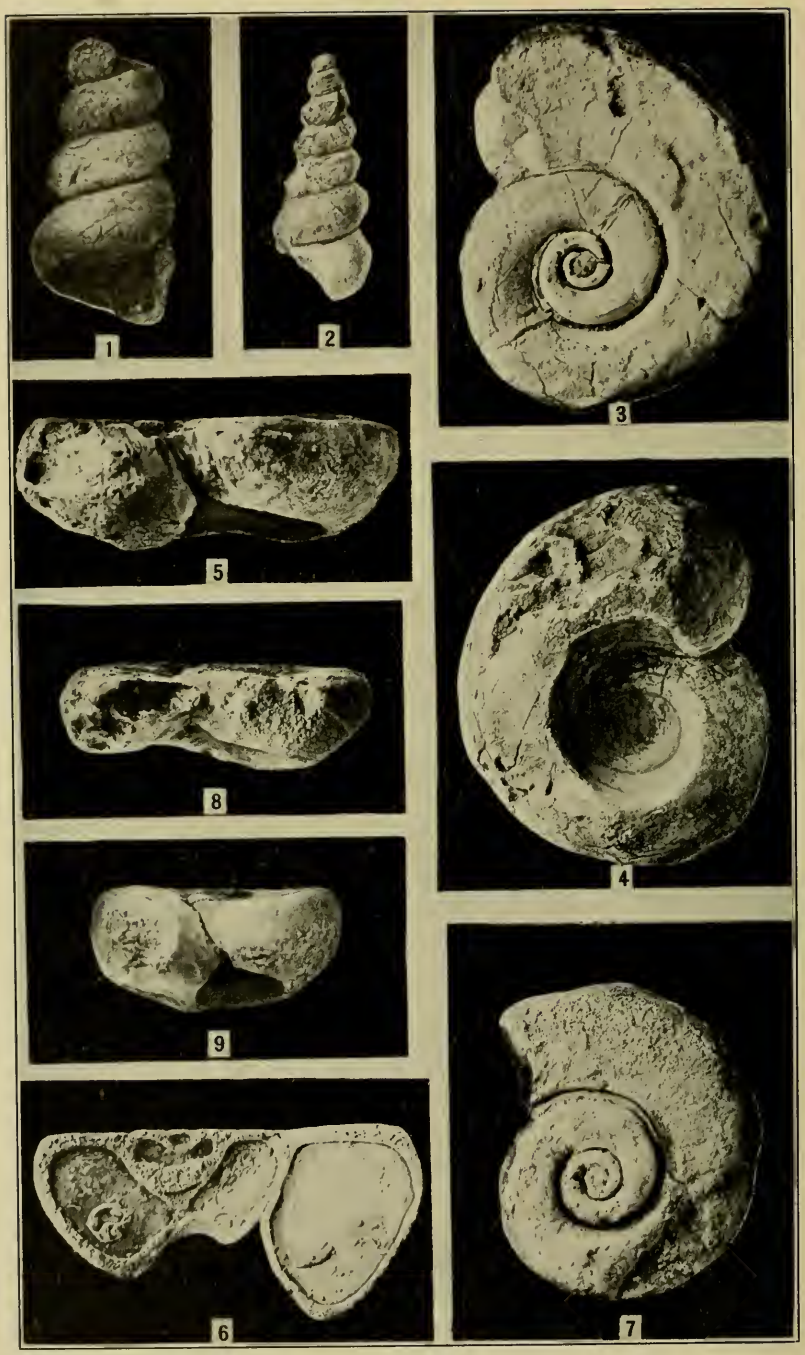
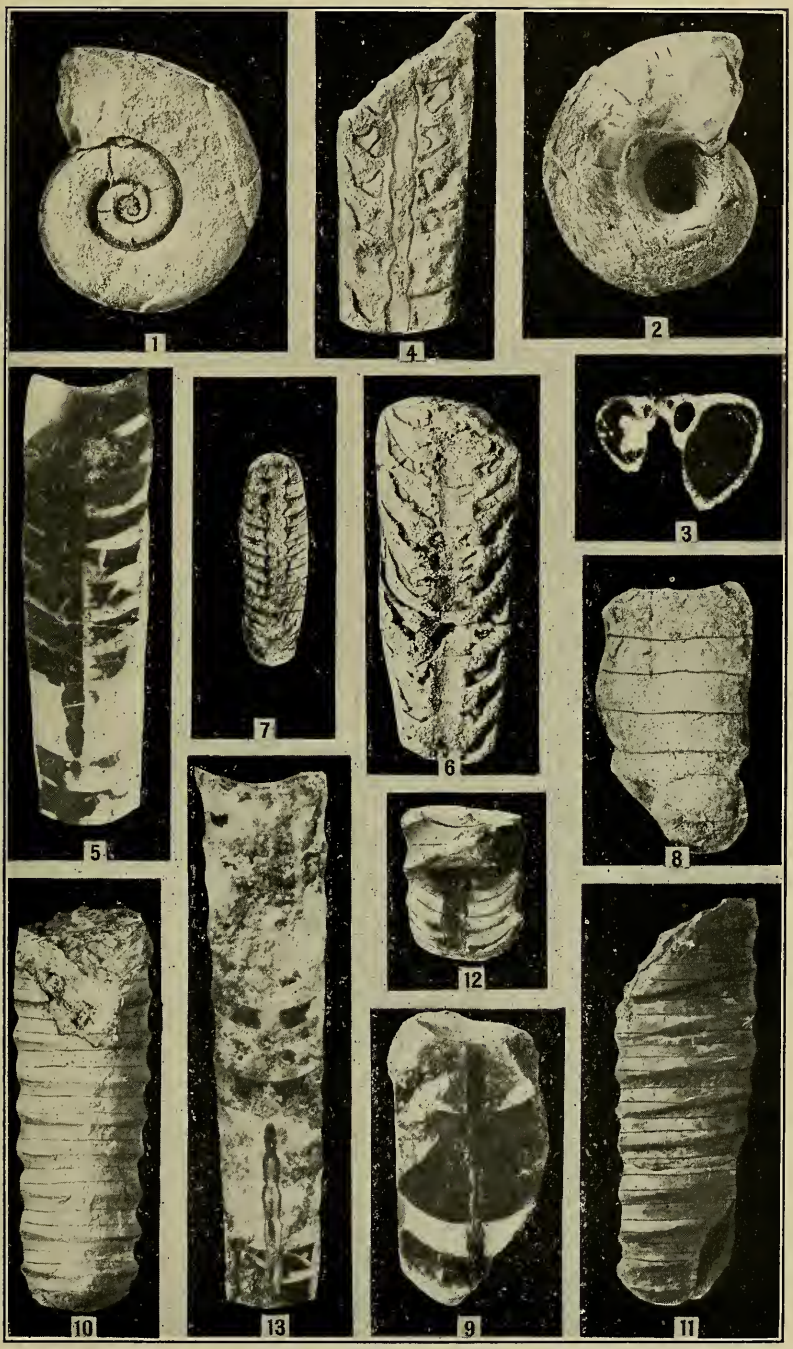


SSUYEN FORMATION

Plate 12

Plate 13



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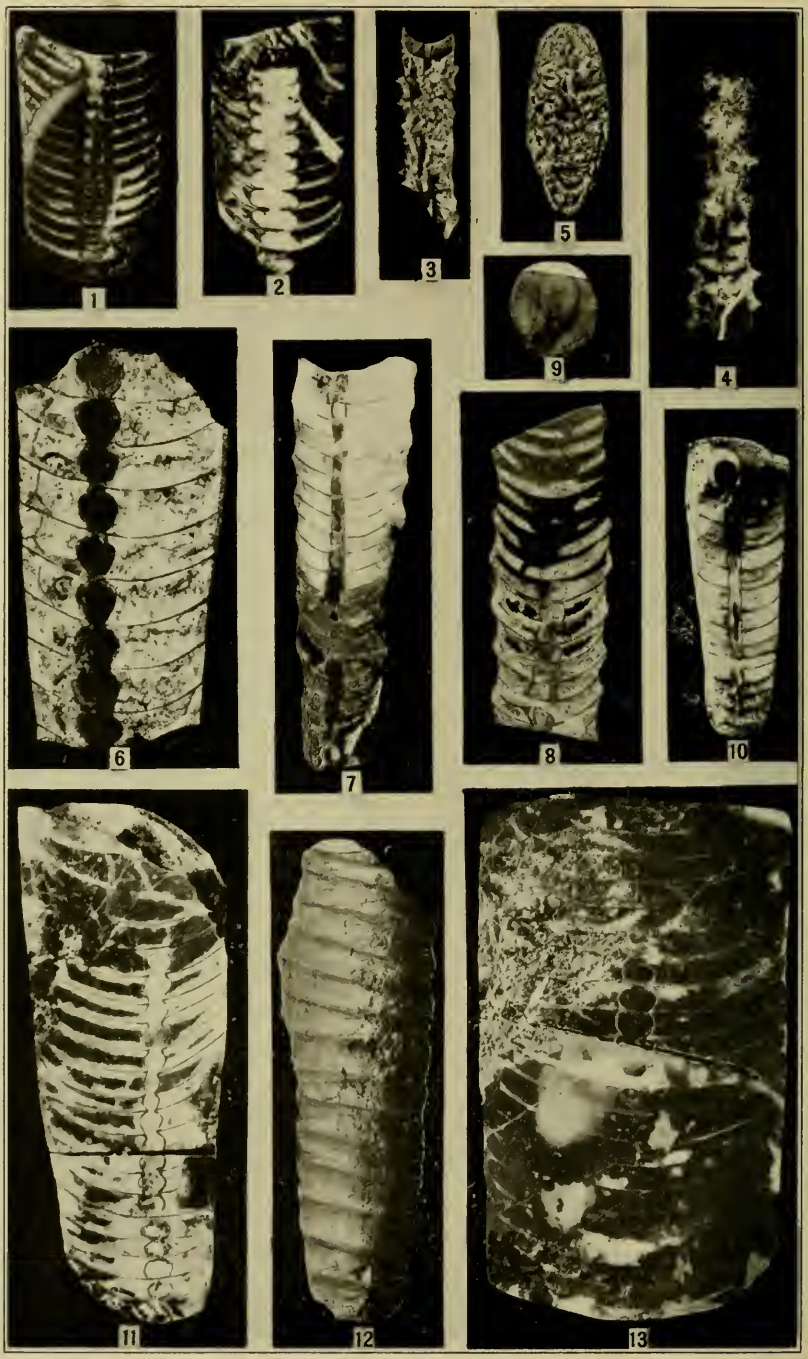


SSUYEN FORMATION

Page

FIGURE 1. *Sactoceras inaii*, new species 76
A polished vertical section in a lateral direction across the conch, exposing the structure of the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone near Penhsi-hu, Liao-tung, Manchuria.

2. *Armenoceras tani* (Grabau) 99
A partly polished vertical section in a lateral direction across the conch, showing the structure of the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone near Wu-hu-tsui, Liao-tung, Manchuria. (See also pl. 21, fig. 7, and pl. 40, fig. 3.)

3, 4. *Cycloceras* (?) *peitoutzense* Grabau 72
3, A natural vertical section showing a part of the siphuncle.
4, A polished vertical section, showing the siphuncle. Middle Ordovician, Ssuyen formation: Limestone near Niu-hsin-tai, Liao-tung, Manchuria.

5. *Ormoceras* species undetermined 107
A somewhat oblique natural vertical section.
Locality same as Figure 1.

6. *Sactoceras kobayashii*, new species 74
A polished vertical section in a dorsoventral direction across the conch, exposing the structure of the siphuncle. (See also pl. 40, fig. 8.)
Locality same as Figure 1.

7. *Cycloceras aokii*, new species 70
A polished vertical section in a lateral direction across the conch, exposing the structure of the siphuncle.
Locality same as Figure 1.

8, 9, 12. *Cycloceras* (?) *manchuriense*, new species 68
8, A polished verticle section.
9, A transverse section of the same along the lower part of the specimen, showing the relative size and location of the siphuncle.
Locality the same as Figures 3 and 4.
12, A lateral view showing the annulations, with ventral outline on left.
Locality same as Figure 1.

10. *Sactoceras liaotungense*, new species 76
A polished vertical section through the conch in a lateral direction, exposing the structure of the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone on Fu-chin-kou ridge, Liao-tung, Manchuria.

11. *Sactoceras* species undetermined 77
A polished vertical section in a lateral direction across the conch exposing the structure of the siphuncle.
Locality same as Figure 1.

13. *Sactoceras niuhsinense*, new species 75
A partly polished vertical section showing some of the siphuncle. (See also pl. 40, fig. 18.)
Locality same as Figures 3 and 4.

Plate 15

Page

Figures 1–3. *Armenoceras elegans*, new species 84

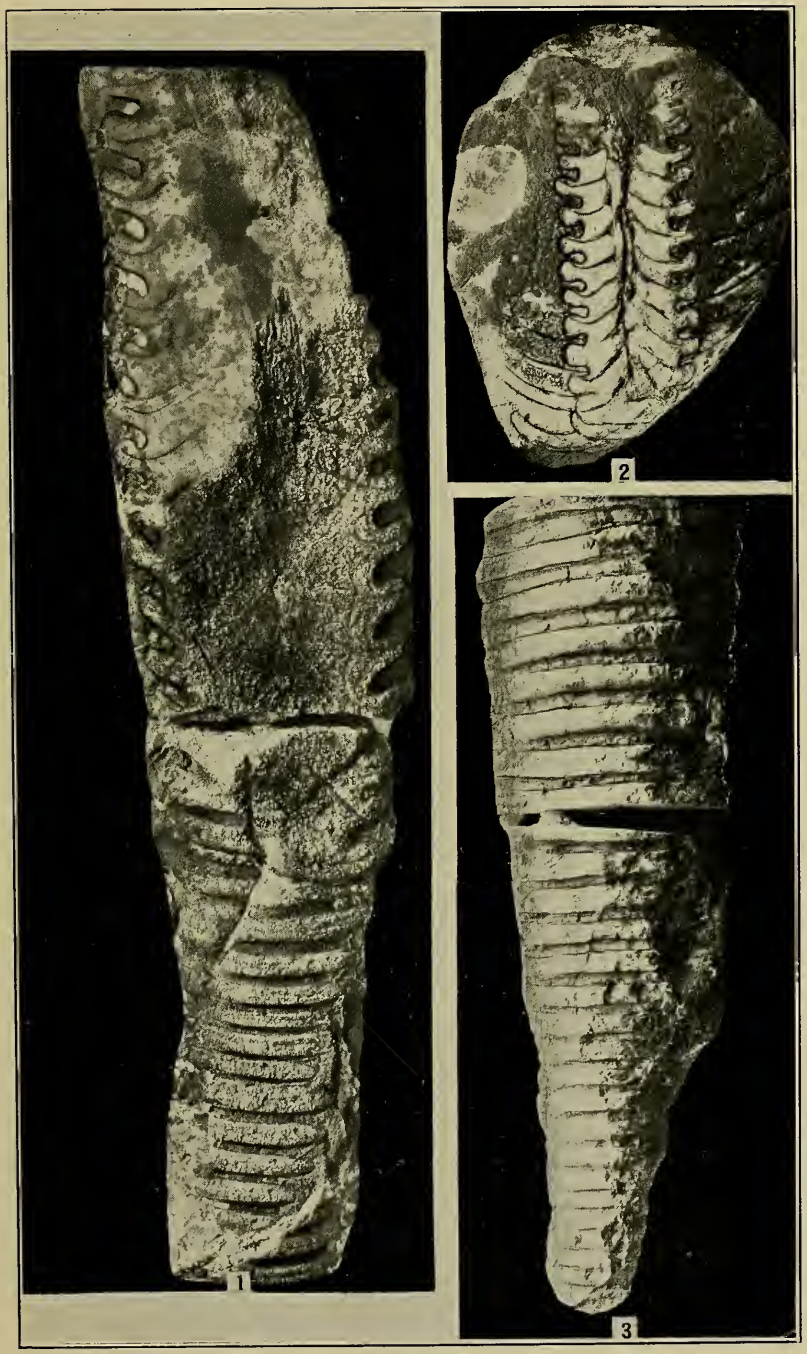
1, A lateral view of the siphuncle. Upper part of specimen cut vertically through the center of the siphuncle to show its structure.

2, A natural, vertical section in a lateral direction across the conch, showing the structure of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Pen-hsi-hu, Liao-tung, Manchuria.

3, A weathered natural section of the siphuncle.

