Bulletin

OF THE

Geological Society of China

Vol. XV. March, 1936. No. 1.

CONTENTS

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Bulletin

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Geological Society of China

Vol. XV. March, 1936. No. 1.

THE GEOLOGICAL SOCIETY OF CHINA

Officers for 1936

C. C. Young (President) T. K. Huang (Secretary) K. L. Feng (Treasurer)

Councillors

(Term expires 1936)

J. S. Lee L. F. Yih A. W. Grabau

(Term expires 1937)

C. Y. Hsieh K. L. Feng Hsihchih Chang

(Term expires 1938)

C. C. Young W. H. Wong T. K. Huang

Executive Officers of the Peiping Branch

C. Y. Hsieh Y. H. King

Vol. XV. *No. 1*

PROCEEDINGS OF THE TWELFTH ANNUAL MEETING

HELD IN NANKING IN THE LECTURE HALL OF THE NATIONAL GEOLOGICAL SURVEY OF CHINA (JANUARY 26-29 1936)

Morning Session, Sunday, January 26.

Professor C. Y. Hsieh, in the chair.

(Owing to the prolonged illness of the President, Prof. L. F. Yin, the Society's Council decided to elect a board of chairmen each of whom was to preside at a particular meeting. The chairmen elected were Prof. C. Y. Hsieh, Mr. Y. Y. Lee, Dr. C. C. Young and Dr. Chang Hsihchih).

Opening the first meeting at 9:30, the chairman remarked that he was exceedingly glad to notice the presence of more than 70 members some of whom came from far distant provinces. This was all the more remarkable at a time when the general situation in China is so discouraging. Then he opened the memorial service for Dr. V. K. Ting who died on January 5th at Changsha as the result of an unfortunate accident occurred during his geological excursion in southern Hunan. He pointed out that Dr. Ting was not only the founder of the Society but also one of the founders of the Geological Survey and that his death is therefore deeply regreted by all geologists in China. As a sign of homage to Dr. Ting, the audience was called to stand up for a three minutes' silence. The chairman then called Dr. W. H. Wong to speak on Dr. Ting's contribution to the Society (See obituary note p. 17).

The chairman called Dr. T. K. Huang to speak on Dr. Ting's contribution to Chinese geology. Dr. Huang first briefly described Dr. Ting's expeditions in southwestern China and his numerous excursions in North and South China. He enumerated the important papers so far published by Dr. Ting, remarking sweepingly the character and significance of each contribution. Dr. Ting's work on Chinese stratigraphy, especially on the Silurian, Devonian, Carboniferous, Permian and Cenozoic systems, was emphasized.

As all of us know, Dr. Ting's field work was very extensive but his writing is comparatively scanty. It is therefore of great pleasure for us to hear that the Geological Survey has appointed Dr. T. H. Ying and Dr. T. K. Huang to take charge of Dr. Ting's copious field notes and manuscripts for the preparation of a memorial volume which will soon appear in the Survey's publications.

Report of the Secretary

The Society's new members:

Ordinary members 25 (of whom 9 were associate members whose promotion was passed by the Council).
Life members 18.
Associate members 16.

Deceased members:

V. K. Ting (Nanking)—Carter and Life.member
H. F. Osborn (New York)—Honorary member
B. Koto (Tokyo)—Corresponding member
D. White (Washington)—Corresponding member
T. K. Tsai (Peiping)

C. C. Young
Secretary

Report of the Treasurer

The treasurer begs to submit the following report of the finances of the Geological Society of China for the period from February 1st, 1935 to January 15, 1936.

Receipts (Feb. 1st, 1935-Jan. 15, 1936)

1.	Balance credit on January 31, 1935	$150.92
2.	Valueless bonds & bank notes	55.00
3.	Membership dues (92 members & 26 associates)	512.00
4.	Institution membership dues	
	(A) National Geol. Survey of China (1935)	600.00
	(B) National Research Institute of Geology, Academia Sinica (Jan-Dec. 1935)	360.00
	(C) Tsinghua University (1935)	200.00

	(D) National University of Peking (1934)	$ 400.00
5.	Bulletin sales	818.12
6.	Interest	6.09
	Total	$3,102.13

Expenditures (Feb. 1st, 1935-Jan. 15, 1936)

1.	Printing bulletin Vol. 13, No. 4 & Vol. 14, Nos. 1-3 (Vol. 13, No. 4 & Vol. 14, No. 3 paid partly)	$1,784.98
2.	Postage (mainly for mailing bulletin & reprints)	622.71
3.	Binding bulletin	11.00
4.	Fire insurance for books &.maps (1935) donated by Prof. A. W. Grabau	100.00
5.	Expenses for 11th Annual Meeting	51.65
6.	Expenses for cards & envelops	77.50
7.	Administration	100.36
	Total	$2,748.20

Total Expenditure	$2,748.20
Balance Credit	353.93
	$3,102.13
Cash on hand Jan. 15, 1936	$ 298.93
Valueless bonds & bank notes	55.00
	$ 353.93

S. C. Chien
Assistant Treasurer

Report on the Endowment Funds of the Geological Society of China

A. The permanent fund. (Including the fund for the library equipment, the Grabau medal fund & the life membershipdues).

Balance in December 1934	$8,616.00
Life membership dues (18 members for 1935) .	900.00
Interest in Jan. 10th, 1936	786.00
(Fixed deposit $10,100.00 & current deposit $202.00)	$10,302.00

B. 南京會所建築捐欵

I. 收入（捐欵收入至二十五年一月十七日爲止）

1.	汪卜桑先生捐	$ 2,000.00
2.	楊晤山先生捐	2,000.00
3.	竹莛生先生捐	1,000.00
4.	陳永清先生捐	1,000.00
5.	葉葵初先生捐	1,500.00
6.	丁文江，翁文灝，曾世英先生捐	2,500.00
7.	交通部捐	1,000.00
8.	中興煤鑛公司捐	3,000.00
9.	劉季辰先生捐	1,000.00
10.	國防設計委員會(資源委員會)捐	1,700.00
11.	上海寶豐保險公司捐	200.00
12.	棉業統制委員會捐	200.00
13.	中國旅行社捐	300.00
14.	上海銀行捐	500.00
15.	陳光甫先生捐	300.00
16.	李學清先生捐	500.00
17.	劉鴻生先生捐	1,500.00
18.	趙汝鈞先生捐	500.00
19.	開灤煤鑛公司捐	3,000.00
20.	孫科先生捐	1,000.00
21.	啓新洋灰公司捐	2,000.00
22.	二十三年銀行利息	1,229.00
23.	中央大學捐	1,000.00
24.	朱庭祜先生捐	500.00
25.	范旭東先生捐募	1,000.00
26.	實業部地質調查所捐	1,000.00
27.	鄧厚懷先生捐	500.00
28.	鐵道部捐	1,000.00
29.	沈棉亭先生捐	500.00
30.	李宗仁先生捐	3,000.00

31.	盧祖蔭先生捐		$ 200.00
32.	二十四年銀行利息		945.48
33.	丁文江先生捐		90.00
34.	中福兩公司聯合辦事處捐		500.00
			$38,164.48

II. 付出（付款至二十五年一月三十一日為止）

裕信公司建築費		$27,091.98
炳耀公司衛生設備暖汽工程		6,832.11
舊有草棚住戶遷移等費		584.00
監工費		40.00
基泰工程司設計費		500.00
華慶復電器公司工程		1,847.16
自來水裝置費		128.73
電燈接火費		4.00
電熱接火費		6.00
電話裝置費		20.00
押金: 自來水表	$ 55.00	
電燈表	30.00	
電熱表	100.00	
電話機	40.00	
		225.00
舖草皮		147.00
五金雜件		64.70
由北平匯京匯款匯水		30.00
美藝木器		469.00
		$ 37,989.68

總收入	$ 38,164.48
總付出	37,989.68
餘款	$ 174.80

It is to be added here that the Chao's memorial fellowship of this year (year 1935), amounting to 1,200 dollars, was awarded to Mr. Y. S. Chi (計榮森) of the Geological Survey of China. Mr. Chi is one of China's most promising young palæontologists; his skill and energy is amply testified by a number of papers and monographs already published by him. His works on the Weiningian corals of China and on the Lower Carboniferous Syringoporas are indispensable for researches on Carboniferous stratigraphy. He is now engaged in a comprehensive study of the Devonian coral fauna and will soon publish his results.

The investment and safekeeping of the Chao's memorial fund was entrusted to Mr. Y. S. Chu of the Peiping branch of the National Commercial Bank. The account for the year 1935 as reported by him is here included:

(一) 中國地質學會趙亞曾紀念研究金

民國二十四年一月一日至十二月三十一日止

賬目報告

收入：

二十四年	一月一日	結存現金	$2219.04
,,	一月七日	上海電力公司息	31.47
,,	一月七日	綏遠庫券本息	68.70
,,	一月十五日	美金債息	332.50
,,	二月二日	綏遠庫券本息	68.50
,,	三月二日	綏遠庫券本息	68.30
,,	四月一日	十四年公債息	15.00
,,	四月三日	綏遠庫券本息	68.10
,,	四月八日	上海電力公司息	31.47
,,	五月三日	綏遠庫券本息	67.90
,,	六月一日	上半年往來存欵利息	39.21
,,	六月三日	綏遠庫券本息	67.70
,,	六月五日	上海電力公司息	31.47
,,	六月八日	海河公債中籤退還本欵	4447.55
,,	六月廿九日	十四年公債息	15.00
,,	七月三日	綏遠庫券本息	67.50
,,	七月十六日	美金債息	39.81
,,	八月二日	綏遠庫券本息	67.30

二十四年九月二日	編遣庫券本息	$ 67.10
,, 九月三日	統稅庫券本息	93.20
,, 九月三十日	十四年公債期滿退還本欵	1015.00
,, 十月二日	編遣庫券本息	66.90
,, 十月二日	統稅庫券本息	92.90
,, 十月四日	定期存欵利息（一千元）	80.00
,, 十月七日	上海電力公司息	31.47
,, 十一月二日	編遣庫券本息	66.70
,, 十一月二日	統稅庫券本息	92.60
,, 十二月二日	下半年往來存欵利息	64.55
,, 十二月二日	編遣庫券本息	66.50
,, 十二月二日	統稅庫券本息	92.40
		$9575.84

支出:

二十四年九月三日 付購二十年統稅庫券票面一萬元本息票自五十一期起	$5025.02
二十四年九月二十五日 付計榮森君獎金	1200.00
結存	3350.80
	$9575.84

(二) 中國地質學會葛利普紀念研究金投資表

(二十四年十二月三十一日結)

十八年編遣庫券票面	壹萬圓
二十年統稅庫券票面	壹萬圓
美金公債 1925 年 5% 票面	捌百伍十圓
上海電力公司六釐優先股票	拾伍股
浙江興業銀行定期存欵	壹仟圓
四銀行儲蓄存欵	叁仟圓

Report of the Board of Editors

The Bulletin of the Geological Society continued to grow in size and in quality. It is a pleasure to note that members in the whole country recognize it as a publication representing all the institutions related with the geological work; and on that ground papers have been received from many different organizations. Such contribution is indeed sincerely welcome and we hope that it will be continued and even further increased in the future.

Dr. T. H. Yin could not help in the editorial as he was busily engaged in his field work in Yunnan province during the past year. The whole work was taken care of by Mr. T. H. Chow whose service to the Society in the long years past is indeed remarkably important and should be fully recognized by members of the Society.

W. H. Wong

Afternoon Session

Professor C. Y. Hsieh, in the chair.

The chairman opened the meeting at 2 p. m. The following communications were read:

1. The Lead-Zinc Deposits of Central Hunan. By C. Y. Hsieh.

2. On the Gemstones of Tushan, Nanyang, Honan. By H. T. Lee.

3. Igneous Rocks of the Hainan Island. By H. T. Lee.

4. Observations on the Taishan Complex. By K. L. Feng and C. Wang.

5. Notes on the Basalt-covered Gold Placer of Tangshan, Chishia, Shantung. By K. L. Feng.

The following paper was read by title:

6. The Rhodonite veins of Hsihutsun, Changping District, Hopei Province. By C. C. Wang. (The full paper is published in this bulletin.)

Morning Visits, Monday, January 27.

At 9 a. m. members of the Society gathered at the Society's new building, No. 21, Omeilu. Thanks to the untiring efforts of the late Dr. V. K. Ting, funds were quickly raised and a two-storyed building was erected in a quiet corner of the city, north of the picturesque Peichikuo hill. The edifice possesses a spacious lecture hall and a library, which evidently gave great satisfaction to all visitors present.

After the inspection of the Society's building, the congregation went to the Geological Institute of the Academia Sinica at Peichikuo. They were cordially received by members of the latter institution who showed them their laboratories, exhibition hall and library.

The congregation then paid a visit to the Geological Department of the National Central University, where they were shown the laboratories, exhibitions and class-rooms.

Afternoon Session

Mr. Y. Y. Lee, *in the chair.*

The chairman opened the meeting at 2 p. m. The following communications were submitted:

1. Discussion on the revised classification of the Palæozoic Systems in the light of the Pulsation Theory. Led by A. W. Grabau. Owing to the absence of Prof. Grabau, Mr. Y. S. Chi, acting on behalf of him, outlined the essential points of the pulsation theory and the need of a new nomenclature for the Palæozoic Systems in the light of that theory. The subject was enthusiastically discussed by Dr. W. H. Wong, Prof. C. Y. Hsieh, Dr. Hans Becker, Dr. T. K. Huang and others.

2. The Sinian Glaciation in the Lower Yangtze Valley. By Y. Y. Lee.

3. The Tremadocian in South Anhui. By Singwu C. Hsu.

4. Note sur la géologie du Woutaichan (Chansi). By Yang-Kieh.

5. Quelques problèmes sur la géologie du Hsichan (Peiping). 1. Discordance de la série du Kiulungchan sur les calcaires cambro-ordoviciens au Chengtzechan. 2. Volcanisme *antérieur de la série du Kiulungchan et postérieur* de la série du Hungmiaoling. By Yang-Kieh.

6. Deposits of Possible Loessial Origin in Western and Northwestern Szechuan. By James Thorp.

The following papers were read by title:

7. On the Sinian Geosynclines. By C. C. Chao.

8. On the Stratigraphy of Upper Huangho and Nanshan Regions. By C. C. Sun.

At 7:30 p. m. Mr. James Thorp, soil specialist of the Geological Survey, showed to a gathering of members and guests some interesting motion pictures taken by him in his journeys in varions parts of China.

Morning Session, Tuesday, January 28.

Dr. C. C. Young, in the chair.

The chairman opened the meeting at 9 a.m. The following communications were read:

1. Soils of Western and Southwestern China. By James Thorp.

2. Theoretical Reflections on the Geomorphology of China from the Viewpoint of Glacio-Eustatism. By J. Hanson-Lowe.

3. Chasmatosaurus from Sinkiang. By C. C. Young.

4. Notes on the Fangshan "Volcano". By Y. Y. Lee and T. Y. Yu.

5. Cenozoic Geology of Lingchu, Shantung. By C. C. Young.

6. Cenozoic Geology of Kaolan-Yungteng Area of Central Kansu. By C. C. Young and M. N. Bien.

7. Sinian Stratigraphy of the Yangtze Valley. By T. Y. Yu.

The following papers were read by title:

8. Ueber einen baumförmigen Lepidophyton-Rest in der Tiaomachien Serie in Hunan. By H. C. Sze.

9. On the Turtle Remains of Anyang. By M. N. Bien.

10. On the Preservation of Coloration in Certain Fossil-Invertebrata and its Geologic Significance. By S. Nomura and K, Hatai.

Afternoon Session

Dr. Chang Hsihchih, in the chair.

The chairman opened the meeting at 2 p. m. The following communications were read:

1. Discussion on the Mesozoic Stratigraphy of China. Led by Dr. Chang Hsihchih. Dr. Chang gave a brief summary of Mesozoic formations in China and made an attempt to correlate them. The subject was discussed by Dr. C. C. Young, Prof. C. Y. Hsieh and Prof. P. L. Yuan.

2. Mesozoic Stratigraphy of Sinkiang, with Latest Determination of Fossils. By P. L. Yuan.

3. Mesozoic Red Beds of Yunnan Province. By T. H. Yin and C. H. Lu.

Morning visit to the Geological Survey, Wednesday, January 29.