Middle Ordovician, Ssuyen formation: Near Niu-hsin-tai, Liao-tung, Manchuria.



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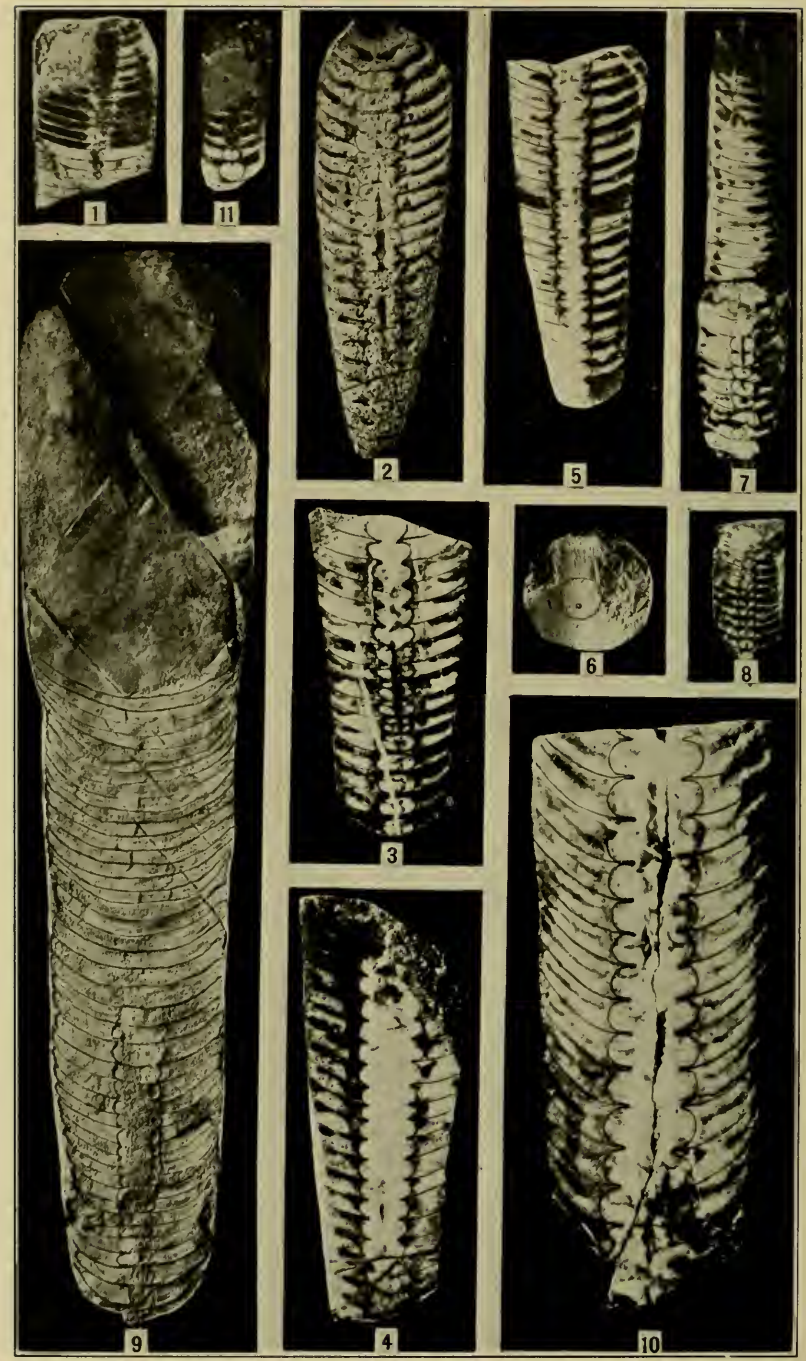


SSUYEN FORMATION

Plate 16

Plate 17

Page

FIGURES 1–4. *Armenoceras elongatum*, new species 85

1, 2. Two polished, vertical sections through the conch in a lateral direction, exposing the structure of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Niu-hsin-tai, Liao-tung, Manchuria.

3, 4. A polished vertical section and a cross section of the conch in the upper part, showing location and size of siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Wu-hu-tsui, Liao-tung, Manchuria.

5. *Armenoceras coulingi* (Grabau) 83

A polished vertical section through the conch in a lateral direction, showing the structure of the siphuncle.

Locality same as Figure 3.

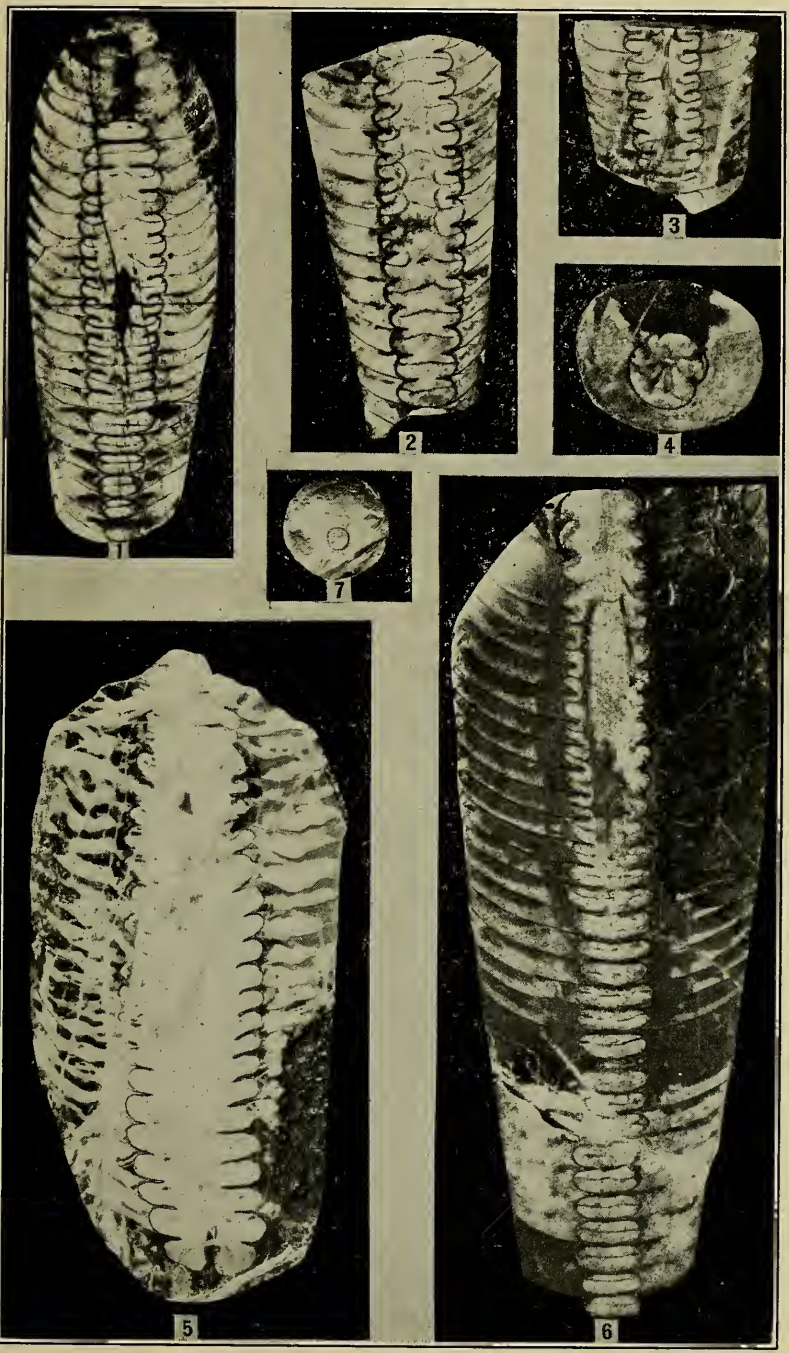
6. *Armenoceras resseri*, new species 83

A partly polished section in a lateral direction across the conch, exposing the structure of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Pen-hsi-hu, Manchuria.

7. *Cycloceras* (?) *manchuricnse*, new species 68

Basal segment of the specimen on Plate 13, Figure 11, viewed from beneath, showing the relative size and location of the siphuncle.



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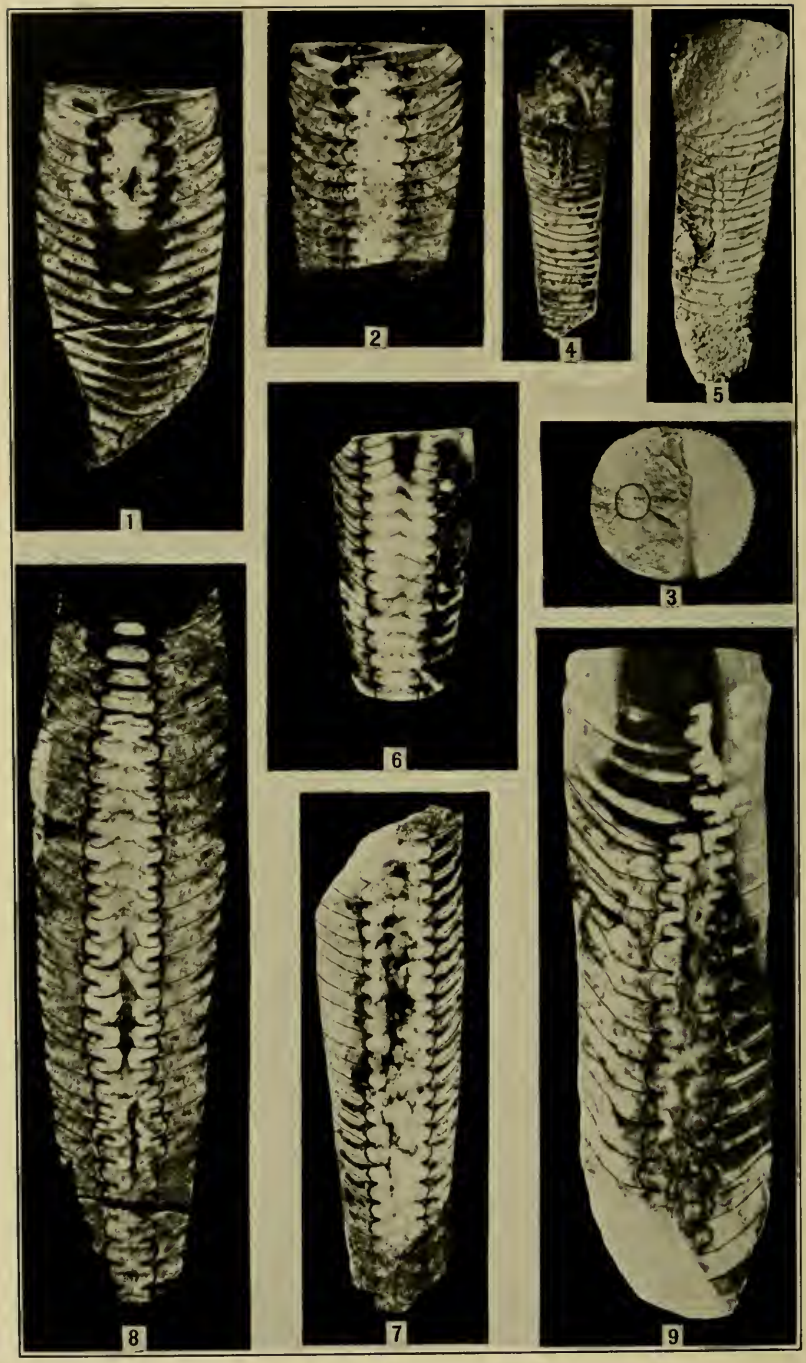

SSUYEN FORMATION

Plate 18

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Figures 1–3 *Armenoceras hatai*, new species 86

A polished vertical section in a lateral direction across the conch exposing the structure of the siphuncle, and a transverse section across the middle of the specimen showing the relative size and location of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Pen-hsi-hu, Liao-tung, Manchuria.

4, 5. *Armenoceras nanum* (Grabau) 92

4, A weathered natural vertical section showing parts of the siphuncle.

Middle Ordovician, Ssuyen formation: Near Niu-hsin-tai Liao-tung, Manchuria.

5, A similar natural section.

Middle Ordovician, Ssuyen formation: Near Pen-hsi-hu, Liao-tung, Manchuria.

6, 7. *Armenoceras hayasakai*, new species 87

6, A somewhat oblique polished section in a lateral direction across the conch, exposing the structure of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Chiao-tou, Liao-tung, Manchuria.

7, A polished vertical section in a lateral direction across the conch.

Middle Ordovician, Ssuyen formation: Limestone block, Niu-hsin-tai, Manchuria.

8. *Armenoceras elongatum*, new species 85

A polished vertical section in a lateral direction across the conch showing the structure of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Niu-hsin-tai, Liao-tung, Manchuria.

9. *Armenoceras kidoi*, new species 88

Vertical dorsoventral section through the conch to show the structure of the siphuncle. (See also pl. 40, fig. 5.)

Middle Ordovician, Ssuyen formation: Near Pen-hsi-hu, Liao-tung, Manchuria.

Plate 19

Page

Figure 1. *Armenoceras teicherti*, new species 89

A polished, vertical section in a lateral direction across the conch, exposing the structure of the siphuncle. (See also pl. 40, fig. 6.)

Middle Ordovician, Ssuyen formation: Limestone block, Niu-hsin-tai, Liao-tung, Manchuria.

2–4. *Armenoceras murakamii* (Kobayashi) ? 91

2, A polished, vertical section in a dorsoventral direction across the conch, showing the structure of the siphuncle.

4, Cross section of the same specimen at its middle, showing the relative size and location of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Wu-hu-tsui, Liao-tung, Manchuria.

3, A partly polished, vertical section.

Middle Ordovician, Ssuyen formation: Limestone southwest of Pen-hsi-hu, Liao-tung, Manchuria.

6–8. *Armenoceras manchurense* (Kobayashi) 90

6, 8, Two polished, vertical sections in a lateral direction across the conch, showing the structure of the siphuncle.

7, Cross section of the same specimen as Figure 8 in its upper part showing relative size and location of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Penhsi-hu, Liao-tung, Manchuria.

9. *Armenoceras* species undetermined 101

Specimen weathered so as to show a part of the ventral side of the siphuncle.

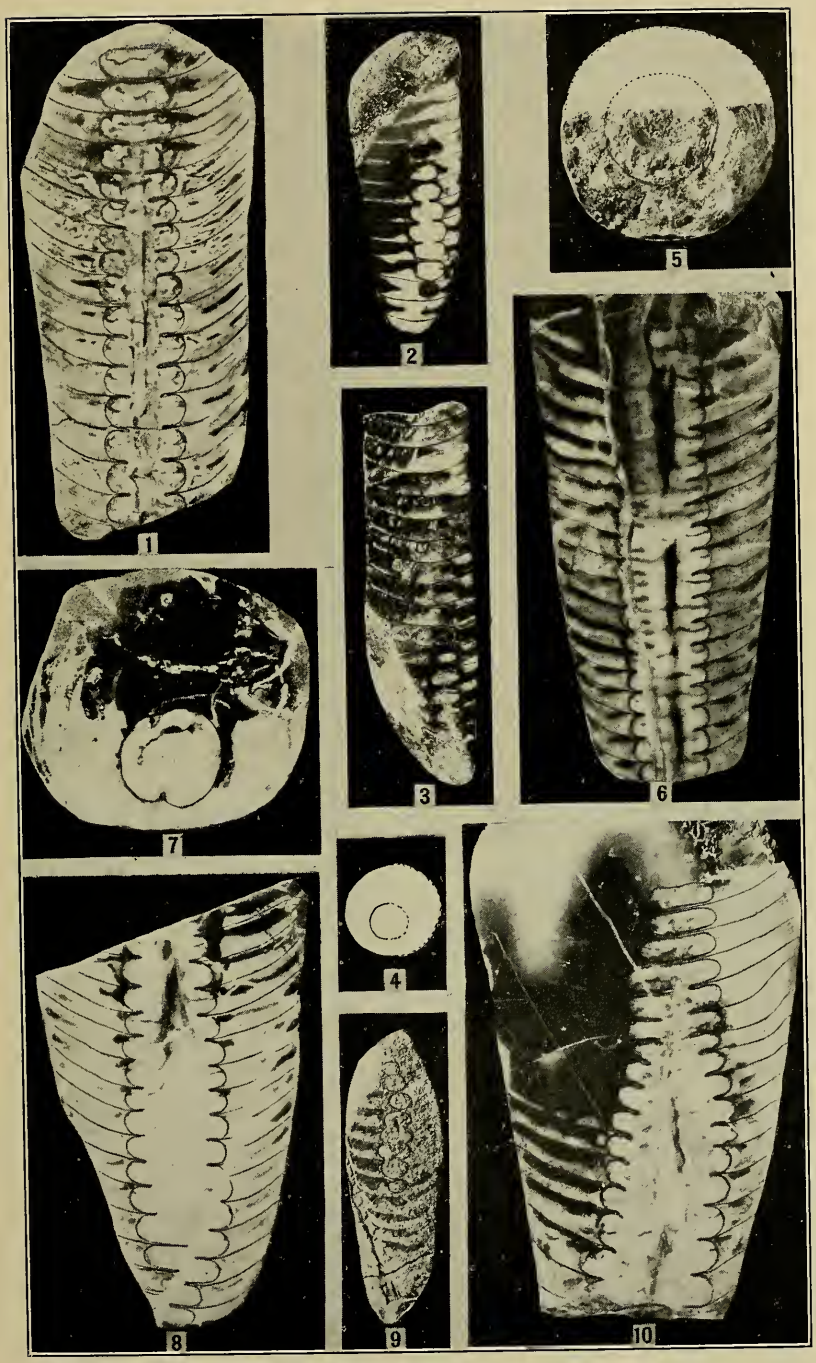
Middle Ordovician, Ssuyen formation: Limestone near Miyanohara, Liao-tung, Manchuria.

5, 10. *Armenoceras magnitubulatum*, new species 91

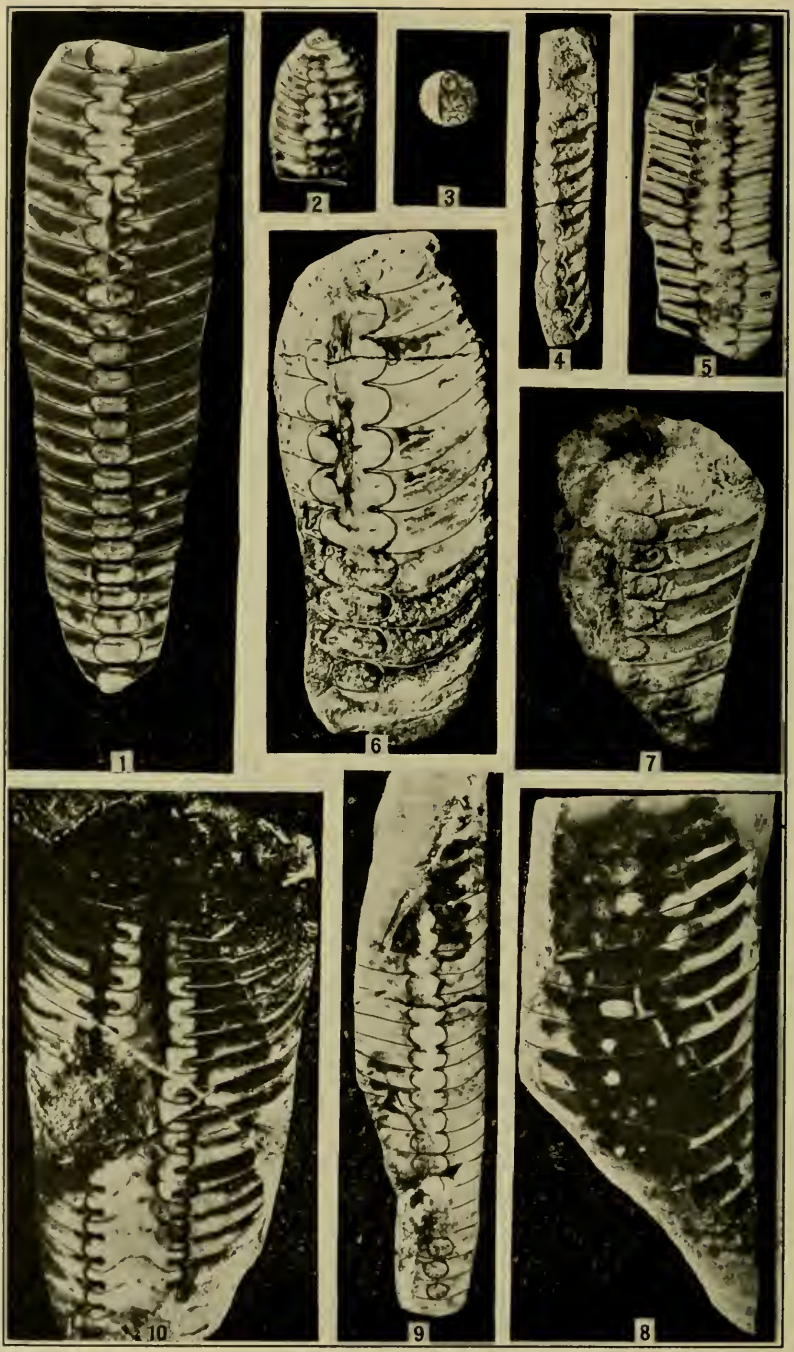
10, An oblique vertical section in a lateral direction across the conch, showing the structure of the siphuncle.

5, Transverse section of the same specimen, showing the relative size and location of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Niu-hsin-tai, Liao-tung, Manchuria.



SSUYEN FORMATION



SSUYEN FORMATION

Page

FIGURE 1. *Armenoceras nudium*, new species 94
A slightly oblique, polished, vertical section in a lateral direction across the conch, showing the structure of the siphuncle. (See also pl. 40, fig. 13.)
Middle Ordovician, Ssuyen formation: Limestone block, Niu-hsin-tai, Liao-tung, Manchuria.

2. *Armenoceras* species undetermined 101
A slightly oblique, polished, vertical section in a lateral direction across the conch, showing the structure of the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone near Niu-hsin-tai, Liao-tung, Manchuria.

3, 4. *Ormoceras proximum*, new species 105
4, Specimen weathered so as to expose the lateral side of the siphuncle.
3, Transverse section of same specimen at the middle showing the relative size and location of the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone near Hsiao-shih, Liao-tung, Manchuria.

5. *Armenoceras shimizui*, new species 97
A polished, vertical section in a lateral direction across the conch, exposing the structure of the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone near Tao-yuan-kou, Liao-tung, Manchuria.

6. *Armenoceras penhsiense*, new species 95
A partly polished, natural vertical section in a dorsoventral direction across the conch, showing the structure of the siphuncle. (See also pl. 40, fig. 15.)
Middle Ordovician, Ssuyen formation: Limestone near Penhsi-hu, Liao-tung, Manchuria.

7, 8. *Armenoceras sondai*, new species 98
7, Specimen weathered on its ventral side so as to expose the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone near Hsiao-shih, Liao-tung, Manchuria.
8, A polished, vertical section in a lateral direction across the conch, exposing somewhat the structure of the siphuncle. (See also pl. 40, fig. 9.)
Middle Ordovician, Ssuyen formation: Limestone near Tao-yuan-kou, Liao-tung, Manchuria.

9. *Ormoceras kimurai*, new species 102
A polished vertical section in a lateral direction across the conch, showing the structure of the siphuncle. (See also pl. 40, fig. 1.)
Middle Ordovician, Ssuyen formation: Limestone near Niu-hsin-tai, Liao-tung, Manchuria.

10. *Armenoceras richthofeni* (Frech) 96
A slightly oblique, polished vertical section in a lateral direction across the conch, showing the structure of the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone near Penhsi-hu. Liao-tung. Manchuria.

PLATE 21

Page

FIGURES 1–4. *Ormoceras orientale*, new species 104

1. A polished, vertical section through the conch in a lateral direction, showing the structure of the siphuncle.

2. Cross section of the same specimen showing location and size of siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Wu-hu-tsui, Liao-tung, Manchuria.

3. Specimen weathered on its ventral side exposing the siphuncle.

4. Cross section of the same specimen showing location and size of siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Niu-hsin-tai, Liao-tung, Manchuria.

5, 6. *Armenoceras suzukii*, new species 98

5. Specimen weathered on its lateral side exposing the siphuncle.

6. Cross section of same specimen showing location and size of siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Pen-hsi-hu, Liao-tung, Manchuria.

7. *Armenoceras tani* (Grabau) 99

A polished, vertical section through the conch in a lateral direction, showing the structure of the siphuncle. (See also pl. 14, fig. 2, and pl. 40, fig. 3.)

Middle Ordovician, Ssuyen formation: Limestone near Pen-hsi-hu, Liao-tung, Manchuria.

8, 9. *Armenoceras yabei*, new species 100

8. Specimen weathered on its ventral side, exposing the siphuncle.

9. Basal segment of same specimen viewed from beneath, showing the location and size of siphuncle.

Middle Ordovician, Ssuyen formation: Limestone block, Tou-fang-kou, Liao-tung, Manchuria.

10. *Ormoceras chinense*, new species 102

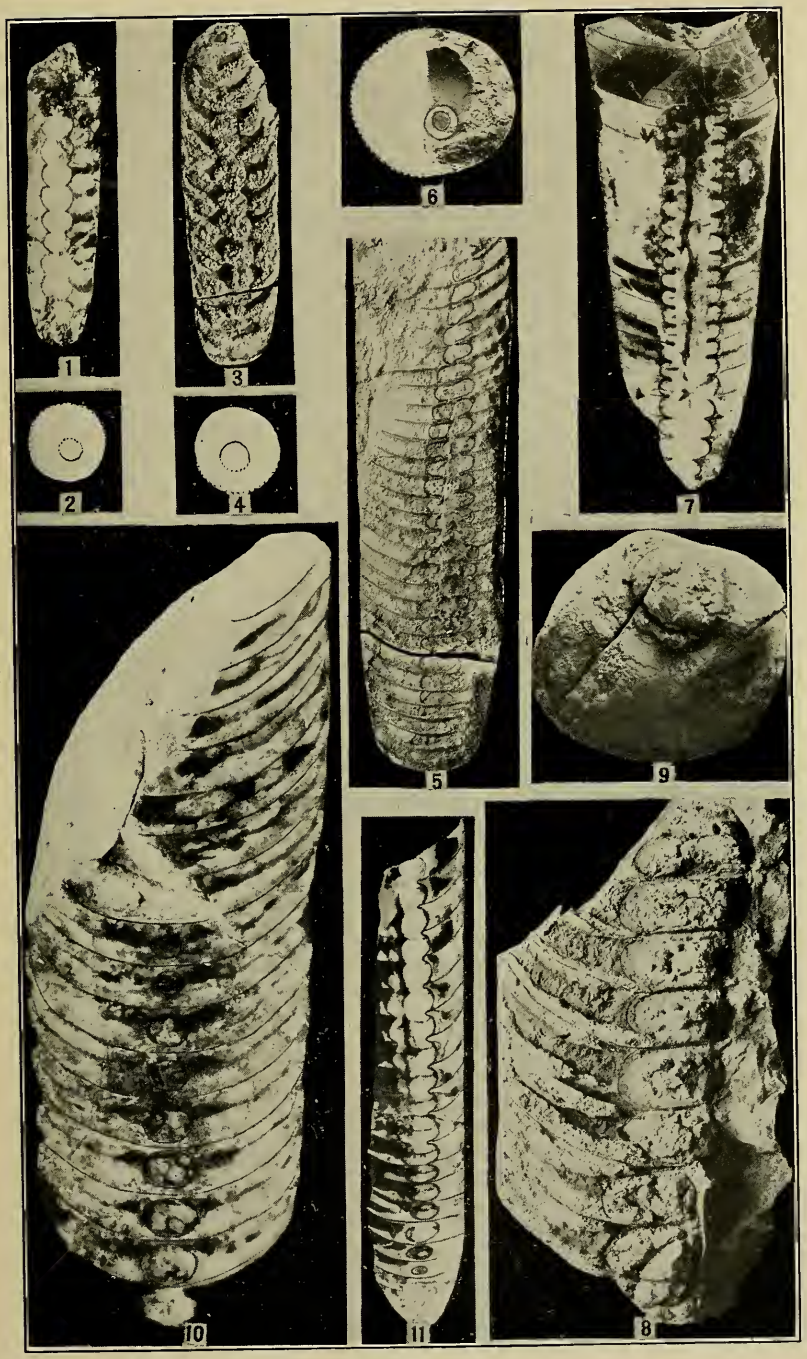
A somewhat oblique, polished vertical section through the conch in a lateral direction, showing the structure of the siphuncle.

Middle Ordovician, Ssuyen formation: Limestone near Niu-hsin-tai, Liao-tung, Manchuria.

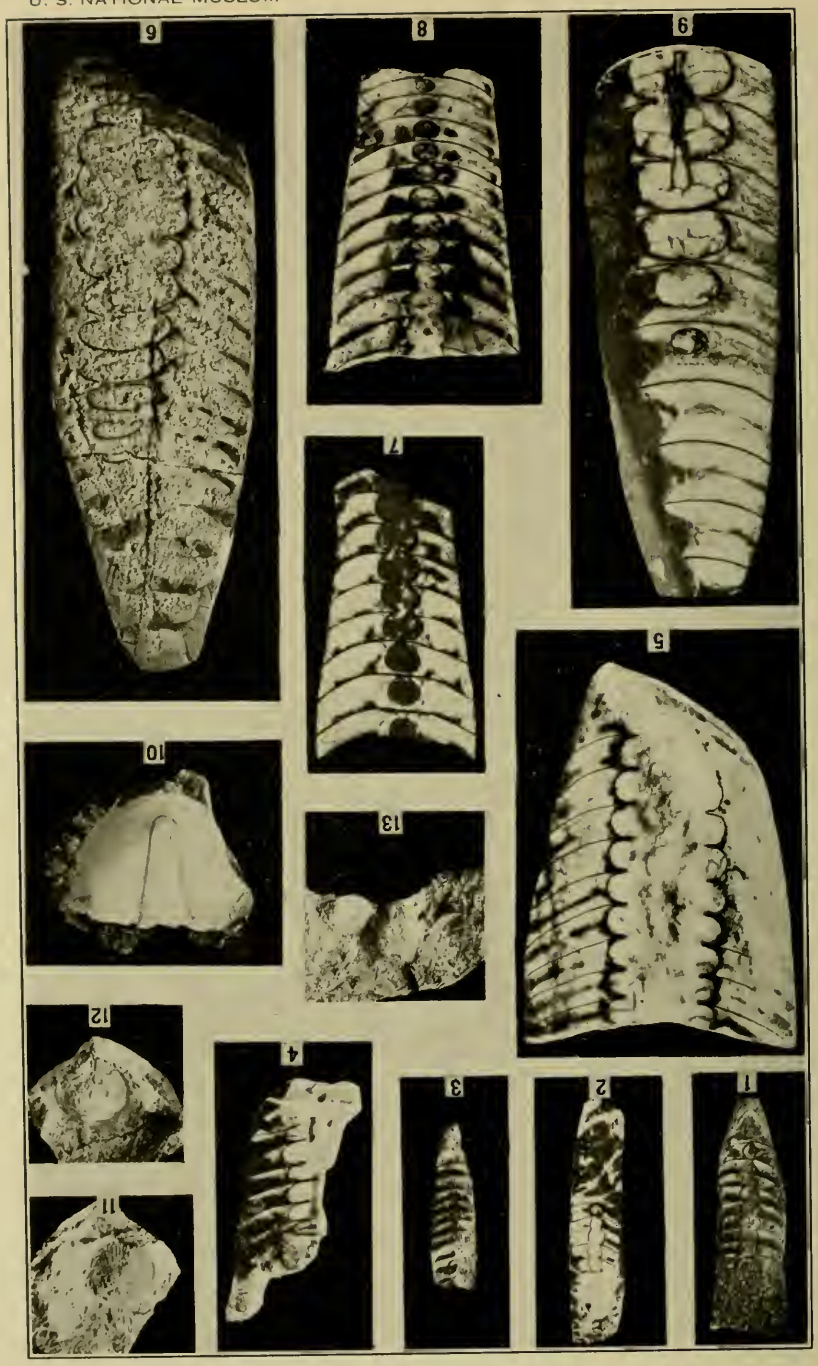
11. *Ormoceras nagaoi*, new species 104

A polished vertical section through the conch in a lateral direction, showing the structure of the siphuncle. (See also pl. 40, fig. 2.)

Locality same as Figure 8.



SSUYEN FORMATION



SSUYEN AND WUTING FORMATIONS

PLATE 22

Page

FIGURE 1. *Ormoceras* species undetermined 107
Specimen weathered on its ventral side exposing the siphuncle.
Middle Ordovician, Ssuyen formation: Limestone near Wu-hu-tsui, Liao-tung, Manchuria.