Early in the morning members of the Society gathered at the Geological Museum of the Geological Survey at Shuitsintai, Chukiang Road. They were cordially received by the staff of the Survey and made visits to the museum, the library and the laboratories.

Afternoon Session in the lecture-hall of the National Central University

Dr. C. C. Young, in the chair.

The chairman opened the meeting at 2 p. m. The following communications were read:

1. Discussion on the Late Mesozoic and Early Tertiary orogenesis, vulkanism and their relation to the formation of Metallic Deposits in China. Led by C. Y. Hsieh. In this dicussion Prof. Hsieh summarized the principal Mesozoic-Tertiary or Yenshanian orogenic movements in China and subdivided them into 5 phases. 4 major periods of igneous activity with extensive granitic intrusion and outpouring of lavas accompany these movements and are suppossed to be responsible for the wide-spread mineralization of South China. Prof. Hsieh further distinguished metallogenetic periods and metallogenetic provinces. The subject was discussed by Mr. H. J. Chu, Prof.

K. L. Feng, Mr. T. Y. Yu, Prof. P. L. Yuan, Dr. Chang Hsihchih, Mr. T. O. Chu and Dr. T. K. Huang.

2. Mineralization at Huangtzetung, Kiangninghsien, Kiangsu. By H. H. Cheng and C. Y. Yuan.

3. Paragenesis of the Iron Deposits at Tayeh, Hupeh. By H. H. Cheng and K. C. Tang.

4. Genesis of the Iron Ore at Hsishan and Leishan, O Cheng, Hupeh. By H. H. Cheng and K. C. Tang.

After the formal meeting the Geological Department of the Central University kindly served the members of the Society with tea and refreshments.

Geological Excursions, Thursday, January 30.

The Society conducted two successful excursions in the environs of Nanking:

1. Excursion to the iron ores of Fenghuangshan and Niushoushan with 19 excursionists guided by Prof. C. Y. Hsieh. & Mr. C. H. Yuan.

2. Excursion to Tangshan and Chungshan with 23 excursionists guided by Mr. C. Li and Mr. T. Y. Yu.

Minutes of the Council Meeting January 27, 1936

The newly elected members of the Council are:

W. H. Wong (re-elected)
C. C. Young (re-elected)
T. K. Huang (newly elected to succeed the deceased Dr. V. K. Ting)

Member list of the Council for 1935-1936:

C. C. Young, President for 1935-1936, term expires in 1938.
T. K. Huang, Secretary for 1935-1936, term expires in 1938.
K. L. Feng, Treasurer for 1935-1936, term expires in 1937.
W. H. Wong, Chief editor for 1935-1936, term expires in 1938.
Chang Hsihchih, term expires in 1937.

L. F. Yih, term expires in 1938.
J. S. Lee, term expires in 1936.
C. Y. Hsieh, term expires in 1937.
A. W. Grabau, term-expires in 1936.

(1) The Council passed the regulations governing Dr. Ting's Memorial Fund.

(2) The Council elected a committee in charge of Dr. Ting's Memorial Fund. The members of the committee are Mr. Chu Yao Shen (竹垚生), Mr. Sotsu King (金叔初), Dr. W. H. Wong (翁文灏), Dr. J. S. Lee (李四光), and Prof. C. Y. Hsieh (謝家榮).

(3) The Council elected Dr. T. K. Huang to succeed Dr. V. K. Ting on the Society's Permanent Fund Committee.

(4) The following new officers were elected for the board of editors: W. H. Wong (chief editor), C. Y. Hsieh, T. H. Yin, P. L. Yuan, C. H. Kao (assistant), C. K. Chao (assistant).

(5) The Council passed a resolution, granting the right to the Society's members in Peiping to form a branch society.

(6) Prof. C. Y. Hsieh proposed a Chinese publication for the Society, to be called "Ti Chih Luen Ping" (地質論評) and to appear every two months. This proposal was unanimously passed and the following board of editors was elected:

Chief editor for Ti Chih Luen Ping: C. Y. Hsieh
Editor for dynamic geology: H. C. Chang
" " stratigraphy: C. C. Tien
" " structural geology: J. S. Lee
" " petrology and mineralogy: H. T. Lee and K. L. Feng.
" " vertebrate palæontology: C. C. Young.
" " invertebrate palæontology: T. H. Yin
" " palæobotany: H. C. Sze.
" " economic geology: H. M. Meng
" " physiography: P. L. Yuan

(7) The work for the bibliography of Chinese geology, began by Mr. T. Y. Yang, is to be continued by Mr. Y. S. Chi.

(8) Messrs. S. C. Chien and Y. C. Chi are re-elected assistant treasurer and assistant secretary respectively.

Principles Governing the Memorial Fund for Dr. V. K. Ting

1. A permanent fund will be constituted through the donations from friends of the late Dr. V. K. Ting. This fund shall be administered by a special committee of 5 to 7 members to be elected by the Council of the Geological Society. Any vacancy among the members of the committee shall be filled in by a new member to be proposed by the members remaining in office and approved by the Council.

2. Only the interest of the fund can be used. An amount up to $1000 a year is to be presented to Mrs. V. K. Ting.

3. Besides the amount presented to Mrs. V. K. Ting the remaining part of the interest shall be used as a geological fellowship to be awarded yearly to one Chinese geologist who has made important contribution. The detailed regulations for the award will be made by the Council.

丁在君先生紀念基金原則

一・本基金由丁先生至好友人捐助於中國地質學會由該會理事會推舉五人至七人組織保管委員會保管之委員如出缺時由其餘委員推舉請理事會核定

二・本基金應長久保存但所得利息至多以每年一千元爲限送備丁在君夫人之用

三・除第二條規定之用途外所有利息作爲紀念獎金對於地質工作有特別貢獻者每年發給一次其詳細辦法由理事會另訂之

The Society's Permanent Fund

It is a pleasure to announce the establishment of the Society's permanent fund, consisting of a generous donation from the Chekiang Law College of

Hangchow. Through the efforts of Dr. V. K. Ting and Dr. W. H. Wong, representing the Society, and of Mr. Chen Shu-tung, representing the College, the amount of $64,961.75 plus a bond of $1,000.00 was transferred to the Society and is deposited in the National Commerical Bank at Shanghai through Mr. Y. S. Chu. A committee, named the Society'e Permanent Fund Committee, was elected by the Council for the safekeeping of the fund. The members elected were Messrs. V. K. Ting, (丁文江), W. H. Wong (翁文灝), S. L. Hsu (徐新六), T. S. Chang (張篤生) and Y. S. Chu (竹垚生). After the death of Dr. Ting the Council elected Dr. T. K. Huang (黃汲清) to succeed him on the Committee.

中國地質學會台鑒敬啓者浙江私立法政學校自停辦後設有財產管理委員會截至二十四年十一月二十三日止計存浙江興業銀行定期存款陸萬肆千捌百元活儲存款壹百肆拾捌元貳角肆分共計國幣陸萬肆千玖百肆拾捌元貳角肆分又二十年統稅庫券原票面壹千元本息伍肆號起敝會同人共同商議夙仰
貴會為專家學術團體不受任何干涉成績昭著議決前載款項捐作
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二十四年十一月二十七日

抄錄浙江興業銀行上海總行信託部保管戶清單

帳號 4116 戶名: 中國地質學會基金保管委員會 中華民國 24 年 11 月 30 日

年 月 日	摘	要	收 數	付 數
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因丁先生病故經理事會推定黃汲清君繼任.

Dr. V. K. Ting
(1887-1936)

OBITUARY NOTE

V. K. TING, SCIENTIST AND PATRIOT

By W. H. Wong

In the lamented death of Dr. V. K. Ting on January 5th, 1936, at the age of 49, China suffered an irredeemable loss. He may be called the founder of the science of geology in China, and it was in geological field work that his contribution was especially great. After his graduation from the University of Glasgow he made his way back from Europe to China in 1912 by terminating his voyage at an overland journey through Yunnan, and finished his trip by making a travel which was highly characteristic of the man. After entering service in the Ministry of Agriculture and Commerce in 1913 he at once set out to do geological field work in full zeal. Both during his incumbency as Director of the Geological Survey from 1913 to 1921 and as Professor of Geology at the National University, Dr. Ting inculcated the spirit of field investigation into the minds of younger geologists by personally conducting the expeditions. He firmly insisted that every student in his course should take part in field work. In the preface Dr. Ting wrote for the first issue of the Bulletin of the Geological Survey of China, which was published in 1919, he quoted the words of Baron F. von Richthofen as saying that Chinese scholars enjoyed sedentary employment of life and detested the rigor of physical exertion such as mountain climbing, and that though other sciences might be developed in China in future, the prospect of founding a flourishing geological science was decidedly dark. Richthofen's fear, however was quickly proved to be quite unnecessary when Dr. Ting presented to the nation the fruitful field investigations of the Chinese geologists under his leadership.

From the autumn of 1933 to the time of his death, Dr. Ting was Secretary General of the Academia Sinica. During the two years of untiring service, he developed the Academia mainly along two lines. Firstly, he gave an added impetus to research work by recruiting more competent men to the research staff and by personally giving proper orientations to the main departments of inquiry, and secondly, he required all the Research Institutes within the

Academy to exercise strict economy, so that more work was done at less expense. The organization of the National Research Council, which fulfilled a long felt need, was also accomplished during his tenure of office. All these testify not only Dr. Ting's rich store of vital energy, but also his comprehensive technical knowledge and experience. It certainly will be a difficult task for the Academy to fill the vacancy occasioned by his untimely death.

Dr. Ting's knowledge was not by any means limited to the field of geology and geography. He personally made many measurements on the cephalic index of the native tribes of the southwestern provinces of China, and the anthropological data of the Chinese races which he possessed are extremely rich. Once he wrote a textbook on zoology, and feeling the need of a good textbook on Chinese History, he started to make plans for compiling one. His field of inquiry was very comprehensive indeed. Besides being a distinguished scientist, Dr. Ting was also an able man of practical organization. As Managing Director of the Peipiao Coal Mining Co., Tientsin, during the period of 1922-1925, he brought the efficiency of coal production to a standard of the highest order in the country.

During the few months in 1926 while he was in office as Associate Director of the Shanghai and Woosung Port Administration, he established local Court under Chinese administration, created the Public Health Department, and laid the foundation for the project of Greater Shanghai. Of problems pertaining to mining, transportation and military affairs of China, he had a firm grasp and a deep insight. His were not the ideals of impracticable visionaries, but sane and feasible ideas of a practical man.

Dr. Ting also took great interest in political affairs of the country. Unfortunately, he was too much a patriot to play politics for its own sake, and was on that account often much misunderstood by his own country men. The distress he experienced was especially great during recent years, when he saw the imminent danger of dismemberment and disruption of the Chinese nation. Even though always busily engaged in the task he had on hand, he never lost sight of the salvation his country had yet to work out and the mission his race was to fulfill. The writer often had occasion to hear his talks to the young men, in which he urged them to work conscientiously, to contribute whatever they were good for, and to live lives of devoted service. He said that if we could not save China from destruction, at least we could so harden the fibre of the Chinese race as to make it imperishable. He deplored the lack of character in the rank and file of the Chinese political circles and regretted much that something could not be done about it. "Dr. V. K. Ting, a True patriot", as the North China Daily News (Jan. 7, 1936) called him, was indeed a becoming epitaph.

Dr. Ting travelled quite extensively, and his comprehensive knowledge about the geology, geography and anthropology of Yunnan, Kweichow, and Kuangsi provinces was unparalleled in the country. His published works, such as *Fifty years of Mining in China*, *Geology of the Yangtze Delta* etc., although already important, are but a small part of all his scientific material which is worth publishing. His friends are now planning to edit his writings in manuscripts or field notes and publish them posthumously, but how keenly they feel the absence of Dr. Ting's sure and critical advice,—if they were only able to do it under his own supervision! He left so many works unfinished for the simple reason that he was very cautious in his scientific writing. He would not put anything down on black and white until a problem was thoroughly thrashed out. He also took meticulous care of his map whether it be geological or topographic. In an age when men of science in China are apt to aim at mere quantitative production regardless of qualities, Dr. Ting's caution in scientific writing should act as a wholesome corrective.

Dr. Ting was one of the most enthusiastic workers for the Geological Society. He took great care in editing Vol. X of the Bulletin in honor of Dr. Grabau. He proposed the building of a new house in Nanking for the Society at the cost of over thirty thousand dollars obtained from donations. That building contains a fine library hall in which all the geological books and journals of Dr. Ting are now stored; they have been generously presented to the Society by Dr. Ting. He has also secured the donation to the Society of all the geological and palæontological literature of Dr. Grabau.

Dr. Ting not only did pioneer work in Chinese geology, but also spared no effort in discovering promising first rate geologists among his younger contemporaries. Memory is still fresh as to how he strongly recommended Dr. J. S. Lee to fill the chair of geology in the National Peking University, how he made it possible for the late Y. T. Chao and his party to accomplish the geological survey of the southwestern provinces of China, and how he wisely insisted that students sent abroad should devote his whole energy to the study of fundamental subjects instead of dissipating it by writing half-baked essays on Chinese geology. He was a good judge of men, and readily appreciated the good qualities in his friends and associates.

Towards the younger generation as towards his friends, Dr. Ting was very candid. When he sincerely believed that a person was in the wrong, he did not hesitate to tell him. And yet, or shall I say, it was on that account that he was much beloved by everybody who had come into contact with him.

Dr. Ting left no children, but his spiritual off springs are many. The torch kindled by Dr. Ting's spark of genius and left burning, they will carry on.

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REVISED CLASSIFICATION OF THE PALÆOZOIC SYSTEMS IN THE LIGHT OF THE PULSATION THEORY

By A. W. Grabau

(Geological Department, National University of Peking, Peiping)

The Chronological classification of the rocks of the Earth's crust began in the 18th century when John Strachey in England, Giovanni Arduino in Italy and Lehman, Füchsel, and Werner in Germany began their subdivision on the lithological and structural basis.

With the beginning of the 18th century Cuvier and Brongniart and Lamarck in France, and William Smith in England, recognized the importance of fossils in the classification of the geological formations, and this has been the primary basis of classification ever since.

Every student of geology is familiar with the history of the establishment of the larger geological systems and the splitting of the older comprehensive divisions into the smaller and more compact systems which we recognize today. The successive splitting off from the old Silurian system of Murchison, first of the Cambrian, then of the Ordovician as distinct systems is well known, as is also the prolonged and often virulent opposition which impeded the process. Even now, some German text-books use "Untersilur" in the Murchisonian sense, while most of the conservatives still cling to the old Carboniferous group, in which both Dinantian or Mississippian and Permian were included.

So long as the basis of subdivision remained primarily a palæontological one, and stratigraphers were concerned with the progress of life rather than with the physical development of the lithosphere, there was little need for a more detailed subdivision, and the discussions regarding the boundaries of individual systems were primarily of a polemic nature.

Thus, when formations intervening between those containing the regular faunas of the systems were discovered, the question of referring them to the lower system as an upper member, or to the higher one as a lower member became the chief concern of the geologist and the question of historic priority in the establishment of a limit of a system was not infrequently invoked.

The three-fold sub-division of each of the older systems into a lower, middle and upper series, was given a theoretic background by H. S. Willians who regarded them as expressions of the Eo-, Meso—and Neo- time epochs, representing the rise, acme and decline of the successive faunas and floras. He thus gave stratigraphic expression to the doctrine of continuity and uniformity of organic evolution, as opposed to the olo doctrine of catastrophism and the successive creations of new faunas after the extinction of the older, which formed the pivotal point of the Cuvierian school.

The insistence of Chamberlain on the diastrophic basic of classification and the gradual penetration of the physiographic view-point of the Davis and Penck schools, and the insistence of Walther and others on the importance of lithogenesis, turned the attention of stratigraphers to the problems of sedimentation and the importance of disconformities, in the study of earth history. The immediate result was the development of the Ulrich—Schuchert—Ruedemann doctrine of successive independent marine invasions of the continents, with its many local sedimentation basins and barriers, a doctrine which ultimately crystallized into the oscillation theory of Haarmann.