2. *Ormoceras* species undetermined 107
A polished vertical section in a lateral direction across the conch, showing the structure of the siphuncle.
Locality same as Figure 1.

3. *Ormoceras* species undetermined 107
Specimen weathered on its ventral side exposing the siphuncle.
Middle Ordovician, Ssuyen formation: Near Miyanohara Station, Liao-tung, Manchuria.

4. *Gonioceras* species undetermined 109
A polished vertical section in a lateral direction across the conch, showing the structure of the siphuncle.
Middle Ordovician, Ssuyen formation: Near Pen-hsi-hu, Liao-tung, Manchuria.

5, 6. *Armenoceras bassleri*, new species 82
6. A natural vertical section in a lateral direction somewhat obliquely across the conch.
5, A polished vertical section of same specimen across the conch, showing the structure of the siphuncle. (See also pl. 40, fig. 12.)
Middle Ordovician, Ssuyen formation: Near Hsia-kang-yao, Liao-tung, Manchuria.

7. *Ormoceras taitzuense*, new species 107
A polished vertical section in a lateral direction across the conch, showing the structure of the siphuncle. (See also pl. 40, fig. 4.)
Middle Ordovician, Ssuyen formation: Limestone block, Niu-hsin-tai, Liao-tung, Manchuria.

8. *Ormoceras taii*, new species 106
A polished vertical section in a lateral direction across the conch, showing the structure of the siphuncle. (See also pl. 40, fig. 10.)
Middle Ordovician, Ssuyen formation: Black banded limestone near Niu-hsin-tai, Liao-tung, Manchuria.

9. *Ormoceras* species undetermined 108
A partly polished vertical section in a lateral direction across the conch.
Formation and locality same as Figure 4.

10. *Isotcloides* species undetermined 112
Dorsal view of the single pygidium found.
Formation and locality same as Figure 4.

11–13. *Dalmanella* (?) species undetermined 44
Three partly exfoliated pedicle valves.
Lower Ordovician, Wuting formation: In gray banded limestone near Pen-hsi-hu, Liao-tung, Manchuria.

Plate 23

Page

Figures 1, 2. *Orthis calligramma orthambonites* von Buch 43
1, Exterior of a partly exfoliated pedicle valve.
Lower Ordovician, Wuting formation: Sandy limestone near Pen-hsi-hu, Liao-tung, Manchuria.
2, Exterior of a partly exfoliated pedicle valve.
Lower Ordovician, Wuting formation: Sandy limestone on top of Wu-ting-shan, Liao-tung, Manchuria.

3–7. *Dalmanella* (?) species undetermined 44
3–5, Three partly exfoliated pedicle valves.
6, 7, Two partly exfoliated brachial valves.
Formation and locality same as Figure 1.

8. *Rafinesquina* species undetermined 45
A poorly preserved pedicle valve.
Lower Ordovician, Wuting formation: In black limestone near Wu-hu-tsui, Liao-tung, Manchuria.

9. *Rafinesquina* species undetermined 45
A partly exfoliated pedicle valve.
Lower Ordovician, Wuting formation: In gray limestone near Hsiao-shih, Liao-tung, Manchuria.

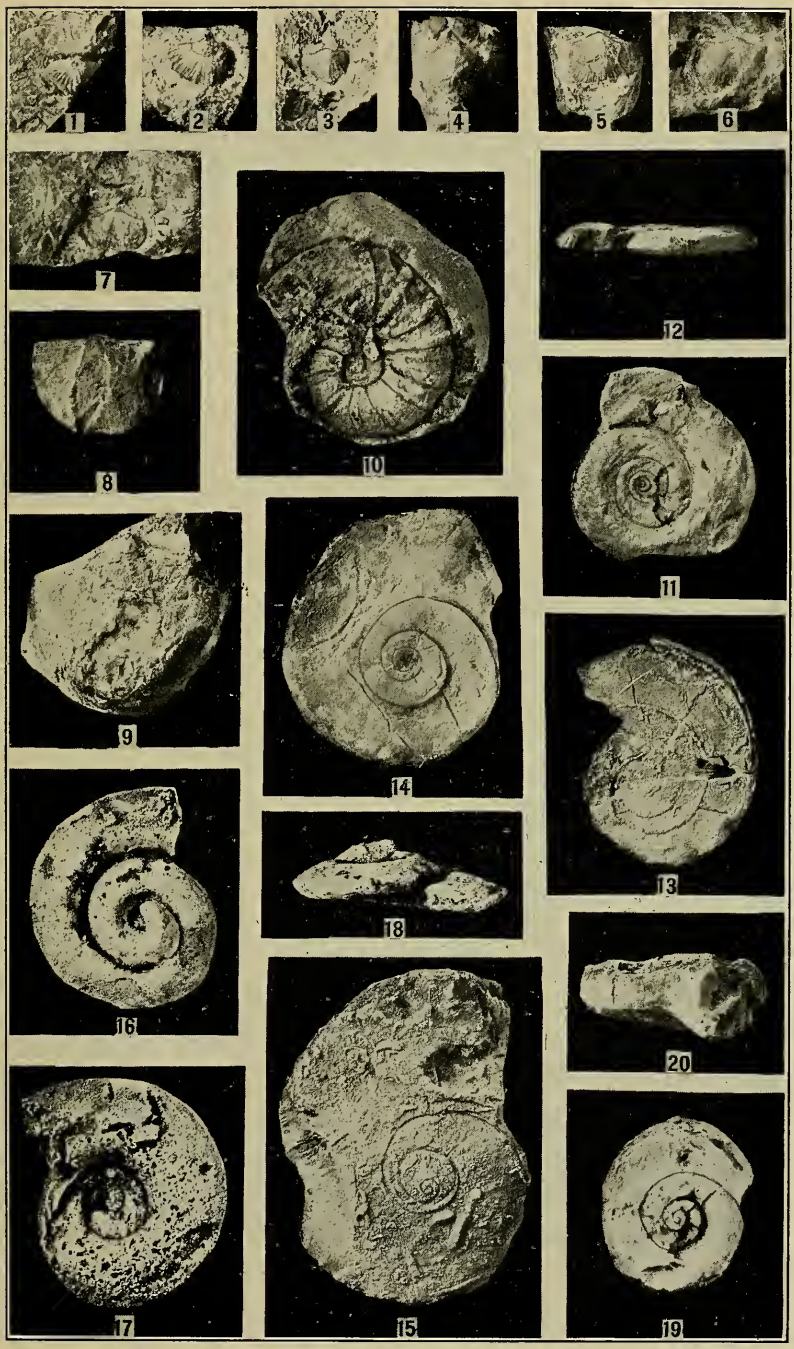
10. *Phragmolites* species undetermined, × 4 50
Umbilical view of the specimen described.
Lower Ordovician, Wuting formation: In black limestone, 2 miles west of Chiao-tou, Liao-tung, Manchuria.

11, 12. *Oxydiscus planulatus*, new species 51
Top and side views of the type specimen.
Formation and locality same as Figure 10.

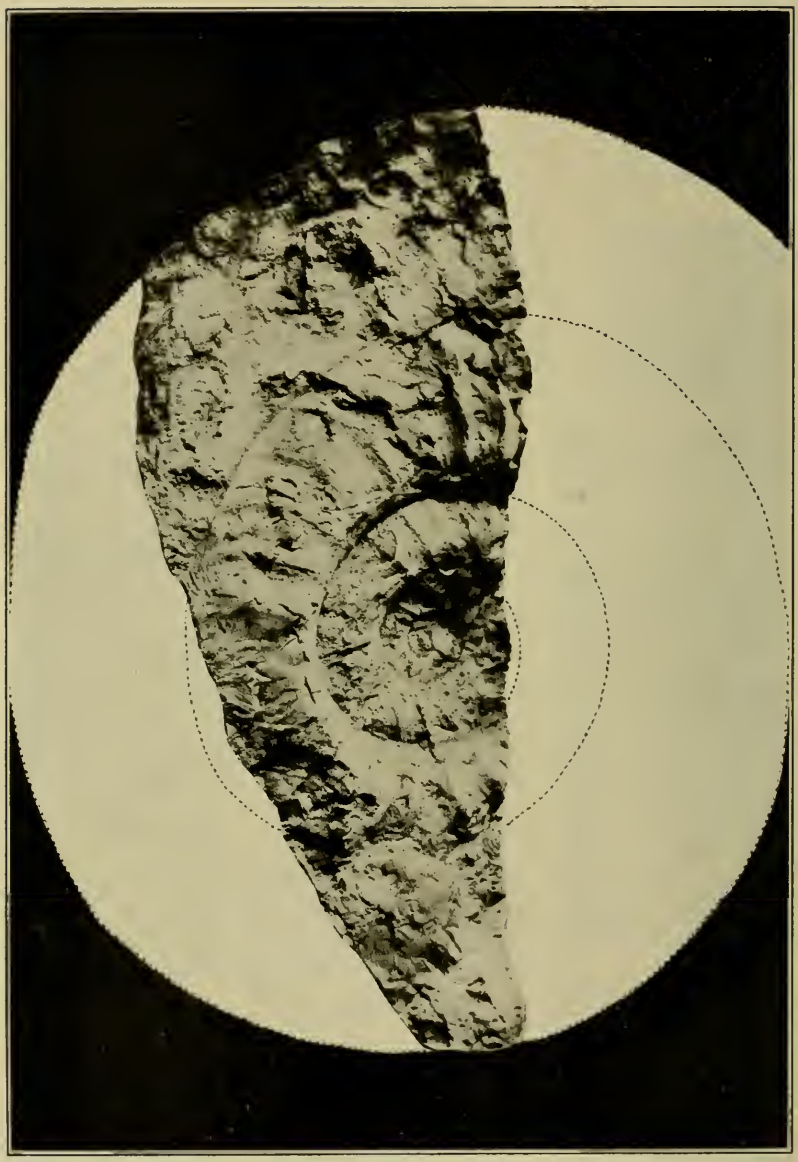
13. *Eccyliopterus* species undetermined 60
Top view of the fragmental specimen.
Formation and locality same as Figure 1.

14–18. *Raphistoma* cf. *aequilaterum* Koken ? 51
14, Top view of a partly weathered specimen.
Formation and locality same as Figure 2.
15, Top view of a partly weathered specimen.
Lower Ordovician, Wuting formation: In black limestone near Hsia-kan-ygao, south of Yen-tai, Liao-tung, Manchuria.
16–18, Top, umbilical, and side views of a cast.
Formation and locality same as Figure 1.

19, 20. *Helicoloma* species undetermined 60
Top and side views of the described specimen.
Formation and locality same as Figure 1.



WUTING FORMATION



WUTING FORMATION

PLATE 24

Page

Plectoceras ohtakai, new species 73

A cast made from the natural mold (×½).

Lower Ordovician, Wuting formation: In the limestone north of Penhsi-hu, Liao-tung, Manchuria.

Plate 25

Page

Figure 1. *Orthoceras rectisceptatum*, new species 66

A polished, vertical section in a lateral direction across the conch.

Lower Ordovician, Wuting formation: Black limestone near Niu-hsin-tai, Liao-tung, Manchuria.

2. *Armenoceras* species undetermined 101

A polished vertical section in a lateral direction across the conch.

Lower Ordovician, Wuting formation: Grayish-black limestone near Wu-hu-tsui, Liao-tung, Manchuria.

3–5. *Nybyoceras foerstei* Endo 79

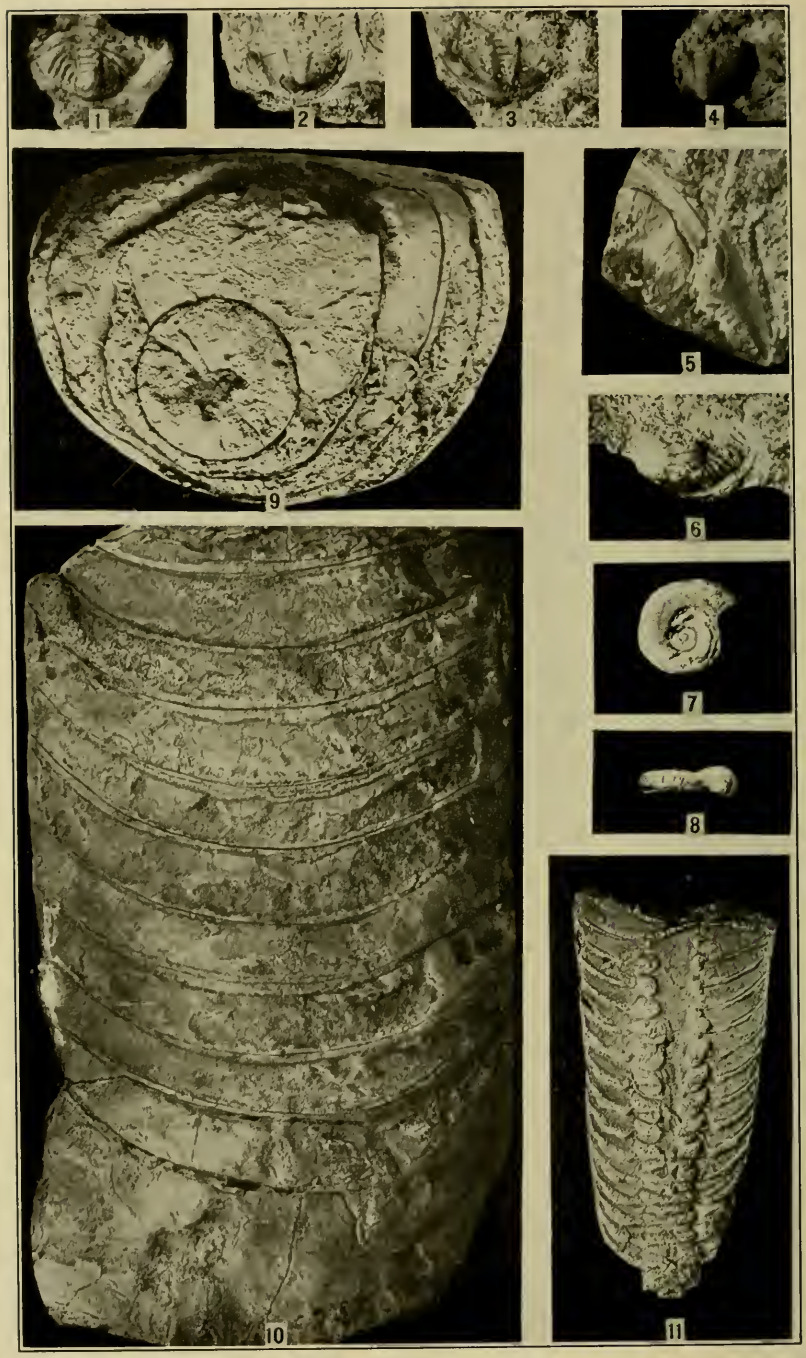
3, A part of siphuncle (× 2) etched by hydrochloric acid, showing the endosiphuncle and septal necks.

4, A lateral view, with sutures of septa running downward toward dorsal side. (Lower portion of specimen cut out in this figure.)

5, Vertical dorsoventral section of the same specimen showing location and structure of siphuncle.

Lower Ordovician, Wuting formation: Black limestone near Pen-hsi-hu, Liao-tung, Manchuria.

WUTING FORMATION



WUTING FORMATION

Plate 26

Page

FIGURE 1. *Bathyurus* (?) species undetermined 110
Dorsal view of a pygidium.
Lower Ordovician, Wuting formation: In the gray limestone near Pen-hsi-hu, Liao-tung, Manchuria.