This was perhaps a logical consequence of the persistence of the belief in the permanence of continents and ocean basins, which permitted the treatment of each continent as a separate unit, subject to independent epeirogenic movements and orogenic processes, or to the alternating tiltings of the seesaw type, or the staggering process, which has been compared to the uncontrolled move ments of a derelict in a storm at sea.

Such concepts necessarily demand a return to the palæontological evidence as the primary basis of classification. For oscillatory movements, and the development of independent seas and barriers, do not permit the use of transgressive and regressive movements to serve a function in primary classification.

CLASSIFICATION ON THE BASIS OF PULSATION

If we can establish the fact that the major transgressions and regression of the sea, have taken place simultaneously in the geosynclines of all the continental blocks, and that local elevations and depressions merely have a modifying influence, we must of course appeal to the periodic rise and fall of the sea-level as a whole, to produce simultaneous effects upon separate continents or of a Pangæa as well. In the latter case, however, with a more of less medially situated pole, the effects of periodic increase followed by decrease, in the rate of rotation, with its accompanying increasing or decreasing equatorward flow of the waters, would produce similar regressions and transgressions. In either case, the effect is a pulsatory one and except where locally modified would effect all the geosynclines.

It is of course presupposed, that each geosyncline is joined to a shallow Epi-sea which would be the source of the invading faunas, as well as the asylum, permitting the continuance of the survivors of the wide-spread extermination which is consequent upon the withdrawal of the seas from the geosysclines. These survivors in turn would form the stock from which the new faunas in the succeeding transgression would develop.

According to the number of such distinctive Epi-seas, the faunas of the dependent geosynclines would be distinctive in each period, subject to the modification due to the confluence, within the same geosyncline, of the invasions from distinct centers. Only pelagic faunas would be able to bridge the deep water gap between adjoining or even distant Epi-seas, and thus become independent invaders.

If Pulsation is the primary cause for the development and spread of successive marine faunas, followed by their decline and disappearance except in the asylums of the Epi-seas, it becomes evident that a two-fold division of our systems is the normal one. We should recognize in each case a lower or transgressive series or positive epoch, during which transgression permits expansive evolution and wide migration of the faunas, and an upper or retreatal series characterizing the negative epoch of pulsation, during which there is progressive restriction of the occupational habitat, with a concomitant extermination of the least fit and the decline of the fauna as a whole. To this should be added the emergent deposits of the continental type, including volcanics and pyro-clastics, and the emergent phenomena of erosion and deformation. Such interpulsation products would of course be subject to more or less reworking during the succeeding transgression, and to the extent of such reworking would become incorporated in the transgressive series of the next pulsation.

It should be evident that such a classification is a far more normal and logical one, taking account not only of world-wide phenomena, but furnishing a logical basis for the development and decline, and in some cases almost complete disappearance of the fauna of each pulsation system.

Application of the Principle to the Palæozoic Rocks

With the application of this principle to the classification of the Palæozoic formations, the number of distinctive systems will of course equal that of the separate pulsations, and it becomes evident that the old terminology is no longer applicable as a whole.

The old systemic names must either be restricted and new terms applied to the pulsation systems separated from them, or an entirely new nomenclature be developed, with a distinctive term for each of the pulsation systems. I prefer the former method as the least likely to cause confusion and because it is a procedure in line with the historic method of the development of our systemic classification.

In the delimitation of the pulsation systems, the physical evidence of transgression with progressive over-lap and retreat with progressive off-lap, as well as interpulsation phenomena and deposits are used on the one hand, and on the other the evidence of faunal expansion and migration, followed by restriction and decline, with ultimate disappearance of distinctive types characteristic of the expansional phase of the system.

The application of these criteria requires either the union of the lower and middle or the middle and upper members, into the restricted pulsation system and the union of the discarded upper or lower portion of the old system with the adjoining lower part of the succeeding or upper part of the preceding old system, into a new pulsation system. Or in a few cases, it may require the erection of one or more of the old triple series into a distinctive pulsation system. This latter is the method required for both the old Lower and Middle Cambrian, while the old Upper Cambrian naturally falls with the old Lower Ordovician into the distinctive Cambrovician system.

THE PALÆOZOIC PULSATION SYSTEMS IN DETAIL

I. THE TACONIAN PULSATION SYSTEM

This is the first marine system of the Palæozoic[1] and is the Lower Cambrian of the old classification. I use this term, first proposed by Ebenezer Emmons, because the folded rocks of the Taconic mountain region on the New York-Massachusetts border and its northward extension into Vermont, are the longest known and include the locality from which the first fossils of the *Olenellus* faunas have been obtained.

Moreover, the formations now referred to the Lower Cambrian in the Type sections of North Wales *i.e.* the Cambrian Mountains, are almost without exception unfossiliferous and of the continental type.

If the term Taconian is applied to this first Pulsation system, wherever it occurs, local names may be used for the development of this system in the different geosynclines. Thus, in the northern Appalachian or St. Lawrence geosyncline, the name *Labradoran system,* proposed by Schuchert and Dunbar may be applied and this may be extended to cover all the Taconian development, characterized by the *Olenellus* fauna. In like manner, the Taconian (old Lower Cambrian) of the Atlantic province or Caledonian geosyncline may be designated by Mathew's term *Etcheminian,* applicable wherever the Taconian strata carry a *Holmia-Callavia* fauna.

This would leave the Taconian (old Lower Cambrian) of the Indo-Chinese geosyncline, without a distinctive name, though as is well-known it carries the distinctive *Redlichia* fauna, with practically none or only pelagic elements in common with the others. Such a distinctive name (*which it is hoped this conference will supply*) will greatly facilitate ready reference.

II. THE CAMBRIAN (SENS STRICT.) PULSATION SYSTEM

I would restrict this term to the wide-spread Middle Cambrian of the old classification which is the first of the truly fossiliferous marine forma-

1 As is well known, I do not regard this as the beginning of the Palæozoic for I include the Sinian (= Beltian = Grönlandian = Algonkian in the restricted sense) as an earlier system of the Palæozoic but one of purely continental character.

tions of the Cambrian Mountains of North Wales. As already noted, this term cannot be applied to the Upper Cambrian of the old classification, since that is only a part of the transgressive division of the Cambrovician pulsation.

The most typical development of this phase of the restricted Cambrian is in the Caledonian geosyncline to which the Atlantic coast sections of Eastern North America belong, and for this development the name Acadian has become widely recongnized and firmly established. It is this phase to which the *Paradoxides* fauna is restricted. But in my belief the Cambrian (*sens. strict*) of the St. Lawrence geosyncline forms merely an extension, and to the development there too, the name Acadian is applicable.

It is different however, when we come to either the southern Appalachian geosyncline, with its extension over the Mississippian marginal plain, or to the Palæo Cordilleran geosyncline of Western North America. It is in the latter that the Cambrian (old Middle Cambrian) has its greatest development, and it is to this that the name Albertan system, which I originally suggested for the entire Old Middle Cambrian should be restricted. Owing to the fact that a part of the fauna of the Albertan of the Palæo-Cordilleran geosyncline is derived from the same source, the *Crepicephalus* Epi-sea, as that of the southern Appalachians and its Mississippian extensions, the name Albertan might also be applied to the Cambrian of that region. And this is likewise true of the Cambrian (Old Middle Cambrian) of the Andean geosyncline in South America.

Finally the Cambrian, (Old Middle Cambrian) of the Indo-Chinese geosyncline remains without a general systemic name applicable to it alone, and here again the present conference may supply the need.

III. THE CAMBROVICIAN PULSATION SYSTEM

I have proposed this term to include the Upper Cambrian and Lower Ordovician of current usage, these forming a complete pulsation unit. The transgressive phase occupied the whole of the Upper Cambrian and the Tremadoc as well, while the retreatal phase is represented by the Lower Ordovician or Canadian, that is the Beekmantown of American usage and the Arenig of the British succession.

In the Caledonian geosyncline, the Upper Cambrian is characterized by the *Olenus-Parabolina* fauna which especially characterizes the Lower or

Maentwrog division and the Upper or Dolgelly, while the intermediate or Ffestiniog of the Welsh section represents local interruption of the transgression, and the spread of continental deposits. This has been fully discussed in Vol. II, of my "Palæozoic Formations in the Light of the Pulsation Theory".

The Dolgelly and Tremadoc represent continuous transgression, the Upper Dolgelly passing without modification into the Lower Tremadoc.

There is, however, an indication of a local disconformity between the Upper Tremadoc and the Arenig in the region bordering the Old Land, but this appears to be primarily a phase of the reversal of movement from transgression to regression, no doubt accompanied by elevation of the Old Land and the consequent increase of terrigenous doposits, and the formation of river-plain deposits of the Huangho type. (See Vol. II Palæozoic formations, etc Chapter II).

The Huangho type of deposit characterizes much of the western part of the Caledonian geosyncline and it is in this portion that the Arenig graptolites are most typically developed. The same thing is true of the St. Lawrence geosyncline, which appears to be largely distinct from the southern Appalachian because of the non-submergence of the Albany axis. The apparent sudden appearance of the Axinolopus Graptozoa in the Arenig-Deepkill rocks is not to be explained on the basis of marine transgression, since the character of the strata themselves are indicative of retreatal condition except in so far as local oscillations occur. They represent rather a faunal invasion of the slowly retreating sea and the stranding of the floating graptolites on the coastal-portion of the river plain series, subject to momentary flooding or marining. That the graptolites do not represent a newly developed biological type in the Arenig, is not only indicated by the marked advance in their development when they first appear, but also by the presence, locally (Mississippi Valley region) of graptolites in Cambrian strata.

Their abrupt appearance indicates either that the center of origin became confluent with the geosynclines, during the period of maximum transgression in Tremadoc time, and remained open throughout the Arenig, or that the planktonic mode of life of these organisms was not generally assumed until the end of Upper Cambrian time.

The more normal marine brachiopod, mulluscan and trilobite faunas, characteristic of the calcareous development of the Lower Ordovician, challenges attention in this connection.

In the Caledonian geosyncline, its chief expression is the *Megalaspis* fauna with *M. limbata* and *M. planilimbata* as the leading types and though the exact source of this fauna is at present unknown, it undoubtedly represents modification types of the fauna that spread in the geosyncline at the period of maximum transgression. The physical evidence for the retreating sea and off-lapping deposits is well shown in the formations of the Baltic region.

That the Beekmantown fauna of the St. Lawrence geosyncline and the similar fauna of the North Cathaysian geosyncline, has a distinctive source, probably in the present Arctic region, seems evident. But the precise delimitation of the transgressive and regressive portions is still a matter under discussion. It may be that the lower part of the Beekmantown is a part of the transgressive series, the retreatal series being represented primarily by the Fort Cassin division.[1]

The similarity of the graptolites in the St. Lawrence and Caledonian geosynclines need not argue against the disconnected character of these geosynclines, since the assumption of a pelagic habitat by the graptolites made possible their entrance into any of the geosynclines.

The Southern Appalachian geosyncline, together with its extension over the marginal plain of Mississippia, was invaded by waters from a distinct source of faunal evolution, as was the case in Middle Cambrian time. The distinctness of this later fauna is so pronounced that it has been regarded as representing that of a separate system, between the Upper Cambrian and Lower Ordovician, i.e. the *Ozarkian* of Ulrich. The uniqueness of the fauna is conceded, but I maintain, in common with many others, that it represents the transgression of the Upper Cambrian Sea from a source in which the distinctive Ozarkian elements have developed, and which for the most part remained isolated from the other Cambrian geosynclines, though the Palæo-Cordilleran geosyncline, seems also to have suffered its influence.

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1 For details see "Palæozoic Formations etc." Vol. II Chapter XIII to XV. Text-figs 27 and 28.

It is, however, the retreatal phase of the pulsation in this geosyncline that is most significant, since it so pronouncedly emphasizes the off-lap of the strata and the spreading over the exposed surface of the continental St. Peter sands.

The term Canadian or even Beekmantown has been very commonly applied to this retreatal Lower Ordovician Series, even though it lacks the distinctive Beekmantown fauna, except in so far as this has transgressed the barrier of the Albany axis, during the period of maximum expansion. It is therefore desirable, that a distinctive name be applied to this series, since its fauna is primarily a declinatory modification of the previously wide-spread Ozarkian fauna i.e. a derivation of the distinctive Upper Cambrian fauna, derived from the Ozarkian Epi-sea. (The name *Shenandoan* is used for it in Vol. III).

Finally, it must be considered that the source of the Cambrovician fauna of the Palæo-Cordilleran geosyncline; is a double one, partly the Ozarkian Epi-Sea on the south and the Boreal Sea on the north. Thus, certain elements characterizing the southern Appalachian formations and others characteristic of the St. Lawrence geosyncline, would here be commingled.

More difficult of analysis, is the Cambrovician fauna of the Indo-Cathaysian geosyncline, south of the Nanking axis. It is true that there are certain Ozarkian elements in the Upper Cambrian series, which show a littoral connection between the respective Epi-Seas. This can be explained in a Pangæa, either by migration along the newly developed continental shelf, or through the Andean geosyncline. Unfortunately however, the Tremadoc and Lower Ordovician faunas and formations of southern Asia are still largely unknown; and their relationship must be left unconsidered for the present.

IV. THE ORDOVICIAN PULSATION SYSTEM

With the separation of the Lower Ordovician and its union with the Upper Cambrian into the *Cambrovician System*, the remainder of the old Ordovician system, that is the Middle and the Upper, will constitute the New Ordovician Pulsation System.

The facts indicating the transgressive character of the Chazyan in America, the Llandeilan in Western Europe, the Machiakouan in North China and the Orthoceras limestone Series in South China and central Europe are well known. There remains the desirability of a distinctive term to cover all the members of this transgressive series in South China, since neither Llandeilo nor the American terms will serve. The similarity between the transgression, in the St. Lawrence geosyncline and that in the northern Cathaysian geosyncline is very marked, both beginning with *Maclurites* Beds in the earlier part and ending with the *Actinoceras* limestone Series, the Black River Formation of North America.

In the southern Appalachians and marginal plain of Mississippia, the Stones River group is the Chazy equivalent.

The retreatal series or Upper Ordovician in both the old and the new sense, is indicated in eastern North America, by the progressive replacement of the normal marine Trenton limestone, first by the graptolite shales of the Utica and still farther east, the Huangho deposits of the Snake Hill, or the Canajoharie and Schenectady beds and progressively by higher clastic deposits, which terminate in the red beds of the Queenston Series.

The last of the marine beds of the restreatal series find a lingering representation in the beds of the Cincinnati group in the central U. S. A.

To what extent these retreatal beds are preserved in South China other than the *Chasmops* limestone of Yunnan, remains to be determined; but from our present knowledge, we should consider that much of what had been left was eroded again during the Ordovician-Silurian inter-pulsation period of emergence.

To what extent the Caradoc-Bala Series of Great Britain is to be referred to the transgressive and how much belongs to the retreatal series is still a matter for investigation, but the Ashgillian Series, which follows it with a hiatus, most probably marks the beginning of the renewed Silurian transgression. This is also the case with the Wufeng graptolite shales of the Yangtze Valley, the lower portion of the old Lungma shales of Lee. And some American stratigraphers hold that the Richmond series is likewise to be classed as the basal portion of the transgressing Lower Silurian Sea.

V. THE SILURIAN PULSATION SYSTEM

The system, as originally defined by Murchison(his Upper Silurian), included the beds from the transgressing basal Mayhill sandstone of Shropshire or the Llandovery Series of South Wales, to the Upper Ludlow shales. The succeeding Ledbury shales, Downton-Castle sandstone and Tilestones, which have since been added to the Upper Silurian, were originally referred by Murchison to the base of the Old Red Sandstone. The older accepted classification is into the Lower or Llandovery Group, the Middle or Wenlock Group, and the Upper or Ludlow Group, of which the Downton sandstone forms the terminal member. More recently, however, the division has been renamed; the lower or Valentian, or the so-called Pentamerus series, which includes both the Llandovery sandstone and Tarranon shale; the Middle or Salopian, which includes the Wenlock shales and limestones, and the Lower Ludlow shale and Aymestry limestone; and the Upper or Downtonian comprising the Upper Ludlow shale and Downton sandstone. The latter has more recently been referred by some British geologists to the Lower Devonian.

The inclusion of the Lower Ludlow shale with the preceding Wenlock limestone and underlying shale in one series seems justifiable, and it would appear to represent the retreatal deposits of the Silurian transgression, which has reached its maximum in the period of the Wenlock limestone formation.

If this is correct, it would appear that the whole of the preceding series, from the Llandovery or Mayhill sandstone to the Wenlock Limestone, forms a single transgressive series, punctuated, no doubt, by some local oscillations.

If I am correct in considering that the Lower Ludlow shale represents the retreatal series of this typical Silurian Pulsation system, the Upper Ludlow and succeeding beds must be separated as a distinct system. The question then arises: Is the Aymestry Limestone an oscillation phase of the retreatal Silurian series or does it represent the transgressive phase of the succeeding Siluronian pulsation?

In America, the classification of the Silurian system, has generally been along similar lines, the Medina-Clinton Series being made the Lower, essentially equivalent to the Valentian, the Rochester shale and Lockport limestone and Guelph dolomite forming the Middle, while the remainder, beginning with the Salina and ending with the Manlius have been referred to the Upper.

Here again, we have a complete transgressive phase in the series, terminating with Lockport limestone, which marks its maximum, and a retreatal phase in the Guelph dolomite with its essential continental equivalent the Schawangunk grit. This is followed by the continental Salina salt- and gypsum-bearing beds, which represents a typical emergent continental inter-pulsation deposit of the Silurian, and therefore should be classed as the Upper Silurian Pulsation series in the revised sense.

In the Baltic region, the Lower Gotlandian series is a distinct unit, terminated by emergent sandstones which in South Gotland show eolian structure, while in the Visby region the beds also show gentle deformation and erosion, with the succeeding Upper Gotlandian resting upon them with a light unconformity.

In South China, the Silurian transgression is represented by the Sintan Shale series, while the evidence of regression is furnished by the terminal sandstone into which these beds merge. The fauna shows a commingling of Boreal types with those of Indo-Cathaysian origin.

VI. THE SILURONIAN PULSATION SYSTEM

I have proposed this name for the new system composed of the old Upper Silurian, a transgressive series and the old Lower Devonian as a retreatal series, the two together forming a complete Pulsation System. The two series are well represented in America, where the Monroe Formation of Michigan and its eastward extension, the Cobleskill and Manlius, together with, in my opinion, the Keyser limestone of southern Appalachians, forms a transgressive series, while the Helderbergian forms the retreatal series so far as preserved.

The chief puzzling element is the Sylvania sandstone, the remarkable ancient sanddune deposits which divides the Lower and Upper Monroe Group. Some would draw the Siluro-Devonian boundary at this sandstone, but the evidence at hand points rather to oscillation, as the true explanation of its occurrence, between the successive advances of the sea, first from the south, then from the north.[1]

The Upper Monroan, which may include retreatal deposits, is followed by evidence of prolonged emergence, with erosion and the final spreading of eolian quartz grains over the erosion surface. In like manner the Helderbergian Series of the Appalachian geosyncline, was followed by a period of emergence

1 · This refers to present compass directions.

with erosion and the spreading of elastic material, including great thicknesses of eolian sands of well-rounded and pure quartz grains. This now constitutes the Oriskany sandstone, for although it represents an interpulsation emergent continental deposit, it was subsequently reworked by the transgressing Devonian (Middle Devonian old sense) Sea and incorporated as a basal sandstone, with a typical Devonian fauna. Hence the Oriskany sandstone and its faunal equivalent elsewhere are to be classed as basal Devonian (basal Middle Devonian, in the older terminology) rather than with the Upper Siluronian—that is—the old Lower Devonian, to which it has usually been referred.

The Siluronian of South China, is represented by the Malung Group of Yunnan, and especially the *Spirifer tingi* beds, as a transgressive Series and the Mientien regressive series, which is characterized by the predominance of sandstones with *Modiolopsis*, beds with *Leperditia*, red sandstones with abundance of fragmentary fish remains, and sandstones with *Cephalaspis yunnanense*. These beds must therefore be classed as Lower Devonian in the old sense and they are followed by the continental Lunghuashan Formation, with *Arthrostigma*.

The Ludlow and Downton Beds form the Siluronian of Britain, the latter primarily the emergent Huangho Series, with Eurypterids and fish remains. A problem for future solution is whether the Aymestry limestone represents the transgressive series. Its distinctness is suggested by the plicated pentameroids, although there are still some forms suggestive of the Silurian-Pulsation system reported from it. The beds with similar plicated pentameroids, described from the Ural and Altai Region, and referred originally to the Silurian, but subsequently placed in the Lower Devonian (old system), apparently also represent the transgressive series of the Siluronian and therefore the Upper Silurian or Upper Gotlandian i.e. Monroan phase.

The Konjepruss Formation of Bohemia also belongs here, though it may represent a lingering phase of the retreatal series, i.e. the old Lower Devonian to which it is generally referred.

The Upper Gotlandian of Gotland clearly represents a transgressive series, whereas the Oesel Beds, with their Eurypterids, clearly represent the retreatal Siluronian Series.

VII. THE DEVONIAN PULSATION SYSTEM

In the new classification I would restrict the term Devonian very much as it was originally used, to cover the beds represented by the Middle and Upper Devonian of later usage. But I would include the Oriskany as the basal bed of the old Middle Devonian, the fauna of this being decidedly Asio-European, but never extending far beyond the Appalachian geosyncline. This is true also of the succeeding Eifelian. As I have repeatedly shown, the Middle Devonian (old sense) fauna of Asia and Europe is of Indo-Pacific origin, while the Middle Devonian fauna of central North America, i.e. the Onondaga-Hamilton fauna, is of Boreal origin, the two scarcely intermingling.

In this revised classification, the old Middle Devonian becomes Lower Devonian in the Pulsation System, while the Upper Devonian remains unchanged.

The Upper Devonian marks a retreatal phase of the Devonian Pulsation system, this being especially well shown in North America, by the gradual replacement of marine by continental sediments of the Red Bed or Huangho type, and in Europe by the advance of Old Red sedimentation, though a part of the so-called Upper Old Red may be equivalent to Middle Devonian.

Much detailed work remains to be done before we can evaluate the several divisions in their relation to the Pulsation theory.

VIII. THE FENGNINNIAN PULSATION SYSTEM

This term, proposed by V. K. Ting from South China for the whole of the Chinese Dinantian or Mississippian, includes one complete pulsation and the transgressive portion of a second. I propose to restrict this term to the lower two, that is the Kolaohoan transgressive series, which in South China has a maximum thickness of 450 meters and the Upper regressive Chiussuan Series, 280 meters in thickness, which terminates with continental deposits, though it is fossiliferous in its lower part. As such, it is the only known partly marine Middle Dinantian (Middle Mississippian) of the old classification, being represented everywhere else by continental plant-bearing beds as in Russia, or an erosion interval and hiatus, as in western Europe and North America.

The transgressive series, in Western Europe, is the well-known Tournaisian and in North America the Waverleyan, with the black Chattanooga Shale of Tschernozem origin as an ascending basal member. In the Mississippi Valley, the Burlington and Keokun Limestones form the deposit of the maximum transgression, though the latter may include retreatal phases in its upper part, this being most marked by the Warsaw Formation of the Mississippi Valley and the Logan and Marshall Sandstones of the Ohio Michigan region.[1]

These beds are everywhere followed by a hiatus and erosion disconformity.

Whether the Pocono sandstone as at present restricted by American stratigraphers, is to be correlated with the entire Waverleyan as has been done before this, or with the regressive part of it, is still an unsolved problem. It is certain that the emergent inter-pulsation period, besides being characterized by erosion, is marked in the East by the Mauchchunk red shale of Huangho and perhaps in part lœssic deposit.

As already noted, in Europe the hiatus between the Tournaisian and Viseén, is everywhere marked by physical disconformities, and by decided faunal change, or by emergent continental beds which are often coal-bearing[2]. It is thus evident that the European-term Dinantian cannot be used in the classification based on Pulsations, or at any rate, it cannot be made to cover the Lower and Middle divisions of the Fengninnian, or the Tournaisian, plus hiatus and continental beds of Europe. Nor can the term Mississippian be used, since that too bridges a gap and includes the transgressive parts of two distinct Pulsation Systems. If either Dinantian or Mississippian is to survive, it should be used for the next Pulsation System.

IX DINANTIAN SYSTEM
(Revised and extended)

Other available terms: *Mississippian System* (Revised) *Visémurian* System (*Viseén-plus Namurian*) *Tennesseean System* (Revised)

1 A. W. Grabau. Problems in Chinese Stratigraphy Part VI Science Quarterly of the National University of Peking. Vol. II, pp. 367-396, 1931.

2 V. K. Ting and A. W. Grabau. The Carboniferous of China and its bearing on the classification of the Mississippian and Pennsylvanian. 16th International Geological Congress report, Washington 1933, preprint July 1934.

The Pulsation System here referred to may be known under any one of the above names, though perhaps *Visemurian* is the most satisfactory. It includes the well-known Viséen of West Europe with its distinctive *Gigantella-Daviesiella brachiopod* and *Dibunophyllum* coral faunas, and its equivalent, the Shangssuan of South China, as a transgressive member and the Namurian of western Europe, as the retreatal member. The latter is the Lanarkian of British authors, and the Kalmiouskaian of the Russian geologists, both of which have usually been placed in the base of the Pennsylvanian or Carboniferous proper. Possibly the name, Lancastrian, might be used to cover the Dinantian and Namurian of the old classification, although in its normal significance it represents primarily, if not altogether, the regressive series.

Where marine members are present in the British section, the goniatite succession is continuous from the Viséen or Avonian upward, whereas in the Moscow Basin, the Viséen species linger and are associated with modifications of a more advanced type. In general, while the Viséen is calcareous the Namurian or Lanarkian is primarily sandstones and shales with subordinate limestones, which is reduced to one per cent in the upper division.

The series is terminated by the continental Millstone Grit in the British region, apparently an emergent deposit.

In North America, the equivalent transgressive beds are the St. Louis or Meramak group, with the oolitic and cross-bedded Salem limestone at the base, or elsewhere the Moorefield shale and Batesville sandstone. The succeeding Chester group in the Mississippi Valley, represents a remarkable succession of cross-bedded continental sandstones, alternating with marine shales and limestones. Four successive occurrences of the former are recognized, ranging in thickness from 20 to 80 ft and regularly alternating with the marine formations, which as a rule are thicker, ranging up to nearly 300 ft in the greatest development.

It is apparent that we have here a probable example of oscillation, manifested by the repeated advances of river deposits, probably of the Huangho type, followed by renewed marine submergence.

One of the most suggestive sections is found in the southern Appalachian Mountains of Virginia, and West Virginia, being best developed in the Cloyd Mountain region.

The series here begins with the salt-bearing Macready shale, which lies disconformably upon the Price Sandstone, the only representative of the Waverleyan or Fengninnian system (*sens. strict*). This contains sea-margin salts which I have discussed elsewhere at length.[1]

The general succession is as follows in descending order.

TENNESSEEAN OR VISEMURIAN PULSATION SYSTEM

IV. HINTON FORMATION 1250-1350 ft.

Variegated shales, similar to those of the Macready formation and showing evidence of sub-aerial origin in the occurrence of amphibian footprints, preserved in the lower part, the variegated colours of the sediments, the presence of partly decayed tree-trunks and the absence of marine fossils, excepting at a few horizons. (Branson)

III. BLUEFIELD FORMATION 1213 ft.

Shales, alternating with limestones in the lower part, becoming thicker limestones with shales higher up, and terminating with a 170 ft bed of dark bituminous shales, with occasional 1 to 2 inch beds of very fossiliferous limestones.

II. GREENBRIAR LIMESTONE 1240 ft.

Limestones with more or less chert below and alternating limestones and shaley limestones above, passing almost insensibly into the overlying Bluefield Formation above.

I. MACREADY FORMATION 22 ft.+

Variegated shales, ranging in colour through various shades of pink, yellow, green, blue and purple, changing frequently along the strike. Occasional beds of sandstone from 2 to 15 ft in thickness occur intercalated with the shales. Marine fossils appear to be absent but mud cracks and other evidence of sub-aerial origin are found. Elsewhere beds of this character have a great thickness.

1 Problems in Chinese Stratigraphy, Part VII, Science Quarterly of the National University of Peking. Vol. II, No. 4, pp. 423-479.

HIATUS AND DISCONFORMITY

WAVERLEYAN OR FENGNINNIAN PULSATION SYSTEM.

PRICE SANDSTONE 200-757 ft.

Continental sandstones with occasional plant remains.

It is clear that in the three to four thousand feet of strata here represented, we have the evidence of transgression in divisions I and II, in the latter of which the Greenbriar limestone reaches its maximum.

The Bluefield shale, No III represents the regressive series, while the Hinton Formation No. IV, is primarily an emergent series. Farther to the southeast the entire system seems to be represented by continental deposits of the Huangho type, these reaching a thickness of 3,000 ft or more and being of the general character of the Macready shale, under which name, they are generally known.

It would thus appear that we have here the complete Pulsation Series, represented in Western Europe by the transgressive Viséen and the retreatal Namurian. Since, faunally, this series represents transgression from the Boreal Epi-Sea it is very largely, if not entirely distinct in its organic types from the contemporaneous European Sea, the fauna of which is derived from the Indo-Cathaysian Epi-Sea. In view of the fact, however, that the succession represents the physical characters of a complete Pulsation System, it seems probable that we have here represented the same time interval that is shown by the Viséen-Namurian Series (Visemurian System) of West Europe.

Despite the evident Chinese source of the Viséen fauna of Europe, the regressive Namurian phase has not yet been positively recognized, unless the Laokanchai Series with *Striatifera* and *Daviesiella* now considered a phase of the Weiningian (Muscovian) is to be classed here. Elsewhere, however, there is a distinct hiatus between the upper Shangssuan, with a maximum thickness of 470 meters and the succeeding typical Weiningian with the *Choristites* of the *Spirifer mosquensis* type.

X. THE DONBASSIAN PULSATION SYSTEM

The name Donbassian was proposed by V. K. Ting[1] to cover the Eurasian marine equivalent of the American Pennsylvanian, and usually referred to as Upper Carboniferous. This series therefore includes the Lanarkian and Lancastrian at the base, the Muscovian, Yorkian or Westphalian in the middle, and the Donetzian (Staffordian and Radstockian) at the top. Now that the Lanarkian is united with the Viséen, as the Visemurian, the Moscovian and Donetzian remain respectively as the transgressive and regressive members of the resticted Donbassian. As originally proposed by me[2] this latter included the whole of the upper division of Tschernychew's and Loutougiun's Donetz Basin section, with a thickness of 2000 meters and covering the interval between the Muscovian and the Schwagerina beds of the Bakhmout Series (Mapingian).

In our paper before the International Geological Congress, we separated the Upper division of this series, C_3^3 or division O of other Russian writers, from the Donetzian and referred it to the Lower Permian, because of the presence of *Schellwienia longissima* in this series. More recently Dr. V. K. Ting, in a paper before the annual meeting of the Geological Society of China, 1935, announced the result of an examination by J. S. Lee of a series of Foraminifera, collected by Dr. Ting himself, from the various limestones of the original Donetzian in the Donetz Basin of Russia. These showed that division C_3^2 of Tschernychew and Loutouguin or division N, of later Russian writers, must also be separated from the Donetzian because the species are all of Mapingian types, while those of division C_3^1 or division M of later writers, represented Muscovian species.

This lowest division (C_3^1) then, comprising some 500 meters of shales, sandstones and some limestones, (10 marine and 10 non-marine beds. Nos. 42 to 23 of the table in the Permian of Mongolia) is the restricted Donetzian, and as such represents the regressive phase of the Donbassian Pulsation System. "As such its fauna would not differ much from that of the underlying transgressive series, except in the gradual diminution of species.

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1 Carboniferous of China and its bearing on the classification of the Mississippian and Pennsylvanian. By V. K. Ting and A. W. Grabau. 16th International Geological Congress report. Pre-print 1934, p. 16.