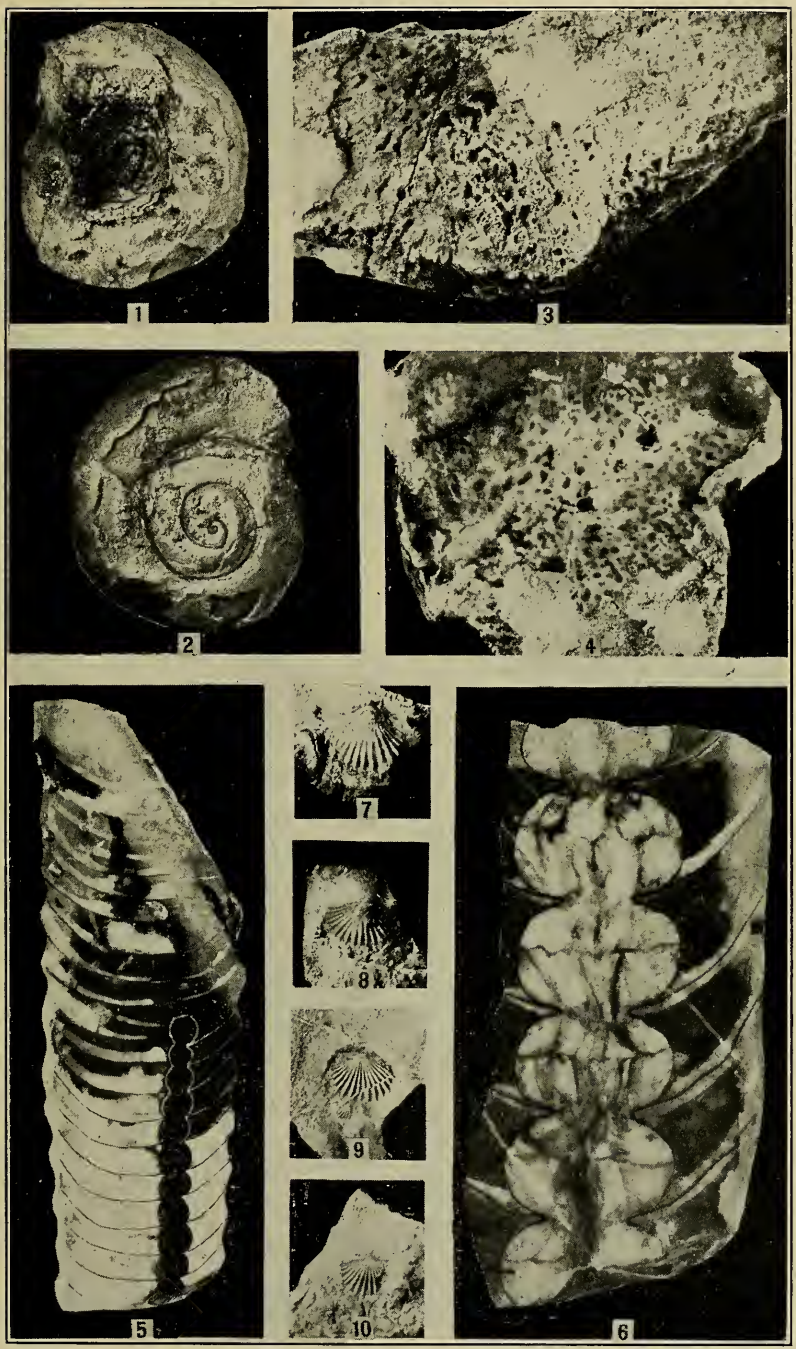
2–6. Undetermined trilobite 114
2–4, Three pygidia, which seem to belong to the same species.
5, An associated free cheek.
6, A pygidium, belonging to a different species.
Lower Ordovician, Wuting formation: Limestone beds on the top of the Wu-ting-shan, south of Yen-tai, Liao-tung, Manchuria.

7, 8. *Helicotoma* species undetermined 60
Top and side views of a specimen.
Formation and locality same as preceding.

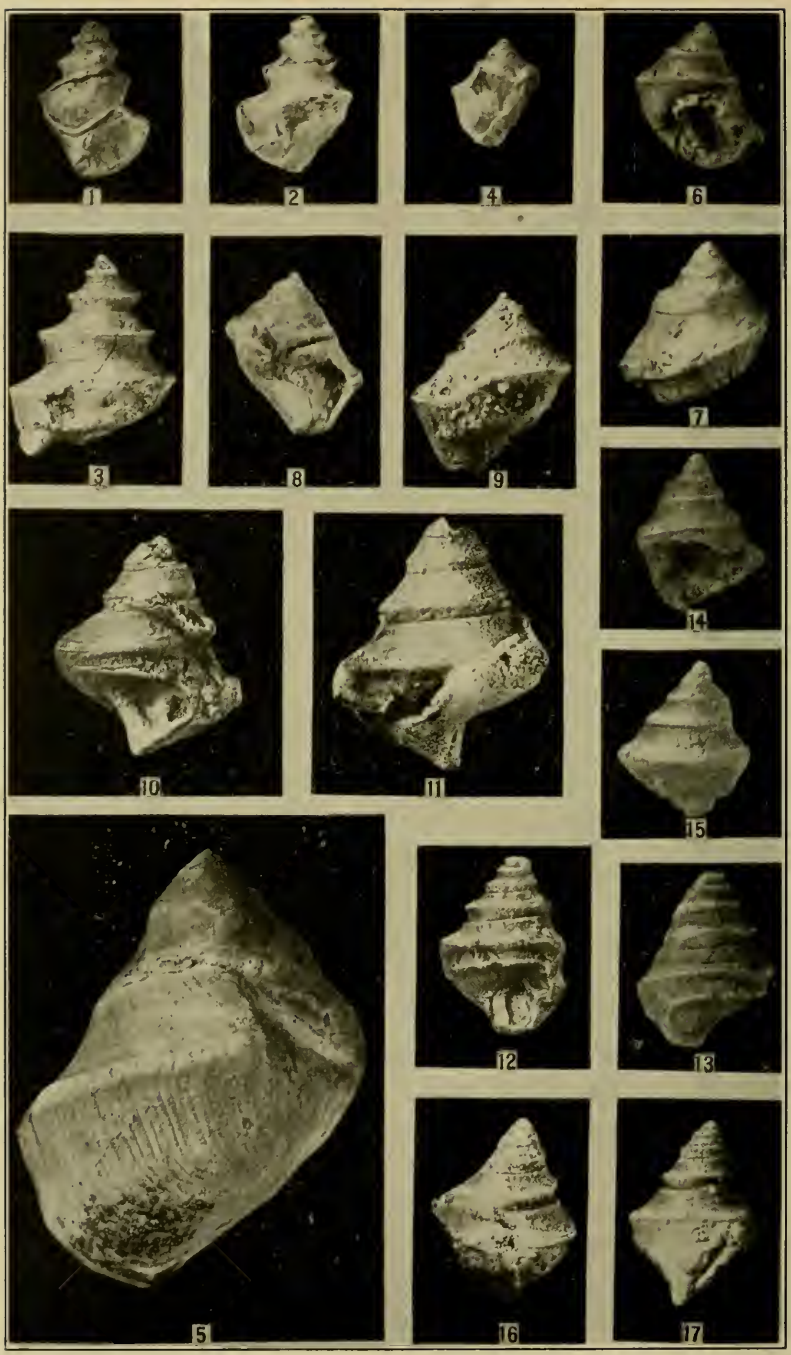
9, 10. *Nybyoceras foerstei* Endo 79
9, Top segment of the specimen shown on Plate 25, Figures 3–5, viewed from above, showing location and size of siphuncle.
10, A dorsal view of the same specimen.

11. *Armenoceras numatai*, new species 94
Specimen weathered out on dorsal side, exposing the siphuncle. (See also pl. 40, fig. 7.)
Formation and locality same as Figure 1.

PLATE 27



WUTING AND KANGYAO FORMATIONS



KANGYAO FORMATION

PLATE 28

Page

FIGURES 1–3, 12, 13. *Lophospira aojii*, new species 52

1, 2, Two side views of the same specimen.

3, A side view of another imperfect specimen (× 2).

12, 13, Different side views of a perfect shell (× 2).

Lower Ordovician, Kangyao formation: In the black weathering limestone, 3 miles south of Yen-tai, Liao-tung, Manchuria.

4, 5. *Lophospira grabaui*, new species 52

Side view of type specimen and enlarged (× 4) view showing fine surface markings.

Formation and locality same as Figures 1 and 2.

6–11. *Lophospira manchuriensis*, new species, × 2 54

6, 7, Side views of a fairly good specimen.

8, 9, Side views of another cotype.

10, 11, Side views of a third cotype.

Formation and locality same as Figures 1 and 2.

14 17. *Lophospira kangyaoensis*, new species 53

14, 15, Side views of a cotype (× 4).

16, 17, Two side views of another somewhat imperfect specimen (× 2).

Formation and locality same as Figures 1 and 2.

Plate 29

Page

Figure 1. *Lophospira aojii*, new species 52
Side view of a good specimen (× 4).

2, 3. *Lophospira* cf. *oweni* Ulrich and Scofield 54
Two side views of the same specimen.

4–6. *Lophospira yentaiensis*, new species 56
4, 5. Side views of the holotype.
6. A fragment of another specimen, showing the surface markings.

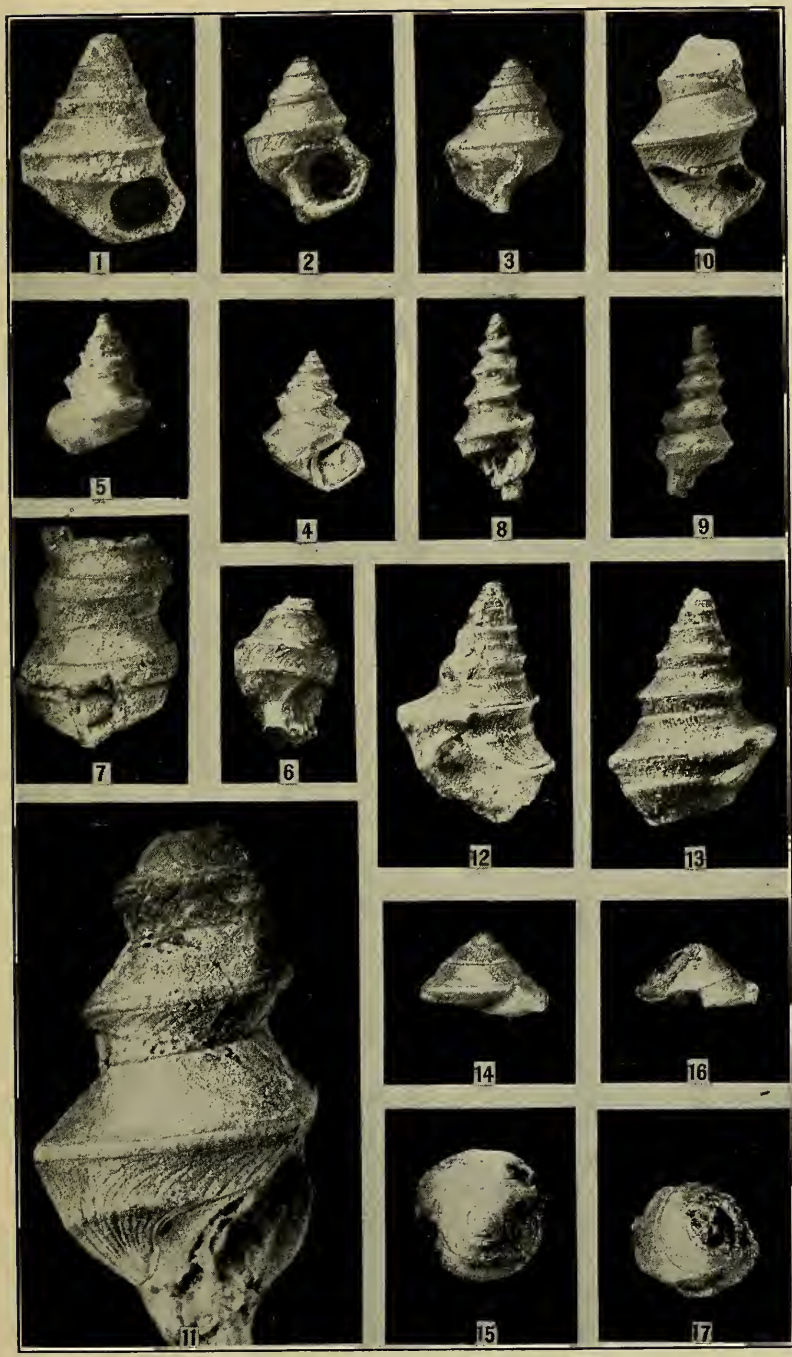
7. *Solenospira* species undetermined 59
A fragmentary specimen (× 4).

8–11. *Lophospira producta pagodai*, new variety 55
8, 9. Two side views.
11. An enlargement of the same specimen, showing fine surface markings (× 4).
10. A fragment, showing fine surface markings and trilineated peripheral bands (× 2).

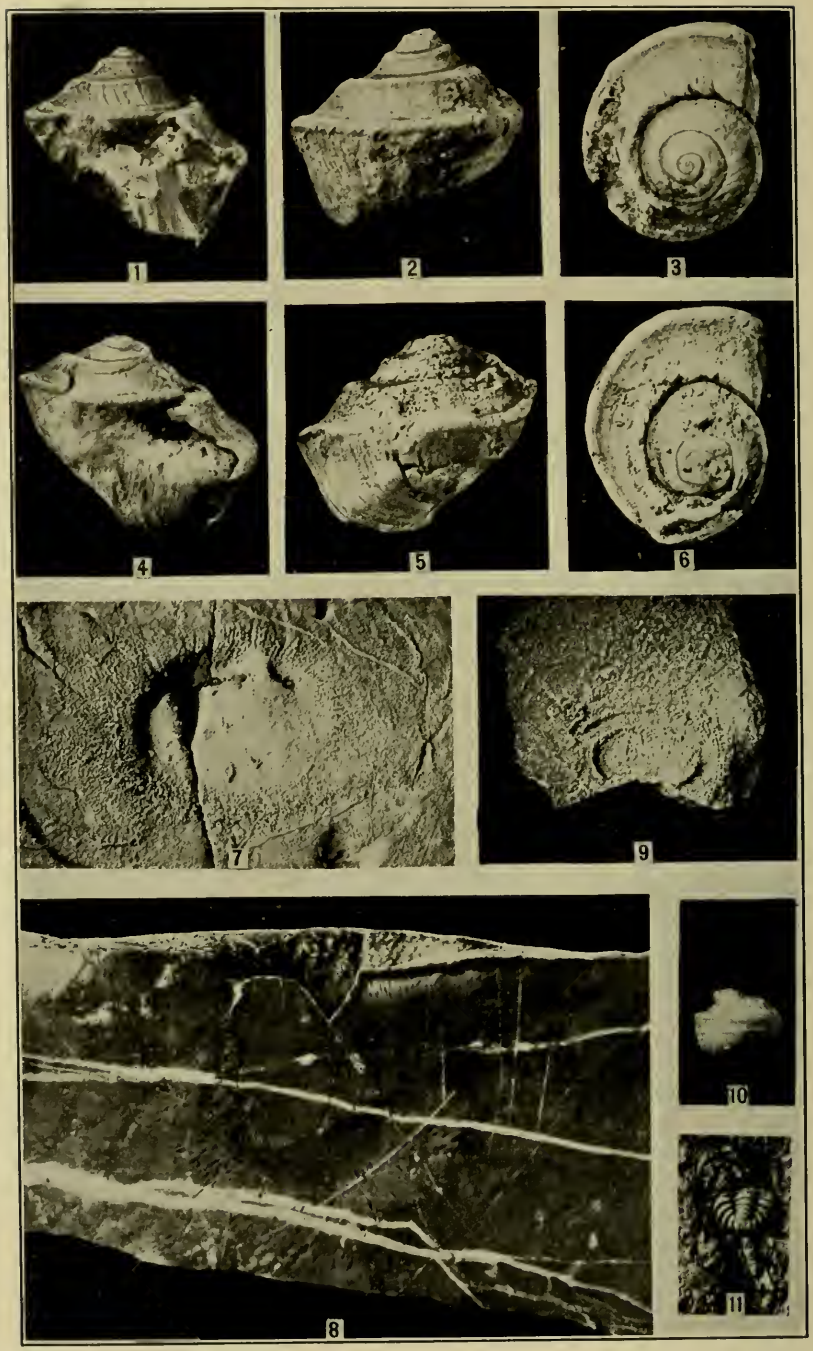
12, 13. *Lophospira turritiformis*, new species 55
Different side views of the same specimen (× 2).

14–17. *Eotomaria barbouri* (Grabau) 56
14, 15. Side and top views of a specimen.
16, 17. Side and top views of another specimen.

All from Lower Ordovician, Kangyao formation: In black weathered limestone, 3 miles south of Yen-tai, Liao-tung, Manchuria.



KANGYAO FORMATION



KANGYAO AND SANTAO FORMATIONS

PLATE 30

Page

FIGURES 1–6. *Eotomaria ulrichi*, new species, × 2 57

1–3, Side and top views of one of the type specimens (× 2).

4–6, Side and top views of cotype.

Lower Ordovician, Kangyao formation: In the weathered black limestone, 3 miles south of Yen-tai, Liao-tung, Manchuria.

7, 8. *Anthaspidella ? radiata*, new species 36

7, Weathered surface of the top of the holotype.

8, A polished vertical section of the same specimen showing the canal system and the cup wall.