2 Permian of Mongolia p. 432 (et. seq.)

Final emergence permitted erosion of the retreatal series, often to its complete removal and the development of emergent deposits such as the Talchir glacial beds of India and the porphyry flows of Tonking."[1]

The corresponding transgression in the North American Pennsylvanian represented by the Alleghany division, everywhere lies disconformably upon the older rocks, part of the interval being occupied by the Pottsville conglomerate of the Appalachian region, an emergent deposit of alluvial fan type. The retreatal series of the Pennsylvanian, the Conemaugh, is developed in marine phase chiefly west of the Mississippi, emergent continental deposits, with coal beds, being the more dominant eastern phase.

XI. THE URALIAN PULSATION SYSTEM (*sens. late*)

(A new name desirable)

As is well known the original Uralian was believed to be Upper Carboniferous, that is pre-Permian in age, the term being made originally to include 3 limestone divisions by Tschernyschew, that is, the *Omphalotrochus* beds at the base, the *Cora* beds in the middle and the *Schwagerina* or Tastuba beds at the top. The series passes upwards into the Artinskian, which still retains a certain number of the older species, while at the same time younger forms, characteristic of the European Zechstein and the equivalent beds of the Ural Mountain section appear.

Since the latter constitute the original Permian of Murchison, the Artinskian apparently formed a transition from the Carboniferous to the Permian and hence the name Permo-Carboniferous has come into general vogue. This term must be discarded, since there is no transitional series between the two older systems.

Unfortunately the name Uralian as originally used seems not to meet the approval of the younger Russian geologists who consider that beds thus designated are complicated by faulting while some of the horizons actually referable to the Artinskian are included. Unless the term Uralian can be redefined in terms of a Pulsation system, it would be better to drop it entirely

1 A. W. Grabau. Fauna of the Maping Limestone of Kwangsi and Kweichow. Palæontologia Sinica, Series B, Vol. VIII, Fasc. 4, p. 38, 1936.

and to apply a new term to the post-Donbassian pre-Permian (in the restricted sense) Pulsation system.

In China, the series is more normally developed, for here the Mapingian, with its rich fauna constitutes the transgressive series while the Lopingian represents the retreatal phase. The details of these formations have already been set forth at length.[1]

In Western Europe, the equivalent formations are, the coal-bearing Stephanian of the age of the Mapingian, and the Rothliegendes, continental sandstones forming an emergent phase of the Artinskian or Lopingian.

XII. THE PERMIAN PULSATION SYSTEM

If we restrict this term essentially to the original Murchisonian sense, it covers a normal Pulsation system. But this means that it is not the equivalent of the German Dyas, for that included the Rothliegendes which we now regard as the emergent phase of the preceding pulsation series, for which the Artinskian of Eastern Europe and the Lopingian of China form the retreatal phase. The North European Zechstein, with its basal member the Kupferschiefer, represents the transgressive phase of the Permian system. This in South China, is represented by the Yehlangian, including the Paoan shale and Sanchiao Limestone. Whether any portion of the Zechstein will be referred to the regressive series of this Pulsation or whether that is entirely replaced in west Europe by the emergent deposits of the Tartarian continental series of red beds, remains to be determined. In China too, sandstones, often salt-bearing, represent a retreatal and partly emergent closing phase of the true Permian.

This is the last of the Palæozoic systems and the final retreat of the sea was so profound as to uncover all the Epi-seas which throughout the Palæozoic

1 V. K. Ting and A. W. Grabau. The Permfan of China and its bearing on Permian classifioation. Report of the 16th International Geological Congress, Washington, July 1933. Pre-print 1934.

Grabau. A. W. The Permian of Mongolia. Natural History of Cental Asia Vol. IV, 1931

Huang, T. R. The Permian Formation of Southern China. Geological Survey of China.Memoirs, Series A. No. 10. For description of the fauna, see T, K. Hvang and B. W. Grabau in the Patæontotogia Sinica, Series B, Vols. VIII and IX.

were more or less intact and which were the centers of successive faunal evolution from the surviving members of the diminshed remnant of the preceding fauna. It was the extreme sinking of the sea level and the uncovering of the littoral districts which brought about all the destruction of the littoral Palæozoic faunas, leaving as the only survivors the pelagic types and a few who could adapt themselves to the abyssal slopes.

It is from these that, after a long time interval, the entirely distinct, early Mesozoic marine fauna was developed, in which there are no Palæozoic survivors.

Discussion

W. H. Wong:—Dr. Wong remarked that many of the new terms coined by Grabau are of Chinese origin and since the pulsation theory considers world-wide geological history these names are rather objectionable. Moreover the names Cambrovician, Siluronian etc. are very confusing and he proposed to use new terms like Primarian, Secondarian, Tertiarian etc. for Grabau's twelve Palæozoic pulsation systems. Dr. Wong further remarked that on the basis of the pulsation theory it is very difficult to explain the major orogenic movements of the world. For instance, the Yenshan movement, roughly corresponding to the Laramide movement in West America, is an important orogenic feature in countries bordering the Pacific Ocean but not conspicuous at all in countries bordering the Atlantic.

C. Y. Hsieh:—Referring to Dr. Wong's first point, Prof. Hsieh remarked on behalf of Prof. Grabau that the new names like Yunnanian (for Taconian) Shantungian (for Cambrian in the strict sense) which Prof. Grabau has orally suggested to him while he was in Peiping refer only to those distinct geosynclines developed specially in China and containing in each case a characteristic fauna. They should not be confused with the general system names which have of course a world-wide nature.

Hans Becker:—Dr. Becker seemed to favour Grabau's bold attempt in the coordination of major geological events by the creation of the pulsation theory but he doubted the wisdom of applying an untested theory to the whole world. He would begin such an attempt in one continent and check the results with the facts gathered in other parts of the earth. He was also opposed to the new terms for the geological systems coined by Grabau, since these would lead to confusion and endanger the usefulness of the old terms.

T. K. Huang:—Dr. Huang congratulated Dr. Grabau on his painstaking labour in recent years and made the following remarks: (a) It is premature to use the Huangho plain as a type specimen in any serious theoretical discussion since the character and the sediments of the Huangho plain are not yet adequately studied, (b) What are the distinguishing characters of the so-called positive and negative pulsations? Are they distinguished by the extent of the sea or by the type of sediments? (c) In some cases it is almost impossible to determine the contemporaneity of two formations in different localities and so long as the age relation of formations is not accurately known the pulsation theory remains without solid foundation. (d) The application of the theory to the Permian system is very unsatisfactory.

Reply by Dr. Grabau

The points raised by the various speakers are of interest and significance and I would like to reply to them *ad seriatim.*

Dr. Wong's remarks.

The first point raised by Dr. Wong is that many of the names suggested are of Chinese origin and not suitable for wide application. The terms which would come under this heading are: The Fengninian Pulsation System and the Mapingian.

With regard to the first, it is difficult to find a term more appropriate, for it is only in South China that the series is completely developed. In western Europe, the Tournaisian, which is the lower half or transgressive portion of the Pulsation System, is the only one represented by marine strata, for the retreatal portion is entirely absent, being represented by a hiatus only. It is true that in some Russian sections this second half of the Pulsation system is represented by continental coal-bearing beds, but as these are emergent deposits they are far less satisfactory than the regressive marine Chiussuan Series of South China.

Again, the Lower Mississipian of America, that is, the Waverleyan, represents only the transgressive portion, except that the Warsaw may be regarded as the beginning of the regressive series. The greater part of that however, is represented by the disconformity which separates it from the transgressive portion of the Tennesseean System.

If then, China shows the most complete series, both transgressive and regressive known anywhere, why should not China have the distinction of furnishing a name for this Pulsation System, since Europe and America have furnished nearly all the others.

As to the Mapingian, this term is suggested to replace the Uralian only, since the Russian geologists are not agreed on the question of the real character of that much misunderstood Russian series. In any case, it could be used only for the transgressive portion and we still need a distinctive term for the entire Pulsation, which in China includes the Mapingian and Lopingian, in the Urals the Uralians Artinskian and in western Europe is entirely represented by continental series the Stephanian and the Rothlegendes.

The 2nd point raised by Dr. Wong is the use of new combinations of old terms and the restriction of others, and he proposes to substitute a numerical system of terms, but here Primary, Secondary and Tertiary etc or their modified form, Primarian, Secondarian; Tertiarian would be equally if not more confusing, because of the historic use of these terms in early classification.

Moreover, a serious difficulty would have to be met, and that would be the ready identification of the numbered Pulsation system with the old division of the geological scale.

Thus, it would not be easy to recognize that the 7th Pulsation includes the combined Middle and Upper Devonian as a system.

It seems to me that the terms Cambrovician, which includes Upper Cambrian and Lower Ordovician of the old classification, the term Siluronian, which includes the old Upper Silurian and Lower Devonian, the term Visemurian, which includes the Viseen and the Namurian, would not be so very difficult of comprehension, once their significance is understood. Nor would the restriction of the old systems to practically their original limits, involve a very serious mental readjustment. One might even say that it would serve a welcome escape from old controversies, since it would at once solve the problem by the destruction of its problematic character.

Thus the question, whether the Tremadoc is to be placed into the Upper Cambrian or the Lower Ordovician would no longer exist, since it belongs to the Cambrovician system. In the Silurian Ulrich and many of his followers have tended to put the Manlius into the Lower Devonian, whereas it is usually recognized as the top of the Upper Silurian. As a part of the Siluronian, it would no longer be in question.

Stamp has recently argued for the inclusion of the Downtonian in the Lower Devonian. In the new classification the Downtonian becomes a part of the Siluronian. This too would solve the problem as to the classification of the Pentamerus beds of the Urals and Altai, first placed in the Silurian; then transferred to the Lower Devonian. They too belong to the Siluronian.

In South China, this becomes of especial significance; since the boundary line between the Upper Silurian and Lower Devonian is a transitional one and the Cephalaspid beds of Yunnan, might belong to either of the old divisions.

Again, if we use the term Visemurian it would solve the problem of the classification of the Namurian, with their Viseen elements and the classification of the goniatite-bearing series of the British succession.

The 3rd point raised by Dr. Wong is the difficulty of explaining the major Orogenetic movements of the world on the basis of the Pulsation theory. This certainly cannot be said for the Palæozoic Systems, which have alone so far been studied in detail from the new point of view. It is certainly a remarkable fact, first brought out at the Washington meeting of the International Geological Congress, that the independently determined interpulsation periods and the equally independently dated orogenic disturbances of Stille, harmonized so completely. There seems to be no reason to doubt, that when the Pulsation Systems are determined for the Mesozoic and later eras, that the orogenic movements will also be seen to fall into the periods of inter-pulsation emergences. Moreover, so far as the studies have been carried, it is clear that volcanic outpourings are chiefly, if not wholly confined to these same interpulsation periods, and that since intrusives are very apt to be associated with such periods of volcanism, this new correlation will serve as a guide for the dating of such intrusions, for which other facts leave precision in doubt.

Dr. Becker's Remarks.

The criticism of Dr. Becker regarding the wisdom "of applying an untested theory to the whole world", would be well taken if the premises were correct. As a matter of fact, it is not a question of coining a plausible theory of world evolution and then attempting to apply it superficially to the history of all continents. The theory is rather a summation of the critical study of stratigraphic and palæontological facts from all parts of the world assembled by me during a period of more than 30 years.

As critical examination of Vol. I of my Palæozoic Systems in the Light of the Pulsation Theory will show, its 636 pages comprise a detailed discussion of all the known Lower and Middle Cambrian sections of the world, with particular attention to those features which admit of more than a single interpretation. In Vol. II, which is just coming off the press, nearly 316 pages are devoted entirely to the Cambrovician sections of the Caledonian geosyncline of Europe and the Atlantic border sections of Eastern North America, while more than 350 pages of the remainder of that volume are devoted to the detailed discussion of the Cambrovician sections of the northern Appalachian or the St. Lawrence geosyncline.

Finally, Vol. III of which more than 100 pages are ready for the press will be wholly concerned with the detailed discussion, first of the Southern Appalachian geosyncline and its marginal plain of Mississippia, (the Ozarkian Type region of Ulrich) 2nd to the known sections of the Palæ-cordilleran geosyncline, including a critical analysis of all recent literature including that of 1935 and finally to a detailed summary of what is known of the Cambrovician of Asia and the other still little explored regions of the world.

If after an examination of these volumes, Dr. Becker still feels that the attempt of applying the theory in one continent needs further checking of the results with the facts gathered in other parts of the earth, I should deeply appreciate the submission to me of all facts which have escaped me so far.

Moreover, I might remark that geologists in all countries, appreciating the desire of comprehensiveness, are generously supplying me with recent literature as well as personal communications regarding the questions involved.

With reference to Dr. Becker's objection to the new terms as endangering the usefulness of the old terms and leadingto confusion, the answer already made to Dr. Wong's objection would apply. Moreover, if it should prove that the new classification is the more exact, the usefulness of the terms in the old sense, would automatically disappear. But to avoid any possibility of confusion in the interim, it would be perfectly feasible to speak of the Cambrovician Pulsation system, the Ordovician Pulsation system, the Silurian Pulsation system and so on.

For it is obvious that if the Middle Ordovician and the upper Ordovician form one complete Pulsation system, they should be known by the name Ordovican and the old Lower Ordovician, formerly attached to it should be dropped, just as long since the geologists have dropped the old Carboniferous and given it complete independence.

Dr. Huang's Remarks.

Replying to Dr. Huang's remarks, I might say with reference to the point raised under (a) it is not a question of the detailed petrographic character of the Huangho deposits, but it is a question of a suitable term to apply to ancient continental deposits spread out by rivers which are too extensive to be referred to any of the old categories, such as flood plain, delta, or alluvial fans. The Huangho Plain has now been penetrated to depth of 800 meters and found to consist of comparatively uniform river sediments throughout with only a rare occasional and short-lived incursion of the sea.

The Indo-Gangetic Plain is of the same character, but its name is less serviceable and so is the Mesoptamian Plain. There can be no question that such deposits as the Ffestiniog of the Upper Cambrian, the Arenig, the Old Red Sandstone, the Rothliegendes, the Triassic sandstones and many other deposits of the older geological periods were formed as river deposits comparable to the modern Huangho Plain.

Some are chiefly of oxidized material, others lack this modification. There is considerable variation in the texture and composition of the material and different formations have suffered variable amounts of submergence or marinings, but all of them have this one essential character in common with one another and with the modern Huangho Plain, namely that they are river deposits in slowly sinking geosynclines, to which the sea had only occasional and very temporary access, while the variation in the grade of the rivers responsible for these deposits were relatively slight, so that the grain varied to a moderate degree only throughout the entire series. Used in this sense, there can certainly be no valid objection to the Huangho deposit as I have used it, and it tends to clearness of perception and avoidance of abiguity.

With reference to point (b) raised by Dr. Huang; it is difficult to put in general terms more than the broader definitions the characters of the transgressive and regressive Pulsation Series. Of course such examples as the Cambrovician of the Mississippi Valley and the Ordovician which follows it, in other words, the series involving the St. Peter Problem, requires only a combination of the various sections for the elucidation of the problem. Such for example as has been given by Thiel (in the 1933 vol. of the G. S. A. Bulletin p. 553).

Again the illuminating sections in the Baltic region of Russia hardly require any further comment. In many cases, however, it requires a more exacting analysis of the facts to determine which formation marks the limit of the transgression and which the limits of regression, though the evidence of emergence is not difficult to recognize.

A pertinent example is furnished by the significance of the Stonehange and Tribes Hill Formations of the Southern Appalachian geosyncline in the Cambrovician Pulsation System and its recognition as the terminal member of the Transgressive Series by Lithology, Palæontology, overlap etc.

Not one, but all the facts must be taken into consideration, as will be abundantly evident from a study of the details so far published in vols. I and II.

Replying to item (c) I fully agree that it is impossible to place any given formation into its proper position in the Pulsation System so long as its age relations and other characters remain undetermined, but ignorance of these facts regarding a given formation cannot be construed as a criticism of the validity of pulsation, for the known facts are too extensive and too wide-spread, and they harmonize too completely with the general principles of the Pulsation theory to permit of any doubt that when the details of other Pulsation are known, they will find their proper place within the Pulsation system.