Uppermost Canadian, Santao formation: In the gray limestone north of Pen-hsi-hu, Liao-tung, Manchuria.

9. *Calathium frechi*, new species 38

Weathered rock surface.

Formation and locality same as foregoing species.

10. *Lophospira* species undetermined 56

Side view of a fragmentary specimen.

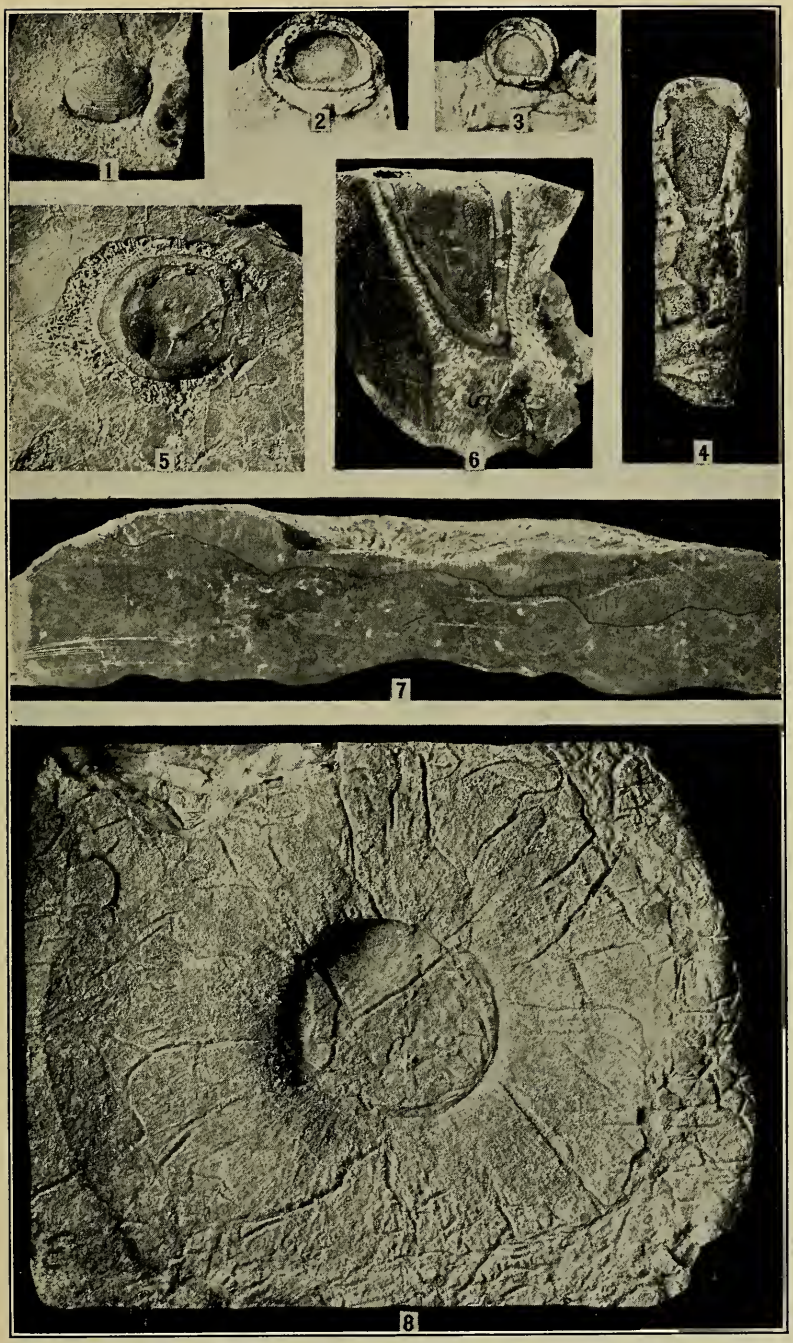
Formation and locality same as Figures 1–6.

11. Undetermined trilobite, × 2 114

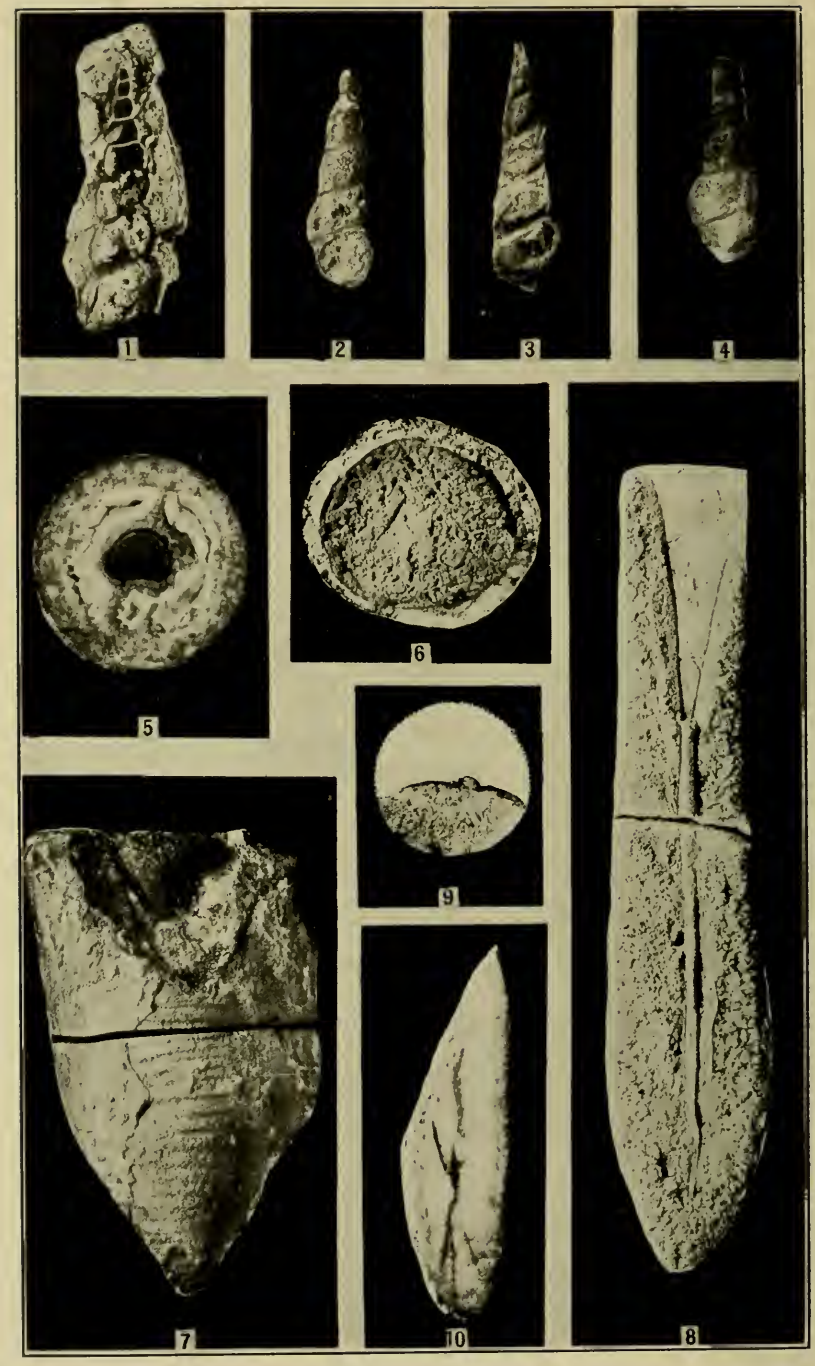
A pygidium.

Formation and locality same as preceding.

PLATE 31



SANTAO FORMATION



SANTAO FORMATION

PLATE 32

Page

FIGURES 1–4. *Hormotoma* species undetermined 58

Side views of four different specimens.

Uppermost Canadian, Santao formation: In the black limestone, 3 miles southeast of Yen-tai, Liao-tung, Manchuria.

5–7. *Piloceras manchuriense*, new species 63

Ventral view and two cross sections in different places showing location and size of endosiphuncle.

Uppermost Canadian, Santao formation: Black limestone, 2 miles west of Chiao-tou, Liao-tung, Manchuria.

8–10. *Penhsioceras fusiforme*, new species 65

8, A natural vertical section of the siphuncle of the type specimen.

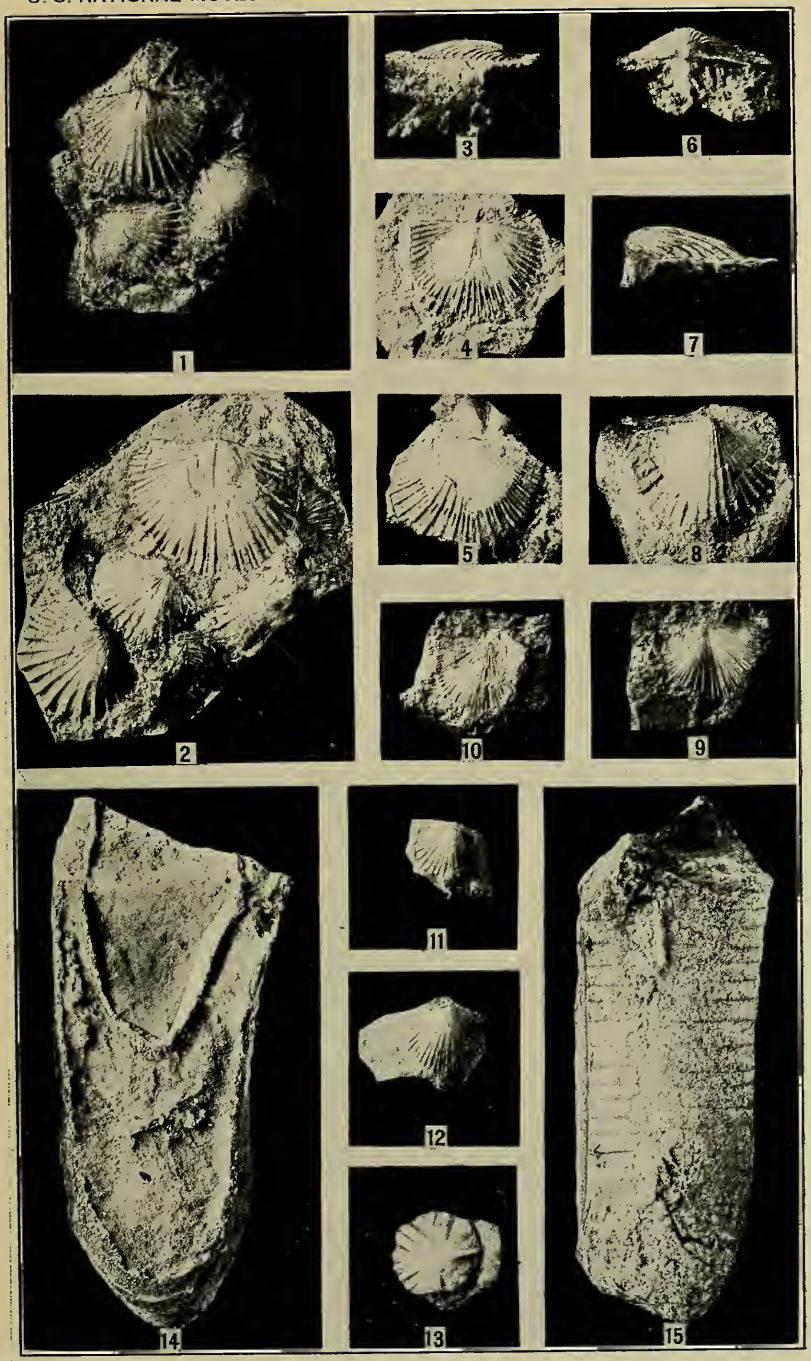
9, A cross section of the same specimen, showing location and size of endosiphuncle.

Uppermost Canadian, Santao formation: Gray arenaceous limestone, north of Pen-hsi-hu, Liao-tung, Manchuria.

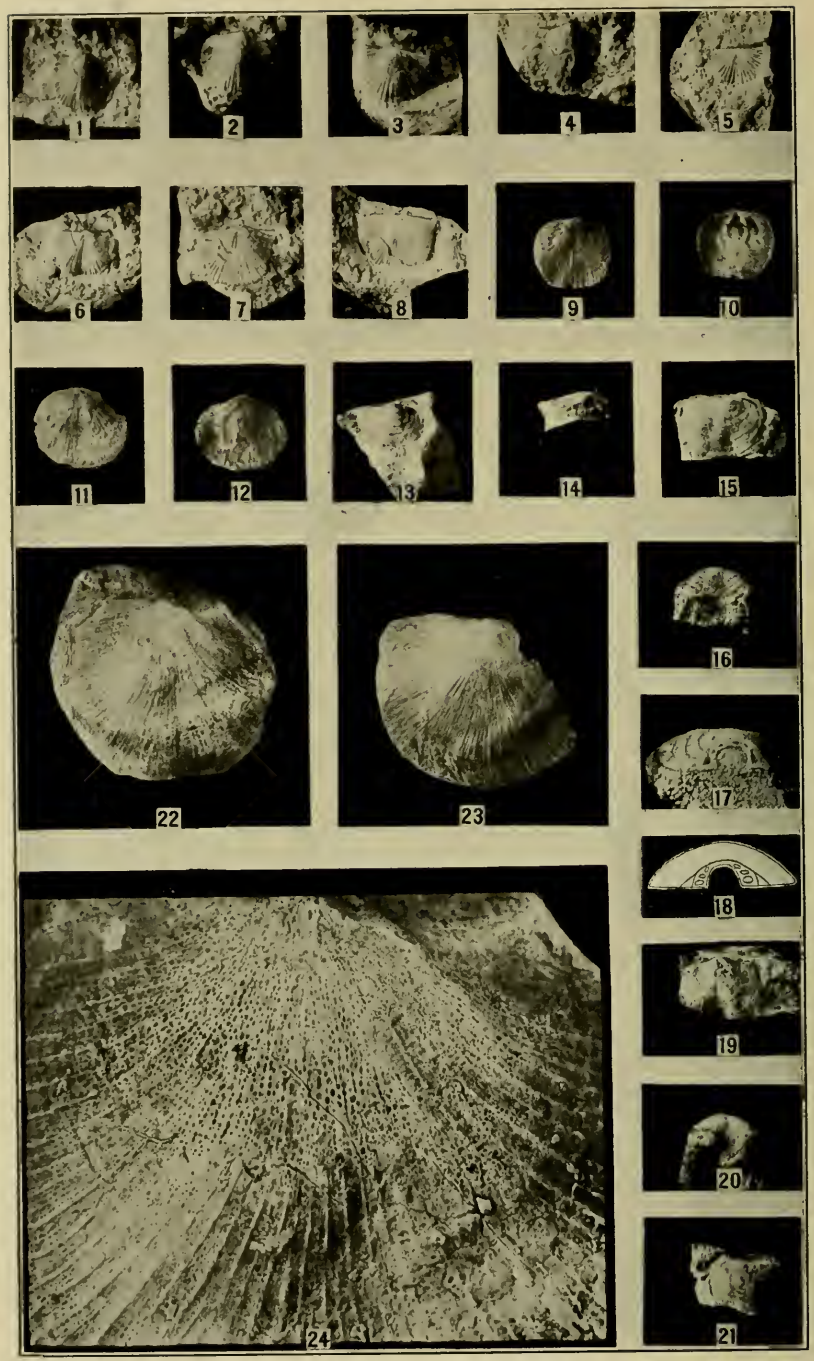
10, A polished vertical section of another specimen.

Uppermost Canadian, Santao formation: Black limestone, near Niu-hsin-tai, Liao-tung, Manchuria.

Plate 33



SANTAO FORMATION OF MANCHURIA AND ORDOVICIAN OF CENTRAL CHINA



ORDOVICIAN OF CENTRAL CHINA

Plate 34

Page

FIGURES 1–8. *Orthis shensiensis*, new species 42
1–4, Exteriors of four pedicle valves.
5–8, Exteriors of four brachial valves .
Ordovician: Huang-pa-yi, Shensi, China.

9–12. *Dalmanella testudinaria* (Dalman) 44
9, 10, Exterior and interior of the same brachial valve.
11, 12, Exteriors of brachial and pedicle valves.
Ordovician: Near Chao-tien, Szechwan, China.

13–21. *Polytoechia chinensis*, new species 48
13, 14, Two views of the apex of a pedicle valve.
15, 16, Exterior and anterior views of a pedicle valve.
17, 18, A transverse section and diagrammatic illustration of the same specimen showing the spondylum.
19, 20, Exterior and interior views of another pedicle valve.
21, An exterior view of a brachial valve.
Ordovician: Near Huang-pa-yi, Shensi, China.

22–24. *Rafinesquina puteata*, new species 45
22, 24, Exterior view of a pedicle valve and an enlargement (× 4) of the apex, showing fine series of pits.
23, Exterior of another incomplete pedicle valve.
Ordovician: Near Huang-pa-yi, Shensi, China.

Plate 35

Page

Figures 1–6. *Ptychoglyptus ulrichi*, new species 46

1–3, Exteriors of three different pedicle valves.

4, 5, Exteriors of two brachial valves.

6, Enlarged photograph (× 4) of the same specimen as Figure 5, showing the surface markings.

Ordovician: Huang-pa-yi, Shensi, China.

7–12. *Clitambonites hemistriatus*, new species 47

7, Exterior of a brachial valve.

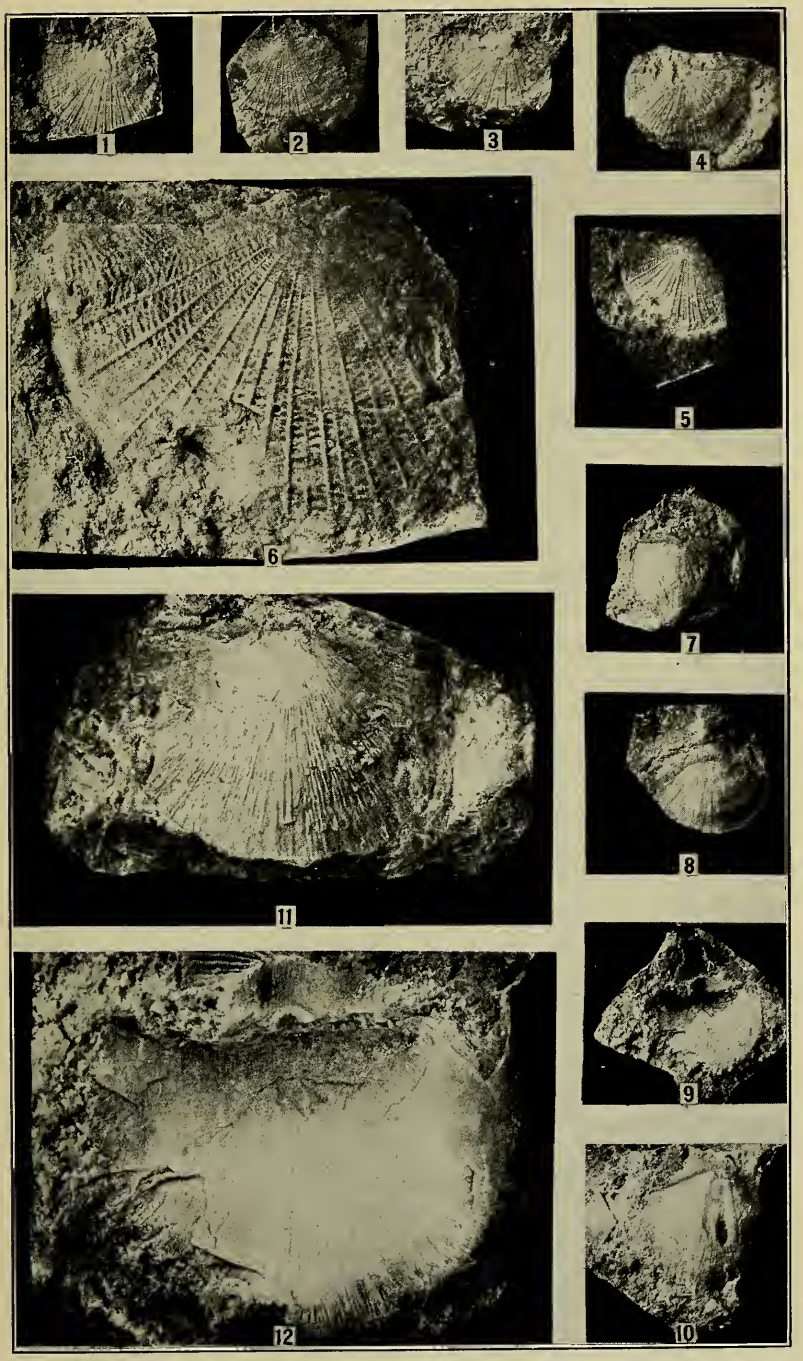
8, A broken pedicle valve, showing surface markings.

9, 12, Interior of a pedicle valve and an enlargement, showing the inner surface markings.

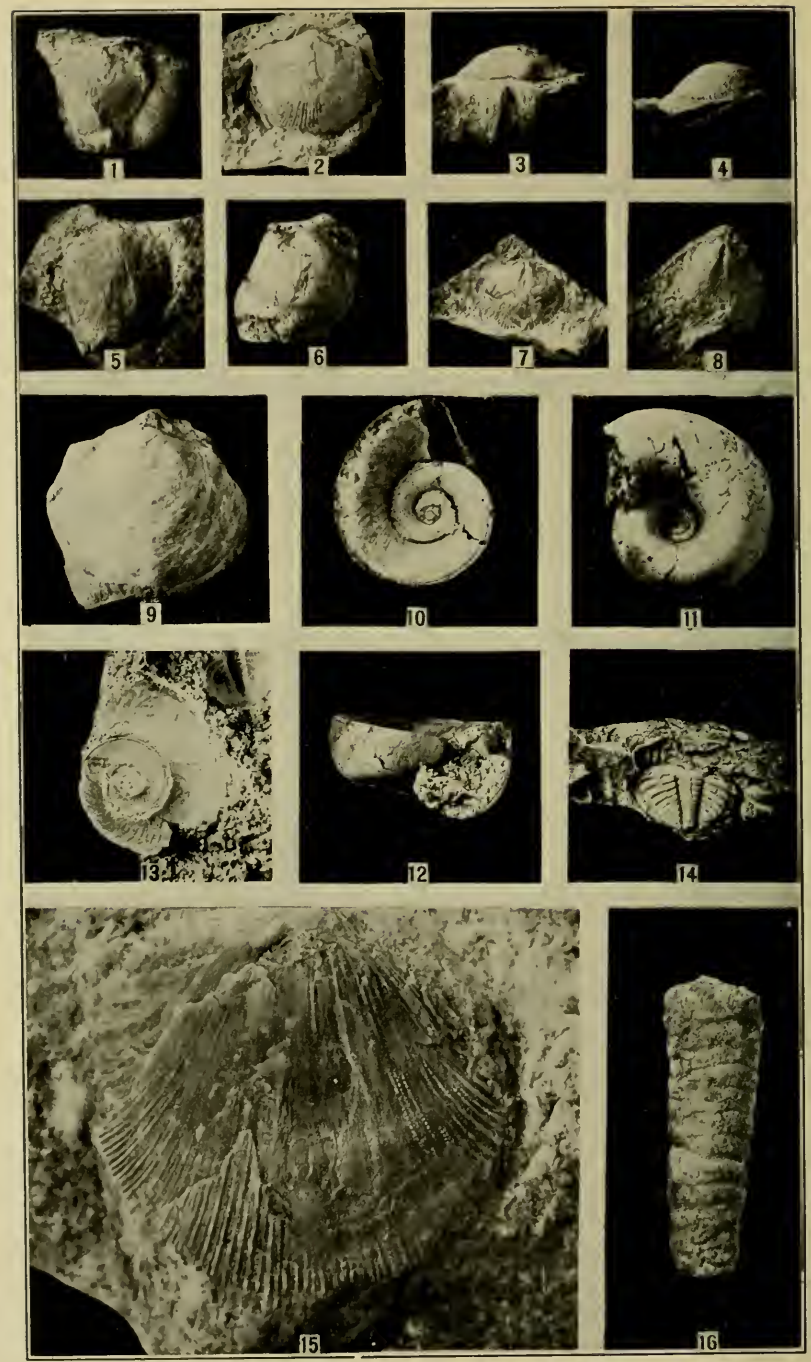
10, Exterior surface of a broken pedicle valve.

11, Exterior of a brachial valve. Compare with fig. 12 for difference between the exterior and interior surface markings (× 4).

Locality the same as Figures 1–3.



ORDOVICIAN OF CENTRAL CHINA



ORDOVICIAN OF CENTRAL CHINA

Plate 36

Page

FIGURE 1. *Clitambonites hemistriatus*, new species 47
Exterior of a pedicle valve.
Ordovician: Near Huang-pa-yi, Shensi, China.

2–8, 15. *Pionodema punctostriata*, new species 48
2–4, Exterior, posterior, and lateral views of the same pedicle valve.
5, 6, Exteriors of two pedicle valves.
7, 8, Exteriors of two brachial valves.
15, Enlarged pedicle valve (× 4) of the specimen shown in Figure 5, showing fine punctation on the surface.
Formation and locality same as Figure 1.

9. *Yangtzeella reticulata*, new species 50
Exterior of pedicle valve of holotype.
Formation and locality same as Figure 1.

10–13. *Eccyliopterus louderbacki*, new species 59
10–12, Top, umbilical, and side views of a cast of the holotype.
13, Mold of the same specimen.
Formation and locality same as Figure 1.

14. Undetermined trilobite 114
A pygidium.
Formation and locality same as Figure 1.

16. *Cycloceras louderbacki*, new species 69
Lateral view of the holotype with ventral outline on left.
Ordovician: Near Han-chung-fu, Shensi, China.

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FIGURES 1–3. *Endoceras centrotubulatum*, new species 62

1, 2, Lateral view and the cross section along the upper part of the specimen showing location and size of siphuncle and endocones.

3, A vertical section of the lower part of the same specimen in a lateral direction across the conch, showing the structure of the siphuncle.

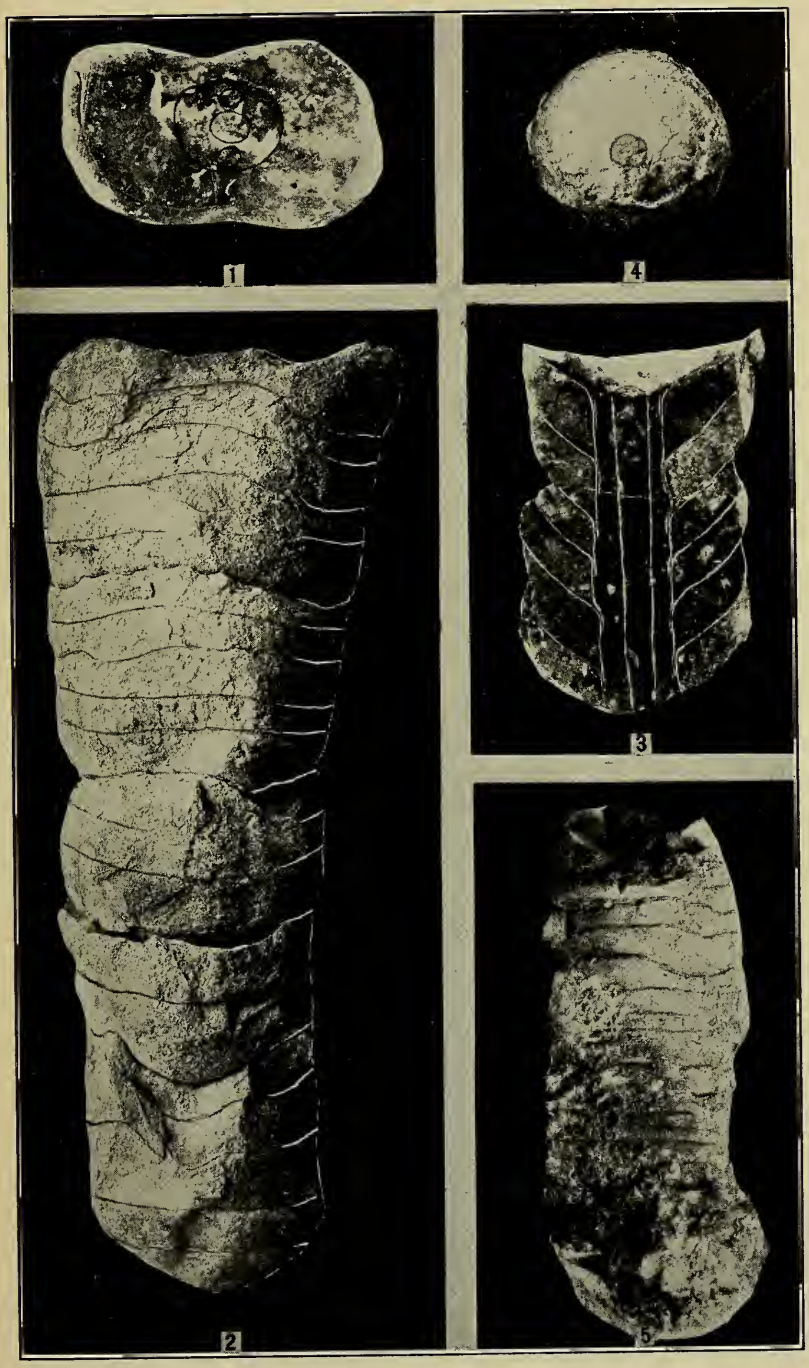
Ordovician: Near Han-chung-fu, Shensi, China.

4, 5. *Cycloceras* (?) *shensiense*, new species 71

5, A lateral view of the holotype showing annulations.

4, A segment of the upper part viewed from beneath, showing location and size of the siphuncle.

Formation and locality same as preceding.



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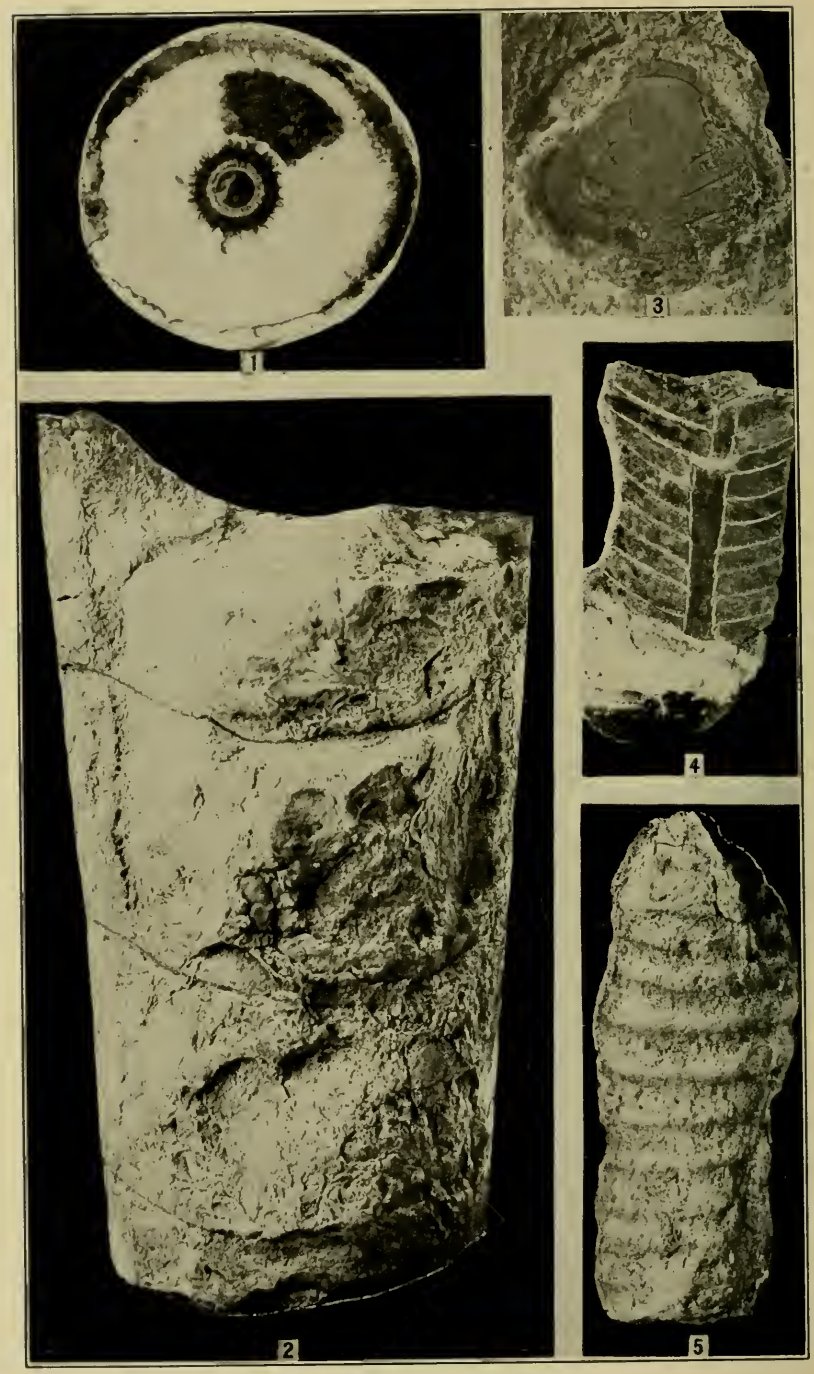

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Figures 1, 2. *Orthoceras magnichinense*, new species 65
Lateral view of the holotype and a section across the lower part showing location and size of the siphuncle.
Ordovician: Near Han-chung-fu, Shensi, China.