It may in fact be said that the application of the Pulsation Theory will help to establish the true classification of the formation in doubt by calling attention to the significance of features the importance of which might otherwise be overlooked. As a case in point, might be cited the age of the Tourmakeady Beds of Western Ireland, discussed in Vol. II, pp. 90-102.

Finally, with reference to item (d) raised by Dr. Huang, the application of the Pulsation Theory to the Permian System *offers no difficulty* whatsoever, once we rid ourselves of the old prejudice regarding the age of the Uralian or Mapingian, a prejudice which is being rapidly overcome by the younger generations of European as well as American geologists, as evidenced by their recent publications.

ON THE MESOZOIC STRATIGRAPHY OF CHINA

By

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GENERAL STATEMENT ON THE DISTRIBUTION OF LAND AND SEA IN CHINA

One leading fact that distinguishes the Mesozoic from the Palæozoic Era in China is the great contrast in wide extent of lands and the withdrawal of the epicontinental seas from the Chinese basins. Such a change might be theoretically resulted from the enlargement of the Pacific Ocean by subsidence and widening and it is evidently resulted from the folding of the Palæozoic strata into mountain systems through the orogenic movement which occurred at the close of the Palæozoic. Between the mountain systems a great number of intermontane basins were formed in which continental type of sediments were accumulated.

In Mesozoic time the greater part of China was dry land, there existed only one way of marine invasion which is the Himalaya geosyncline on the Tibet border. From this invasion the marine sediments were deposited in the provinces of South China and in the Yangtze gorge provinces. But this phenomenon maintains only true in Early Mesozoic time and during the Upper Mesozoic the sea withdraw entirely from China. Since then no marine sediments were formed.

In China proper the Mesozoic strata of continental type are extensively developed, they consist chiefly of conglomerate, sandstone, shale and sometimes with thin layers of marl, clay and freshwater limestone. They contain frequently coal seams and plant remains.

In this paper more emphasis is paid on the Mesozoic formations of Kwangtung and Kwangsi which are not yet systematically studied. Now let me proceed to describe some known occurrences of Mesozoic formations in China and starting from Triassic.

I. THE TRIASSIC SYSTEM

The marine Triassic beds are found in Yangtze provinces such as Szechuan, Hupeh, Hunan, Kiangsu and Anhwei and in the provinces of South China, but their extent and character still remain to be determined. In South China the Triassic has been long reported from Yünnan, where both Lower and Middle Triassic are represented. The Ladinic is especially well developed, widely distributed and richly fossiliferous. According to Deprat the Triassic in the south-east of Yünnanfu consist of sandstone, marl, marly shale and thick series of limestone. The leading fossils are *Trachyceras fasiger* Mans., *T. costulatum* Mans., *Myophoria radiata* Loczy and *Myophoria elegans* Dunk, etc. In other part of Yunnan the Triassic beds are also found though they are not so well developed.

Recently Messrs. J. L. Hsu and T. I. Sun, geologists of the Geological Survey of Kwangtung and Kwangsi, discovered marine Triassic beds from south-western and western parts of Kwangsi in Pinghsiang (凭祥縣), Lingyun (淩雲) and Hsilin (西林) districts. In Pinghsiang district, the formation consists predominantly of shale, generally yellowish and greenish in color. Impure limestones interbedded with yellow and green shales are also abundant. The Triassic beds are generally disturbed, folded, intruded and overlain by rhyolite.

Fossils in the Triassic beds are rare. From the yellowish and greenish shale interbedded with impure limestone, several Pelecypods were found. According to the preliminary determination by the writer of this paper, the following species are identified:—

Myophoria goldfussi Alb.

Pecten sp. indef.

Lima sp. indef.

In Lingyün district the rocks of the Triassic beds are similar to those of Pinghsiang. From the greenish and yellowish shale many well preserved specimens of the genus Daonella were found. The rocks in Lingyün district is very richly fossiliferous.

According to the fossil content the Triassic beds in Kwangsi province is very probably Ladinic or in part Scythic. From the known evidences the marine Triassic beds are very widespread in western part of Kwangsi near the border of Kweichow and Yunnan provinces.

In Yangtze gorge the Triassic beds were designated long years ago by Prof. C. Y. Hsieh and late Mr. Y. T. Chao as Patung series. The rocks of this series consist of purple, green and yellow shales with thin-bedded limestones. The total thickness is about 800 meters. The Patung Series lies disconformably upon the Tayeh Limestone, the latter forms the upper part of the Wushan Limestone of B. Willis.

In Szechuan the Triassic was named by the late Mr. Y. T. Chao as Feisienkuan shale for the lower part and Chaohua Limestone for the upper part of the system. It overlies disconformably upon the Omeishan basalt. The total thickness is about 850 meters. In western Kweichow the fossiliferous Triassic beds are rich in Ammonites as Trachyceras, Cladicites etc.

In Kiangsu and Anhwei provinces the marine Triassic, designated as Chinglung Limestone, is wide-spread and well developed. The Chinglung Limestone lies disconformably over the Lungtan Coal Series and its thickness is variable.

Continental Triassic especially the Rhätic, seems rather wide-spread in China. Owing to its similarity of the rock characters, it is very difficult to be distinguished from the Lower Jurassic, the Liassic. One fact remans to be true, that is, the coal seams of the Triassic beds are mostly not workable and of no economic value. The lower part of the Hsiangchi Series is generally held as Rhätic. The plant-bearing beds of the Hweili district in Szechuan are generally regarded as Rhätic. Recently Messrs. Y. L. Chi and C. H. P'an subdivided the Shüangtsüan series from the Mentoukou Coal series of the Western Hills and regarded it as Lower Triassic.

In Kwangtung and Kwangsi there is no definite Triassic of continental type.

Summarizing from the known facts we can see that the marine Triassic of China exhibit more or less the same characters in different localities. It consists of a series of shales generally of purple, green or yellow in color with a series of thin-bedded limestones. In general it overlies the Permian beds disconformably and its thickness is variable in different localities. In age it ranges from Lower to Middle Triassic, rarely also Upper Triassic, while the most well developed and wide-spread one is Ladinic.

II. THE JURASSIC SYSTEM

The marine Jurassic is rarely represented in China proper, though it has been long reported from the Tibet border, Himalaya and Indo-China. The only known Jurassic beds in China proper are found in western Yünnan, in the region of Luchiang or Salwen river. Reed studied the fossil collections of that region and regarded them as of Bathonian age.

In south-eastern China, the Liassic fossiliferous beds have been found from the Tolo Channel, not far from Hongkong, where the *Ammonites Hongkongites hongkengensis* Buckman were collected and the formation was named as Tolo-channel Formation.

Recently Mr. T. H. Ting, member of the Sino-Swedish expedition discovered fossiliferous Jurassic beds from western Sinkiang in the Kashgar region, but the result has not yet been published.

Continental beds of Jurassic age are wide-spread in all parts of China showing practically the same lithological characters. They consist of a series of shale, sandstone, black carbonaceous clay-shale, conglomerates and arkosic sandstones of various colors. Coal seams are frequently present, though sometimes unimportant and not workable. Plant remains are not seldom. Among the Jurassic beds the Liassic is most wide-spread and well developed.

In North China many productive coal fields are of Liassic age. The Tatung Coal Formation in Shansi, the Shensi coal series and the Mentoukou coal series of Hopei etc. belong all to this age. In Yangtze gorge the upper part of Hsiangchi series is also of Liassic.

In Kwangtung the Liassic beds are widely distributed almost throughout the whole province. The Hsiaoping Series first designated by Dr. A. Heim after the name of a Station on the Yueh-Han Railway line, consists of a series of black carbonaceous clay-shales, gray or yellow micaceous sandstones and white arkosic sandstones. Several coal seams of inferior nature and many fossiliferous layers were found in this series.

The fossils of the Hsiaoping series are mainly plant remains and fresh-water Crustaceans (Astheria). The plants identified are the following:

Pterophyllum æquale Brongn.
Pteraphyllum multlineatum Shir.
Podozamites lanceolatus (L. & H.).
Podozamites shenki Heer
Cladophlebis? denticulata (Brongn.).
Tæniopteris sp.

Judging from the fossil contents, the Hsiaoping series is undoubtedly of Liassic age.

Along the Canton-Kuilung railway in the neighbourhood of the stations Changmoutou (樟木頭), Tutang (土塘) Ch'angping (常平) and Hungli (橫瀝), the Jurassic beds are also wide-spread; they can be subdivided roughly into two parts: the lower part consists of conglomerate, white coarse sandstone and yellow sandstone, while the upper part fine sandstone, pink or gray clay-shales and clays. The lower part is strongly metamorphosed while the upper part is rather soft and less metamorphosed. The Jurassic beds are strongly disturbed, being affected by foldings and igneous intrusions.

No fossils were found from the above regions, but at Tungkuan district where the same beds extended, many plant fossils were collected. They are of the same type as those contained in the Hsiaoping series.

Besides the above mentioned localities, there are many other occurrences in Kwangtung province, which for simplicity sake will not be mentioned here.

III. THE CRETACEOUS SYSTEM

In China proper the marine Cretaceous rocks are entirely unknown till to present, though the Cretaceous rocks of continental type are rather wide-spread. They are the deposits of intermontane basins. The rock consist mainly of conglomerate, sandstone, shales and sometimes thin layers of marl and clay. They are generally red or pinkish red or green in color. They contain in general a rich amount of iron oxides showing that they have probably been deposited under an arid climate.

The Cretaceous beds are sometimes rich in organic remains, especially fishes (Lycoptera), insects, plants and also bones of reptiles.

In Shantung the Cretaceous beds are widely distributed in the basins of Laiyang, Chaohsien and Menyin. The rocks consist mainly of conglomerates, sandstones and shales, Well preserved *Lycoptera* fishes, insects and plants were collected. Reptile bones are also found from the Lower Cretaceous beds.

In other provinces of North China such as Jehol, Kansu, etc, Cretaceous beds with *Lycoptera* fish are also found. In Yangtze gorge the Kweichow Series belongs to Cretaceous while in Szechuan the Red Beds of the red basin are especially famous. The Chiente series and the Rhyolite lava sheet of Chekiang provinces belong to Upper Cretaceous.

In South China especially in Hunan, Kwangtung and Kwangsi the Red Beds are very wide-spread. The rocks are on the whole rather similar in character consisting of conglomerate, sandstone, shale and sometimes thin layers of marl and clay. Layers of salts and gypsum are often found. The color of the rock is in general red or pinkish red.

Mr. C. C. Tien has subdivided the Red Beds of Hunan into two parts: the Heng Yang series for the lower part and the Tan Shih series for the upper part. The former belongs to Eocene while the latter Cretaceous.

In Kwangtung and Kwangsi the basal part of the Red Beds consist of conglomerate with boulders of quartzite, granite and other igneous rocks. (In northern part of Kwangtung the conglomerate composed fully of limestone pebbles.) They contain also red sandstone and clay in intercalation. The upper part of the Red Beds consists of massive, coarse sandstone, red clay, and sometimes thin layers of marl. The total thickness of the Red Beds is about 1,000 meters.

The Red Beds lie nearly horizontal or they show only a little warping. Intense folding has never been seen in both Kwangtung and Kwangsi provinces.

Correlation Table of Mesozoic Beds in South China

Locality / System	Yunnan	Kwangtung & Kwangsi	Hunan	Hupei	Szechuan	Chekiang Kiangsu & Anhwei	Fukien	Western Hills of Peiping	Shansi & Shensi	Shantung	Kansu & Sinkiang	Suiyuan & Mongolia
Cretaceous		Red Beds	Tanshih Red Beds & Hsiang-tan Red Beds	Kweichow Series	Red Beds of the Red Basin	Rhyolite Lava Flow Chiente series	Wuyi Formation	Tunglankou Formation Green Rhyolite Tungling Formation Tiaochi	Red or green sands & shales	Wangsh h Formation Mengyin series with fish & reptile bones etc.	Wusunpu Formation with Lycoptera fish.	Irendabasn Formation Djadochta Formation Ondaisair Formation Oshih Formation with Dinosaurs *bones etc.*
Jurassic	Beds of Ba-thonian in Lu-Chiang or Salwen River region with Terebra-tula, Rhynchon-ella etc.	Hsiao-ping series with plant remains and Estheria Fo-ho Channel Formation with ammonites	Hsiang-chi coal series	Upper part of Hsiang-chi series	Hsiangchi series (Mienhsian series Tishuip'u series and Suchiaho series)	Conti-nental beds with Coalseries	Lishan Coal Series	Fichi shan series Chinlung-shan series Mentoukou Series	Tatung coal Formation *Shensi* coal series	Santai series *Fangtze* coal series		*Conglo-merate,* Sandstone with coal seams
Triassic	Sandstone, marl, marly shale and thick series *of lime-*stone with Trachyceras Myophoria, Avicula etc.	Pingerkuan Formation with *Myophoria*, Pecten etc. in Western Kwangsi	Thin-bedded *limestone* & yellow shale	Lower part of Hsiang-chi series Patung series with Spiriferina	Chaohua limestone (Chialing limestone) Feisienkuan series	Chinglung limestone		Shuangtsuan Series Hungmiao-ling series? (Permo-Triassic)	Shihchien-feng series	Hsikunlun series Quartzite & Sandstones	Theromor-pha *Beds of* Sinkiang	

IV. THE OROGENIC MOVEMENT AND THE IGNEOUS ACTIVITIES IN MESOZOIC ERA

In general the Triassic and the Jurassic beds suffered more disturbances than that of the Cretaceous. The Yenshan Movement with its accompanied igneous activities has rendered the Early Mesozoic beds to be strongly folded, tilted, and sometimes strongly metamorphosed. Such features have been seen in all parts of China. In Kwangtung and Kwangsi provinces both Triassic and Jurassic of either marine or continental origin suffer very intense orogenic and igneous disturbances.

The Cretaceous beds, on the other hand, lie in general horizontal or dip very slightly. They show only a gentle warping, while strong foldings have been very seldom seen. Whoever has made geological travelling through Hunan, Kwangtung and Kwangsi provinces, will well remember the immense deposit of the Red Beds showing slight inclination toward the periphery of the inland basins. So far as I have observed, no igneous intrusion has been found in the Cretaceous beds.

ON THE LATE MESOZOIC-EARLY TERTIARY OROGENESIS AND VULKANISM, AND THEIR RELATION TO THE FORMATION OF METALLIC DEPOSITS IN CHINA

BY C. Y. HSIEH (謝家榮)

CONTENTS

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1. INTRODUCTION

That there are close relations between Orogenesis, Vulkanism and formation of metallic deposits is unanimously accepted by geologists. Among the different metallogenetic epochs in China, the late Mesozoic and early Tertiary periods seems to have given the most important and at the same time the most varied metallization. It is remarkable to see that it is also during this period or periods, that the wide-spread orogenesis and vulkanism in China took place. In the present discussion, I am attempting to bring together some of the major facts in regard to these three most important geological processes and to see what relationship, if any, they may possess.

2. OROGENESIS

Thanks to the work of W. H. Wong[1], V. K. Ting[2] and J. S. Lee[3], the orogenic history of China is becoming more and more clear. In the present discussion, however, I shall limit my attention to the late Mesozoic and Early Tertiary orogenesis only, i.e. the Yenshan movement of W. H. Wong. In their latest discussion on the Yenshan movement, Wong and Ting subdivided it into three phases as follows:

Phase 3: Sharp folding and overturning in the orogenic zones ending in intense over-thrusting. Broad and gentle folding outside these zones. All took place in the Middle Cretaceous period.

Phase 2: Intense volcanic eruptions, granitic and dioritic intrusions in Upper Jurassic and widely in Lower Cretaceous.

Phase 1: Broad folding or warping at the end of Jurassic or the beginning of Lower Cretaceous.

The above classification is based on the assumption that all the Mesozoic volcanics, tuffs, agglomerates, porphyries, rhyolites etc were of the same age which is variously assumed to be Jurassic or Cretaceous. Recent studies by K. Chern and Y. S. Hsiung in the Western Hills* and by P. Kao[4] in eastern Chekiang, have definitely established the existence of at least two volcanic series separated by a marked unconformity. The lower one, consisting chiefly of agglomerate and andesite, which grades upward into a pyroclastic and clastic phase and contains at many places fossil fishes, *Cyrena*, *Estheria* etc, is most probably of Upper Jurassic to Lower Cretaceous age. This is equivalent to a part of the well known Tiaochishan formation in the Western Hills, or the Kienteh formation of Chekiang. The upper volcanic series is chiefly a rhyolite formation which at many places in S. and Central China is overlain unconformably by the red beds. Besides, in the Western Hills of Peiping, several more unconformities have been discovered both above and below the volcanic series, so that the Yenshan movement is really much more complicated than it at first appeared. In the Western Hills section, for instance, at least five phases may be distinguished, while in other regions, usually three or more have been described. A tentative correlation of the different phases is shown in Table I.

From this table it can be seen that three phases from 2-4 of the Yenshan movement are the most important and widespread ones, and are to be correlated with the phases I-III of Wong's original classification. The phase I seems to be restricted to the Western Hills and is more of epeirogenic rather than orogenic nature. The phase 5 is also widely distributed though rather of a gentle character; it marks the end of the Mesozoic orogenesis.

* Report not yet published.

Table I Late Mesozoic and Early Tertiary Orogenesis in China

	Western Hills (Several Authors)	Peipiao (Wong)	Eastern Chekiang (Kao)	Nanking Hills (Yih)	Shantung (Tan)	Weichang (Teilhard)	Phases of Movement	Wong's Classification
Eocene	......Warping Changsintien gravel (fossiliferous) ...Unconformity.		Basalt	Basalt Fanshan Gravel	1 Kuanchuang conglomerate		Himalaya Movement	
Upper Cretaceous	Hsiachuang (fossiliferous) Lushanwen Tuoli ...Unconformity.	....	Red Beds	Chihshan Pukow	Wangshih Series ....?	Conglomerate & gravel (Nantienmen	......Phase 5 ......Phase 4	Phase III
Lower	Rhyolite etc ...Unconformity.	Upper Volcanic Series	Rhyolite	Dacite-Rhyolite Series	Chingshan or tuff conglomerate ....?	Rhyolite ....?	......Phase 3	Phase II
Cretaceous	Hsinchuang Tahuichang (fossiliferous)	Upper Coal Series (fossiliferous) Lower Coal Series	Shaohsing tuff Hutoushan conglomerate	Hsiangshan	Laiyang and (with fish) Meng-yin series (fossiliferous)	Lycoptera & insect beds Tuff conglomerate		Yenshan Movement
Upper Jurassic	Tiaochishan Kiulung ...Unconformity.	L. Volcanic Series	Juao (andesite etc)		Santai series (Red & green sandstone)	....	......Phase 2	Phase I
Lower Jurassic	Mentoukou ..Disconformity.	Sinian			Fangtze Coal Series	Lingsi Series		
Triassic	Diabase (partly intrusive & partly extrusive) Shuangchuan						......Phase 1	

The warping of the Changsintien, Fanshan and Kuanchuang gravel or conglomerate, all of which are here tentatively assumed to be of Eocene age, belong evidently to the Himalayan movement. Under this epoch again several phases may be subdivided as is evidenced especially by the Nanking Hills sections.

The age of the so-called red beds of South or Central China remains still an unsettled question. Field geologists have until now all assumed for it a late Cretaceous or early Tertiary age. Both in Hunan, Hupeh and perhaps Szechuan, field observations have recently established the existence of an unconformity within an otherwise monotonous red series. In Hunan and Hupeh fossils (fishes, plants in Hunan* and gastropod in Hupeh†) have been discovered in the younger horizon which is essentially horizontal and is very likely of Eocene age. If that is true, then the upper horizon may perhaps be correlated with the Changsintien gravels or Kuangchuang conglomerate of Northern China. The writer is therefore of the opinion that the red beds ‡ in the restricted sense, i.e. the lower, tilted sequence should belong entirely to Upper Cretaceous and can be tentatively correlated with the Tuoli group[5] of the Changsintien area, the Wangshih series[6] of Shangtung etc. With this assumption as basis, the above correlation table is prepared.

3. VULKANISM

By vulkanism it is meant here to include all kinds of igneous activities, both intrusion and extrusion. The igneous history of China is as obscure as that of the orogenesis; nevertheless, some essential features have already been worked out by various investigators; and these may be briefly discussed here. As is allowed by the scope and title of the paper, I shall limit my discussion again to the late Mesozoic and early Tertiary vulkanism only, which is a most remarkable epoch of igneous activities in China.

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* Discovered by the Tsinghua Students Party in 1934

† The fossil bearing limestone, the Yangchi limestone was first discovered by C. C. Liu and C. Y. Hsieh. (See Bull. Geol. Surv. No. 9, 1927). Recently it has been revisited by Teilhard and Young (See Bull. Geol. Soc. China, Vol. 14. No. 2).

‡ In my former communication, I have assumed the red beds of Hupeh to be of Tertiary age (see Bull. Geol. Surv. no. 9 Geology of Southwestern Hupeh.)

Table II shows succession and correlation of igneous activities in different part of China. Owing to lack of detailed facts, what is given in this table can only be considered as provisional. However, a few conclusion can already be obtained from a study of this tentative correlation.

(1) In the late Mesozoic time there were at least two periods of extrusion, separated by a marked unconformity. The earlier extrusion consists of agglomerate and andesite which grades upward into a sedimentary and pyroclastic phase. This is the Tiaochishan formation of the Western Hills and the Kienteh formation of the southeastern China. The later eruption is characterized principally by rhyolite and although several divisions of this group have been proposed by K. Chern in the Western Hills section, for general correlation they can be grouped together as a single unit. The geological age of these two eruptions can roughly be fixed as from Upper Jurassic to the end of Lower Cretaceous.

(2) The early Tertiary extrusion is very simple in composition consisting almost everywhere of a basaltic rock. The eruption took place probably in Oligocene-Miocene time.

(3) The nature and succession of the intrusive rocks are much more complicated. From the metallogenetic point of view, the basic intrusives can perhaps be excluded, since practically none of them have yielded any important metallic deposits. As to the granitic rocks, at least three or perhaps four types can be distinguished. These may be called: (1) The Mongolian granite of pre-Tiaochishan age. (2) The Lingsi granite[7] which is nearly contemporaneous with the great rhyolite extrusion (3) The grano-diorite intrusion which can perhaps be correlated with the Taitam formation of Hongkong and is of post rhyolitic and pre-Red beds age. (4) The Hongkong granite[8] which is the most widely distributed type in southern China dated perhaps a little later than the granodiorite but is still of pre-Red beds age.*

(4) The lamprophyre and other basic dikes mark the latest phase of the intrusion, with some of them extending even upward into the red beds. (as seen in Hunan and Hupeh).

* If the Tuoli group could be correlated with the Red Beds of Southern China then its post-granitic age should admit of no question. My former idea as to assume the Tuoli beds having been affected by the granite intrusion needs therefore further consideration.

(5) As has been stated before, the most intense orogenic movement took place in the post rhyolitic time, i.e. the phase 4 of the above table. It was also during this very epoch that most of the intrusive rocks like grano-diorite and Hongkong granite were formed. The pre-rhyolitic orogenic period or phase 3 was accompanied by the intrusion of the Lingsi granite and other basic intrusives while the intrusion of the Mongolian granite was perhaps caused by the pre Tiaochishan and Kiulung disturbance i.e. phase No. 2. Thus it is remarkable to see how close these two chapters of the geological processes, orogenesis and vulkanism are related to each other.

4. Metallogenetic Epochs

After the discussion of the orogenic periods and igneous activities, it is now fitting to inquire what would be the most important metallogenetic epochs in China and how are they related to the principal epochs of orogenesis and vulkanism.

A great number of metallic deposits like tungsten, tin, bismuth, molybdenum etc in southern China are genetically related with a granitic intrusion, the lithological characters of which are closely similar to those of the Hongkong granite. On the other hand, the numerous iron deposits of the Yangze Valley as well as the lead-zinc deposits of central Hunan are genetically related with an acid igneous rock which has been variously named as grano-diorite, diorite or quartz monzonite. It can perhaps be correlated with the Taitam formation[8] of Hongkong, and therefore its age of intrusion dated probably a little earlier than the Hongkong granite. The Lingsi granite with which the precious stone deposits of Suiyuan are probably related, has until now not yet been identified in central and southern China. The Mongolian granite which is probably equivalent to the Habota granite (in Jehol) of Teilhard,[7] forms probably the mother rock of the gold deposits. The same rock extend to the Three Eastern Provinces and Shantung as well as in the Tsingling since in these regions gold-bearing quartz veins are also widely distributed. The Kingpeng monzonitic granite in Jehol is yet difficult to correlate with any of the occurrences in southern China; from the occurrence of tourmaline, a mineral of pneumatolytic origin it may be suggested that this is essentially a type of Hongkong granite, since in the latter rock pneumatolytic action as evidenced by the occurrence of tourmaline together with other high temperature minerals is also well developed. Thus for the intrusive magmatic deposits, the following four metallogenic epochs may be distinguished:

Middle Cretaceous?	Epoch 4	Characterized by the high temperature deposits like tin, tungsten, bismuth, molybdenum and the low temperature phase antimony and mercury. Genetically related with the Hongkong granite.
	Epoch 3	Characterized by the contact pyrometasomatic as well as mesothermal deposits of iron, copper, lead and zinc, being genetically related with a grano-diorite intrusion, or the Taitam formation of Hongkong.
Lower Cretaceous	Epoch 2	The formation of precious stone deposits in Suiyuan. It is related with the Lingsi granite.
Upper or Middle Jurassic	Epoch 1	This is chiefly a period of gold formation associated with other metals like copper, lead, zinc and tungsten. The Mongolian granite forms the mother rock of these deposits.

As to the extrusive magmatic deposits two metallogenetic epochs may be distinguished; they are all unimportant and only the non-metallic mineral like fluorite is of some economic value. These two epochs are:

Early Tertiary	Epoch 6	— Traces of copper, cobalt, and nickel forming amygdaloidal filling in basalt. Not important.
Lower Cretaceous	Epoch 5	— Hydrothermal veins or deposits of fluorite in rhyolite, being the exhalation-effect of the rhyolitic eruption. This is the principal source of fluorite in China with Chekiang as the chief producer.

Thus there are altogether six metallogenetic epochs when both the intrusive and the extrusive types of deposits are considered together.

5. Metallogenetic provinces

The regional concentration of one or more similar types of mineral deposit is a fact that has now been widely recognized by geologists of different countries. To De Launy we owe the first introduction of the term "metallogenetic province". The existence of such similar provinces in China was first announced by W. H. Wong[9], who divided the different provinces and zones as follows:

3. Southern China Metallogenetic Province	d. Zone of Mercury c. Zone of Antimony b. Zone of lead, zinc and copper a. Zone of tin, tungsten, bismuth & molybdenum
2. Contact metamorphic province	This includes the famous iron deposits of the Yangtze Valley as well as some copper deposits of the same origin.
1. Pre-Cambrian metamorphic Provinces	A great variety of minerals are included such as gold, tungsten, copper, lead, zinc, and also non-metallic deposits such as asbetos, talc, magnesite, apatite, tourquois etc.

The different metallogenetic provinces herewith proposed are named according to their geographical position, no attempt is made to define the provinces or zones either by kinds of metals or by types of deposits. The reason is obvious because in each province there may occur several kinds of deposits of different origin. In the Nanling region, for instance, the high temperature deposits of tin, tungsten, bismuth etc may be associated with the low temperature type of antimony; such localization being chiefly dependent on their relative distances from the igneous mass (see fig. 1). In other words, zonal arrangement of various types of deposits may be expected in a very small area, such a case is clearly demonstrated in the region east of Yuanning, Kwangsi[10], South of Chenhsien, Hunan and in northern Chükiang; Kwangtung. On the other hand zonal arrangement on a large scale is also present, the most remarkable case being found in the four zones of southern China already so fully described by Dr. Wong. The writer, however, does not agree with him in the naming of the different zones by their characteristic metals. It is of course quite true that a certain metal or metals may be especially concentrated in certain zones, like the mercury of the Kweichow plateau, the antimony of western Hunan etc, but a strict exclusion of others is in most cases impossible. So in the case of western Hunan there occurs besides antimony, also abundant deposits of gold, copper and lead, all of which belong more or less to the same type of low temperature metallization. Therefore, in my opinion if any nomenclature besides the geographical one should be given to these different zones, they should be named according to their type of deposits, like the epithermal zone, the mesothermal zone etc, rather than the zone of antimony, the zone of lead and zinc etc.

In the accompanied map (Pl. I) the different metallogenetic provinces of the late Mesozoic and early Tertiary epochs are indicated. Meanwhile the map shows also principal physiographic units and important structural lines, the latter chiefly following the system recently proposed by J. S. Lee. From west to east these different provinces may be briefly described as follows:

1. Western Szechwan and northern Yunnan:—This is a complicatedly folded and faulted region with numerous igneous intrusions. The principal metallic deposits are copper and gold, of less importance are lead and zinc. The copper deposits of Tungchuan in Yunnan and Huaili in Szechwan all belong to pneumatolytic type with the characteristic gangue mineral tourmaline. The Penghsien copper deposit of Szechwan is of hypothermal type, with chalcopyrite and pyrrhotite as the principal ore. Gold quartz veins are found in the vicinity of Kengting and Tanpa in Hsikang district.

2. Kweichow plateau:—This is a high plateau made by strata of Palæozoic to Mesozoic age. Sharp and closed synclines of small magnitude are of frequent occurrence in an otherwise nearly horizontally bedded uplifted plateau. Igneous rocks are practically absent. Principal metallic deposit is mercury which is especially abundant on the northeastern, eastern and southeastern borders of the plateau, although scattered occurrences are also found in the center of the highland. This mercury belt partly extends to Szechwan in the north, Hunan in the east and Yunnan in the south, so it practically occupies the border land of these three provinces. As is well known in geology all

mercury deposits belong to the epithermal type, being situated very far from the igneous contact.

3. Western Hunan:—This region is characterized by high hills and deep gorges, a topography of slight dissection; it resembles in some respect a plateau although its relief is not as high as that of the Kweichow highland. It forms a transitional land between the Kweichow plateau to the west and the central Hunan hilly region to the east. The geological formations are principally of Palæozoic age forming gentle domes and synclines with only a few occurrences of igneous rocks. The region is richly mineralized, with antimony as the principal ore forming either replacement deposit or fissure-filling vein. The former type is represented by Hsikuangshan at Hsinhua and the latter type by Panchi, Yiyang. In both regions igneous rock is absent. Besides antimony, there are also gold, lead and zinc; the first named is more important and in the Yuanling and Taoyuan districts, gold quartz vein with albite, chlorite etc forms a very characteristic type. Sometimes both antimony and gold or even mercury may be found together in one vein. The lead-zinc deposits have not yet been carefully studied; most probably they represent also a mesothermal to epithermal type. The realgar and orpiment deposits of Tzuli and Shihmen represent also the characteristic mineralization of this region.

4. Central Hunan:—This region comprises central Hunan as well as the northeastern part of Kwangsi; it is made up chiefly of older Palæozoic formations which are intruded at many places by granite or grano-diorite. Closely associated with the intrusions is a series of lead-zinc deposits, with Shuikoushan in Changning as the leading example. The region has been affected by the Caledonian orogenic movement, but besides a few deposits like manganese, this movement seems to have had little influence on the development of metallic ores. The lead-zinc deposits are as a whole of mesothermal origin since only low temperature minerals like chlorite, epidot, sericite, quartz, fluorite, calcite are found among the gangues. On the other hand, a high temperature phase with the development of garnet, diopside etc previous to the episode of the main mineralization is also present, and as a last phase there may occur not infrequently an epithermal type with the formation of zeolite etc. Such a complete sequence has been recently identified in the Shiukoushan deposit.