3. *Robergia striata*, new species 109
The cephalon (× 4) showing the characteristic surface striation.
Ordovician: Near Huang pa-yi, Shensi, China.

4. *Cycloceras(?) shensiense*, new species 71
Vertical section in a lateral direction, showing the structure of the siphuncle.
Locality same as Figure 1.

5. *Spyroceras* species undetermined 73
A lateral view, showing the annulations and vertical striations.
Locality same as Figure 1.

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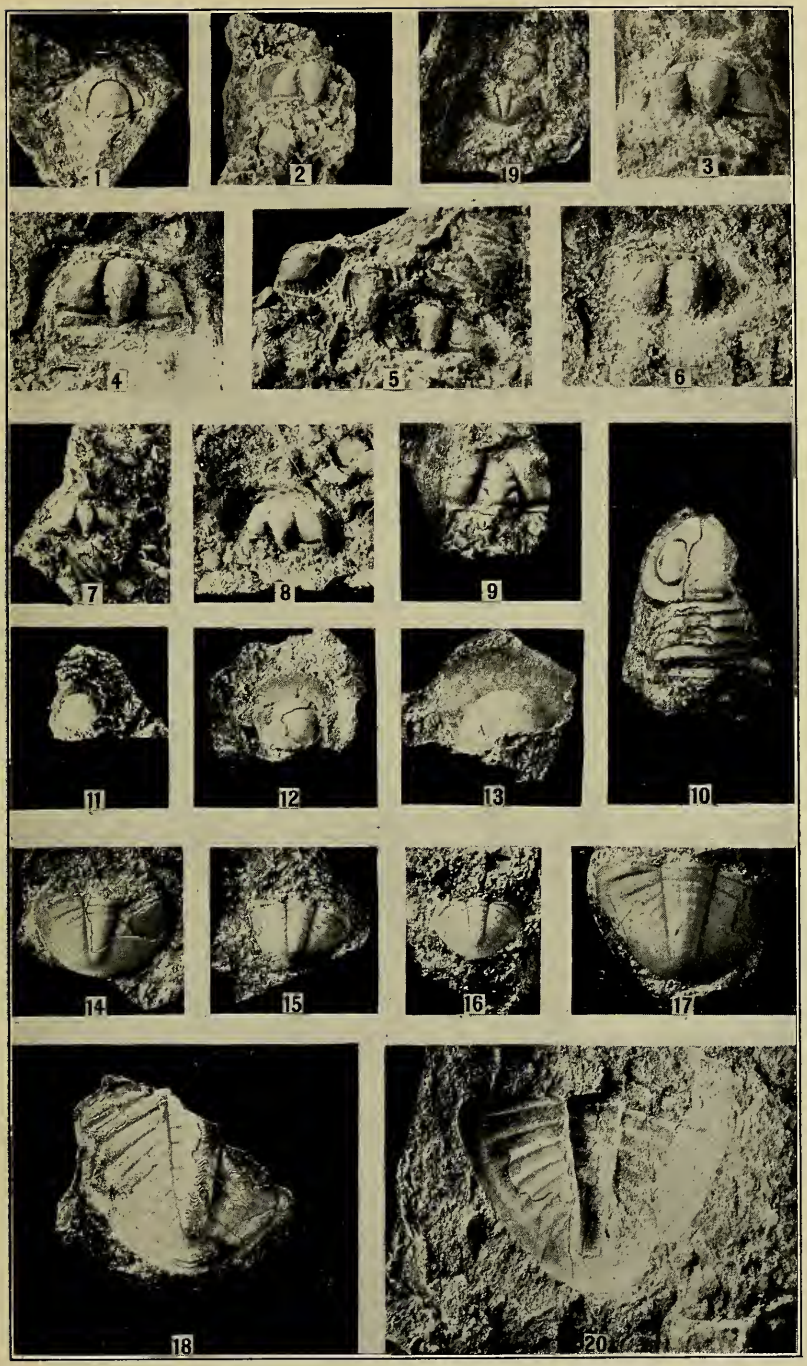

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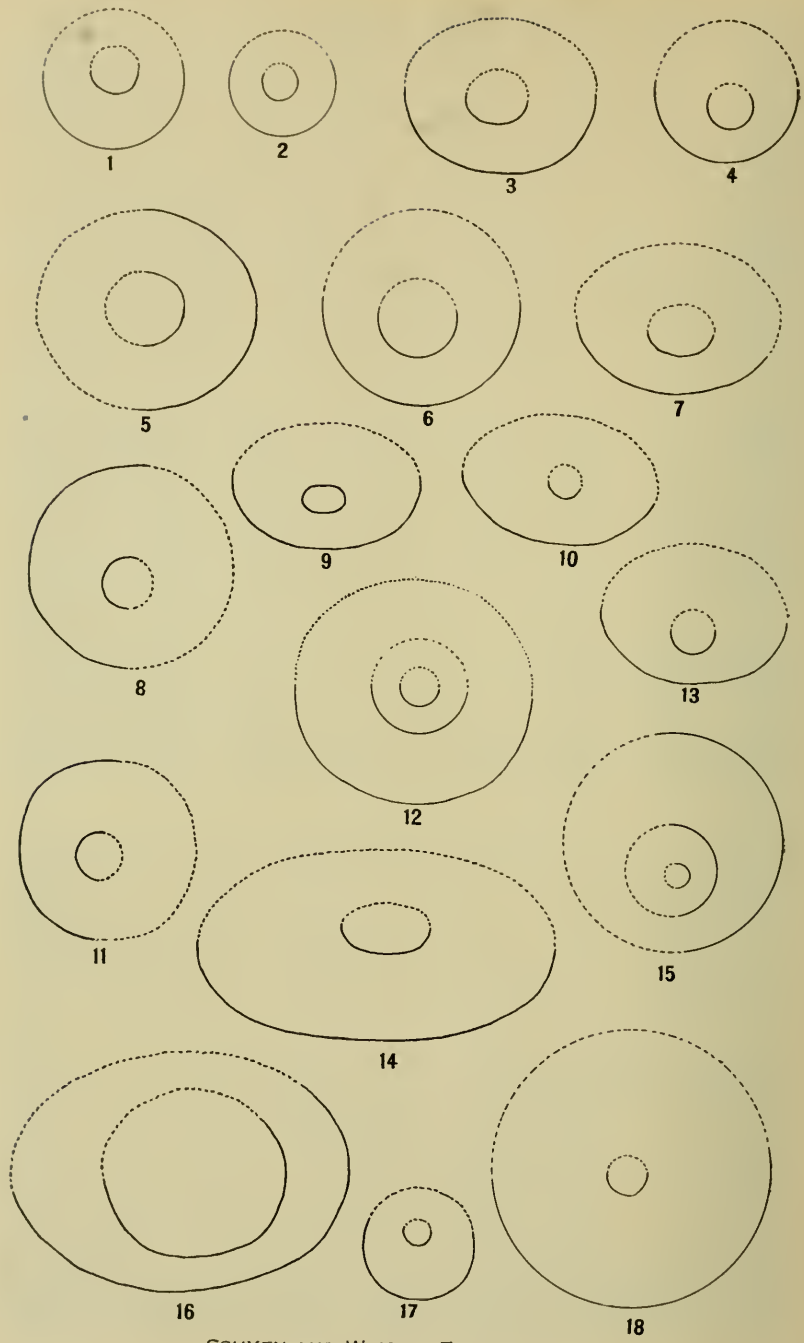


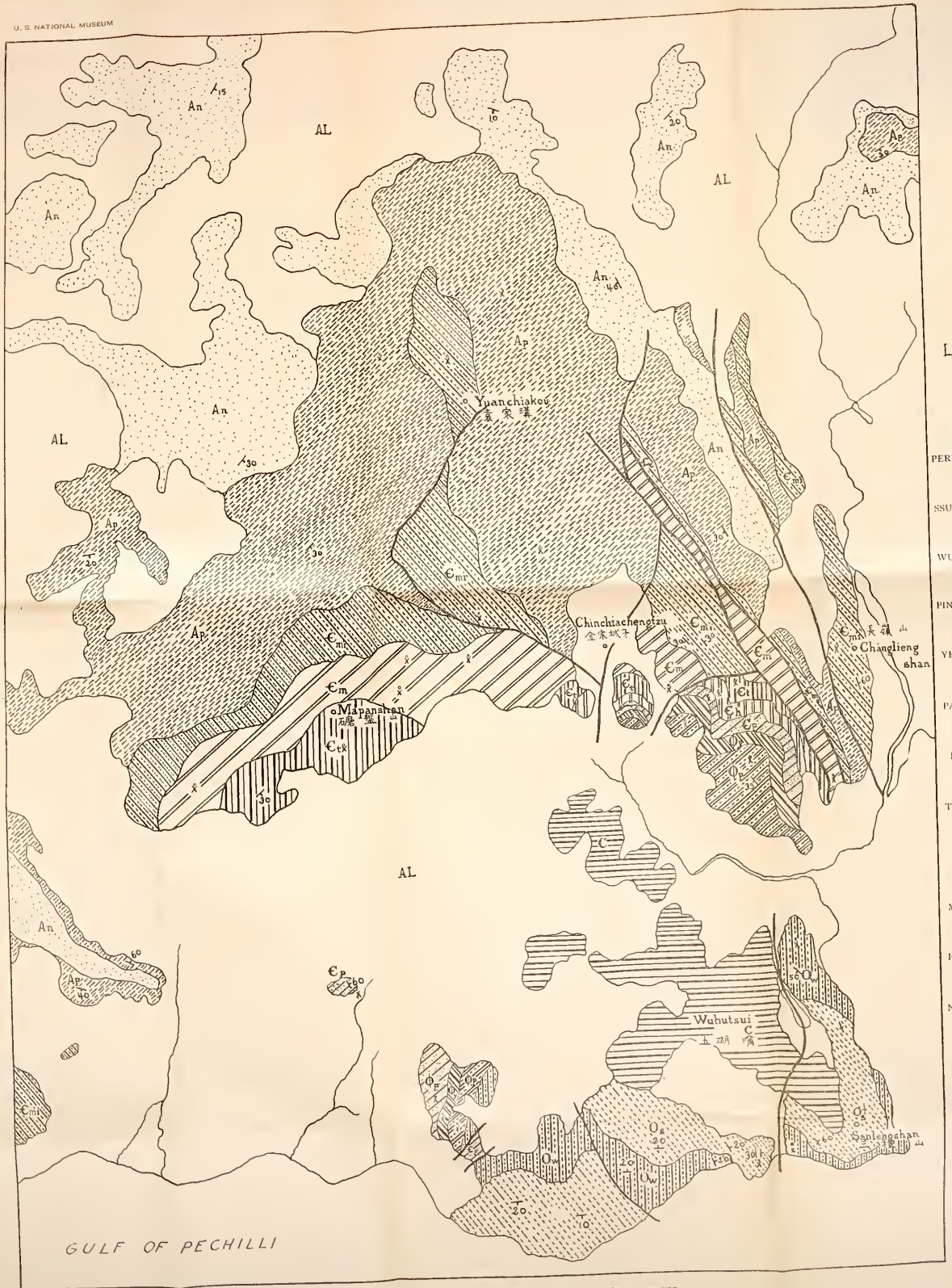
SSUYEN AND WUTING FORMATIONS

Plate 40

Cross sections of cephalopods showing position and size of the siphuncle (natural size)

INDEX TO GENERA AND SPECIES

(Principal references are given in **boldface** type)

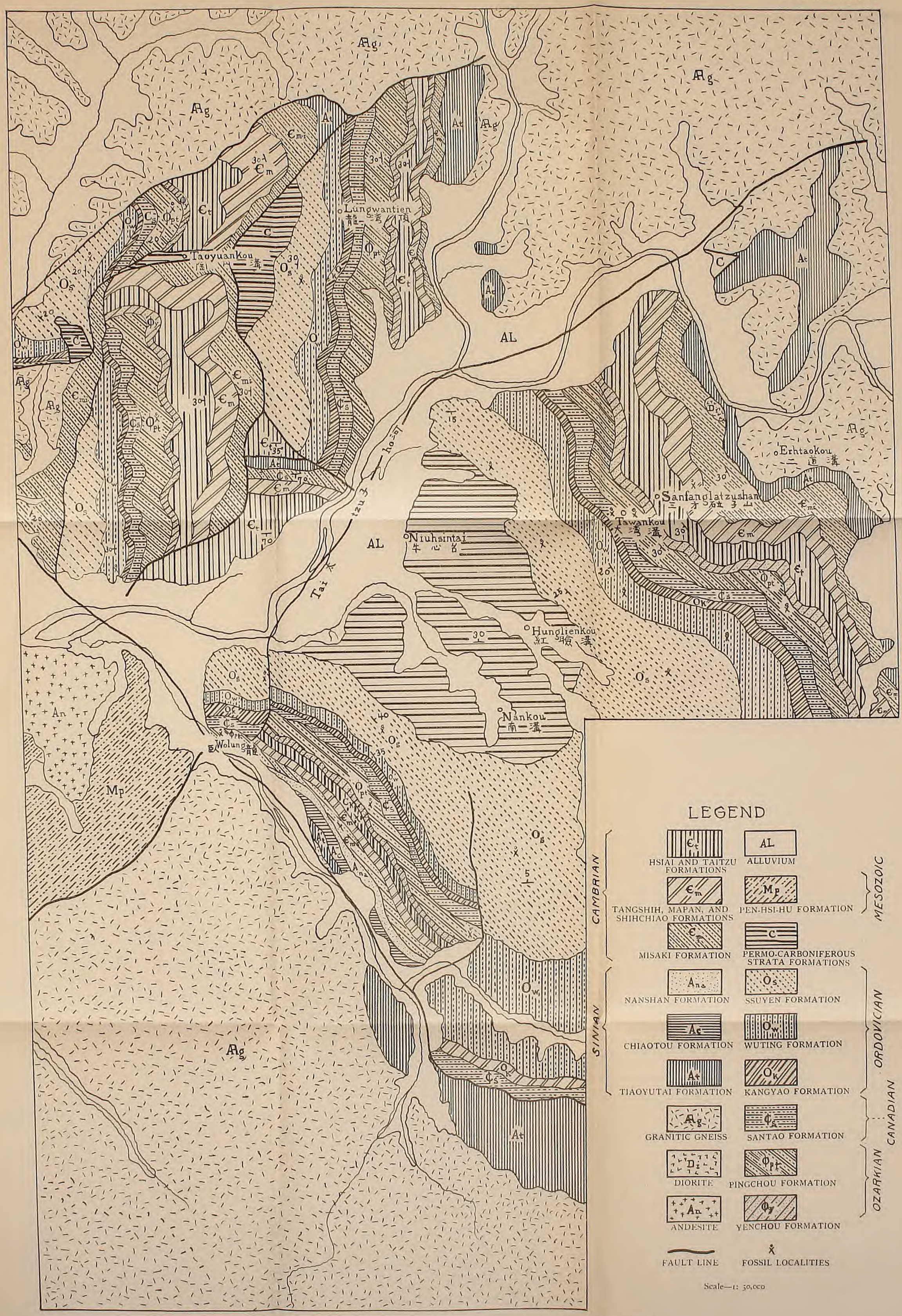


GEOLOGIC MAP OF THE WU-HU-TSUI AND CHIN-CHIA-CHENG-TZU SUBDISTRICTS

Scale 1: 50,000

GEOLOGIC MAP OF THE YEN-TAI AREA, TAI-TZU-HO DISTRICT

GEOLOGIC MAP OF THE PEN-HSI-HU AND CHIAO-TOU AREAS, TAI-TZU-HO DISTRICT



GEOLOGIC MAP OF THE NIU-HSIN-TAI AND TAO-YUAN-KOU AREAS, TAI-TZU-HO DISTRICT