5. The Nanling region:—As is indicated in the accompanied map the Nanling region comprises also the mountainous belt in central Kwangsi, because there the mineralization shows many similar features with that of the Nanling in the ordinary sense. Within the region considered, tectonic features are very complicated, with here and there large exposures of granite which are undoubtedly connected below to form a big batholith. In the granite or within its contact, a rich mineralization of tin, tungsten, bismuth and rarely also molybdenum is commonly found, all these deposits represent high temperature type being formed at considerable depth and under the active influence of the pneumatolytic agent. At some distance from the igneous contact, there may be found in the slightly altered sedimentary rock, replacement deposits or fissure fillings of lead, zinc and copper, and still further away from the igneous mass; antimony deposit may be found. Such an orderly arrangement of metallogenetic zones from the higher temperature type to the lower ones within an area of only a few tens of square kilometers is well displayed in the Nanling region. Best examples are to be seen in the vicinity of Chukiang, Northern Kwangtung, Chingchuantang, Chenhsien in southern Hunan and east of Yunning in central Kwangsi (Fig. 1). The Nanling region includes therefore a complicated series of deposits of different origin, but predominantly it consists of high temperature types.

6. Southeastern Coast:—This province includes the mountainous regions of eastern Chekiang, Fukien and southeastern Kwangtung. Geologically it consists of an immense field of extrusive rocks ranging in age from upper Jurassic to lower Cretaceous, and penetrated in many places by granitic intrusions of various sizes. The topography is bold and precipitous, presenting a youthful aspect. Metallic deposits are abundant and varied, but they are not as rich as in the Nanling region. Tin, tungsten, bismuth and molybdenum have all been found, the last named one, being specially important in the provinces of Fukien and Chekiang. Deposits of copper, lead, and zinc are also found, which from evidences at hand, seem to belong also to the high temperature type. The only important mineralization related to extrusive action seems to be the fluorite deposit, which finds its chief supply in the province of Chekiang. Within this region, hot springs are exceptionally abundant attaining in most cases very high temperature; they are indicative of the recent volcanic phenomena.

7. Shantung horst:—The shattered horst of Shantung is composed essentially of Palæozoic-Mesozoic formations in the west, and pre-Cambrian mass if with granitic intrusions in the east. Metallic deposits, chiefly gold, are especially abundant in that pre-Cambrian land, being genetically related to a granitic intrusion of at least post Gneiss or perhaps late Mesozoic age, therefore the gold deposits of Shantung are much younger in age than was formerly thought. Most eminent example is the deposit of Chaoyuan which has been mined for a long period of time.

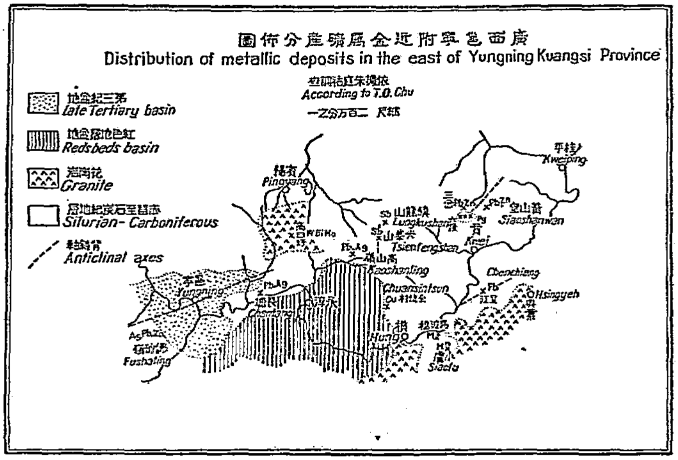

Fig. 1. Zonal arrangement of metallic deposits near Yungning, Kwangsi.

8. Border zone of Shansi and Kweichow plateau:—From a glance at the accompanied map, one will notice at once the symmetrical position of the two plateaus, the Shansi plateau in the north and the Kweichow plateau in the south. The eastern border of these two plateaus show in many places a dislocated zone and closely associated with it are a number of copper, lead and zinc deposits, all being in sedimentary rocks, and very far from any of the igneous exposures. Noted examples are the copper deposits of southern Shansi and northern Honan, the copper and lead deposits of northwestern and southwes-

tern Hupeh respectively. The origin of these deposits still remains obscure; probably they are the product of cold water deposition, the source of the metals being chiefly from solution and concentration of such trifling amounts as were originally contained in the country rocks. Their genesis is therefore closely comparable with the Mississippian lead-zinc deposits of the United States.

9. Hopei-Jehol border land:—In this region gold is the most important deposit with also some lead, silver and zinc, the last three being chiefly found in Jehol. Associated with gold occurs occassionally some tungsten. In the lead-zinc deposits, lead is usually more abundant than zinc, a feature just in contrast with those deposits found in Central Hunan. The geology consists essentially of pre-Cambrian schists and gneisses intruded at many places by granite of different generations with one of them appears to be pre-andesitic and is therefore of pre-Upper Jurassic age. Only the type just named seems to have developed any metalliferous deposits.

10. Liaotung region:—This includes the mountainous region east of the Sungliao plain. The geology appears to be quite complicated by faultings and foldings, but the formations are more or less similar to those seen in northern China. Igneous intrusions and extrusions are abundantly represented. Unlike other northern-China provinces, the Liaotung region is richly mineralized especially in iron. The most noted examples are the iron deposits of Anshan and Miaoerhkou, both of which have supported now a modern iron industry of considerable importance. The origin of these deposit is exceedingly interesting because it shows in certain phases similar development to the Lake Superior iron deposits of the United States. The formation of the proto-ore as well as the secondary enrichment must have been well completed in the Pre-Cambrian time, but later enrichment caused by magmatic activities in the late Mesozoic-Early Tertiary periods may be also of some importance. Besides, there are abundant occurrences of gold, copper, lead and zinc; but none of them seem to have given any important production. The characteristic deposits of the Nanling region like tungsten, tin, bismuth, antimony, mercury etc are conspicuously absent.

11. Yangtze Valley:—Iron deposits formed as an after-effect of the grano-dioritic intrusion constitute the principal mineralization of the region. Several types varying from contact pyrometasomatic to hydrothermal may again

be divided. At Tayeh and Yangsing in southeastern Hupeh, the same magma has developed a copper deposit at its contact with the Permian limestones.

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Table II The Late Mesozoic and Early Tertiary Vulkanism in China

	Western Hills region of Peiping (K. Chern)		Weichang Area, Jehol (Teilhard)		Hongkong (Uglow etc)		Nanking Hills (Yih & Yu)		Eastern Chekiang (P. Kao)	
	Extrusive	Intrusive	Extrusive	Intrusive	Extrusive	Intrusive	Extrusives	Intrusives	Extrusives	Intrusives
Early Tertiary			Basalt				Basalt		Basalt	
UpperCretaceous	Touli group (Sedimentataries)		Conglomerate & gravel		Junk Bay formation, conglomerate, tuffaceous sandstone argillites	Lamprophyre dikes	Chihshan red beds Pukow red beds		Red Beds= Kiangkow series (Purple tuff ss, tuff conglomerate red shales etc.	Lamprophyres
	Unconformity	Aplites & pegmatites	*Unconformity*		*Unconformity*	*Lantoa intrusion* (granite porphyry) Hongkong Granite	*Unconformity*	*Aplite intrusion* (quartz porphyry included)		
Middle Cretaceous?		Andesite dikes & lamprophyre Granite intrusions (4 types are distinguished)		Kingpeng monzonitic granite with tourmaline		Taitam formation (granodiorite, porphyritic horn blende granite porphyry)		Gabbro-diorite & dikes of lamprophyre Grano-diorite intrusion		Granite intrusion
Lower Cretaceous	Tunglangkou Agglomerate & andes te Green rhyolite & pyroclastics Tunglingtai { Rhyolite, trachyte, agglomerate, tuff also tuff, sandstone and shale }		Andesite (Pei-Piao) Great Rhyolite Extrusion	Dikes of basaltic andesite at Linyuan Lingsigranite, pegmatitic with smoky quartz, Probably equivalent to Suiyuan granite with topaz-Beryl.	Rocky Harbour Volcanics a dark colored aphanitic rock with phenocrysts of pink feldspar & quartz		Dacite Rhyolite Series { *Dacite flow*, Dacite tuff, Rhyolitic tuff, Rhyolitic flow }		Rhyolite	
	Unconformity		Unconformity		Unconformity				Unconformity	
Upper Jurassic	Tiaochishan { Andesite, Agglomerate } Kiulungshan		Trachyte. Andesite,	Dikes, laccoliths etc of andesite Biotite granite of Mongolian plateau=Habotou granite.	Repulse Bay volcanics, Lava (felsite, quartz porphyry) agglomerate, tuff, ash beds	Taimoshan Intrusion (Necks, Sills, dikes) quartz porphyry to granite porphyries	*Hsiangshan formation* (equivalent to uppermost part of Tiaochishan with Estheria etc.		*Shaohsing tuff* Hutoushan conglomerate Juao volcanic series	

Table III The Late-Mesozoic and Early Tertiary Metallogenetic Provinces and Epochs in China

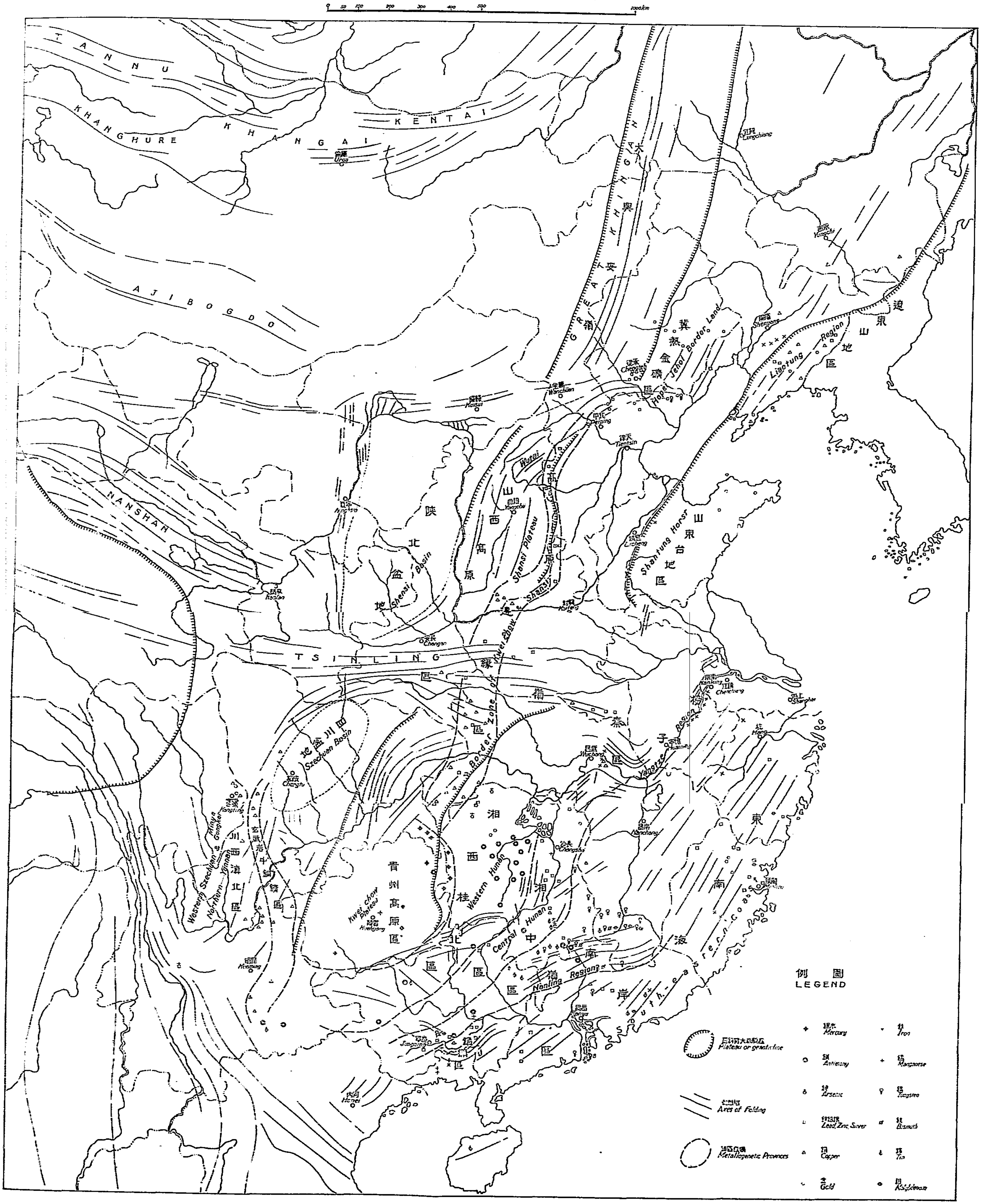
Metallogenetic Provinces	Class of Deposits	A: Deposits related with intrusive rocks				B: Deposits related with extrusive rocks		C: Deposits not related with igneous rocks
	Epoch	Epoch 1 Upper Jurassic	Epoch 2 Lower Cretaceous	Epoch 3 Middle Cretaceous	Epoch 4 Middle Cretaceous	Epoch 5 Lower Cretaceous	Epoch 6 Tertiary	Cretaceous
	Related Igneous rooks	Tungling Granite	Lingsi Granite	Grano-Diorite	Hongkong Granite	Rhyolite	Basalt	
1 Western Szechwan & Northern Yunnan				Cu (Pneumatolytic type) Pb, Zn	Sn hypothermal also Sb of epithermal origin			
2 Kweichow Plateau					Hg (Very far from the igneous rocks			
3 Western Hunan					Sb, (Most abundant) Au, Pb, Zn, Cu.			
4 Central Hunan				Pb, Zn, (Zn >Pb) Cu. (Chiefly mesothermal type)				
5 Nanling					Sn, W, Bi, Mo, (Hypothermal) Pb, Zn, Cu, also Sb of mesothermal to epithermal type)			
6 Southeastern Coast					Sn, W, Bi, (Hypothermal) also Pb, Zn, Cu etc.	Fluorite	Co, Cu in basalt	
7 Shantung Horst		Au (Mesothermal type)		Fe (contact metamorphic type)				Flourite, barite
8 Border zone of Shansi-Kweichow Plateau								Cu, Pb, Zn (Pb>Zn) Tourquois
9 Hopei-Jehol borderland		Au, also Pb, Ag, Zn.	Smoky quartz & precious stones of Suiyuan					
10 Liaotung region		Au, Pb, Zn?		Fe, Pb, Zn?				
11 Yangtze Valley				Fe, Cu (contact metamorphic type)				

中國地質構造及金屬鑛産分佈圖

A Simplified Map showing tectonics and distribution of Metallic Deposits in China

By C. Y. Hsieh 謝家榮

(Tectonics chiefly after J. S. Lee)



ON THE STRATIGRAPHY OF UPPER HUANGCHO AND NANSHAN REGIONS*

BY C. C. SUN (孫健初)

(Geological Survey of China)

In the spring of 1934, Mr. T. F. Hou and the writer were instructed by the Geological Survey of China to explore the provinces of Kansu[1] and Ninghsia with a view to extending the geological map[2] of Suiyuan. They left Peiping on the 7th of May and arrived in Kansu on the 19th. A few days later they started for Yungteng (永登) with the specific object of studying stratigraphically and tectonically the eastern part of the Richthofen Range (See Fig. 1). They returned to Kaolan (皋蘭) from Chingtai (景泰). From Kaolan they proceeded northeastward to Chingyuan (靖遠), Haiyuan (海原) and Chungwei (中衛). Thence they went further northeast to Ninghsia taking a view of the Alashan which constitutes one of the most interesting territories in NW China. Going northward from the Alashan they reached Langshan and turned east to Paotou (包頭) at the beginning of October. In the spring of 1935, continuing the geological survey in Ninghsia and Kansu, Mr. T. C. Chow and the writer again made a reconnaissance in Kansu and Kukunor. Arriving at Sining (西寧) from Kaolan, they went through the Latsishan pass to reach Kueite (貴德) and turned west along the Hueichu river first up to Dabassunnor and the from Dabassunor to Tulan (都蘭). A short excursion was also made to Hsiangjihha (香日哈), in the Tsaidam basin. From Hsiangjihha they moved northeastward to Kukunor and again eastward from Kukunor to Sining. From Sining they proceeded northward across the Tapanshan (Chingshihling) to Mongyuan (亹源) and visited the Tolaishan and the Richthofen Range. They returned eastward

* Received for publication on January, 1936.

1 This has been partly published in Bull. Geol. Soc. China, Vol. XIV, No. 1, 1935.

2 It has been printed in Atlas for Mem. Geol. Surv. China, Ser. A, No: 12, 1934.

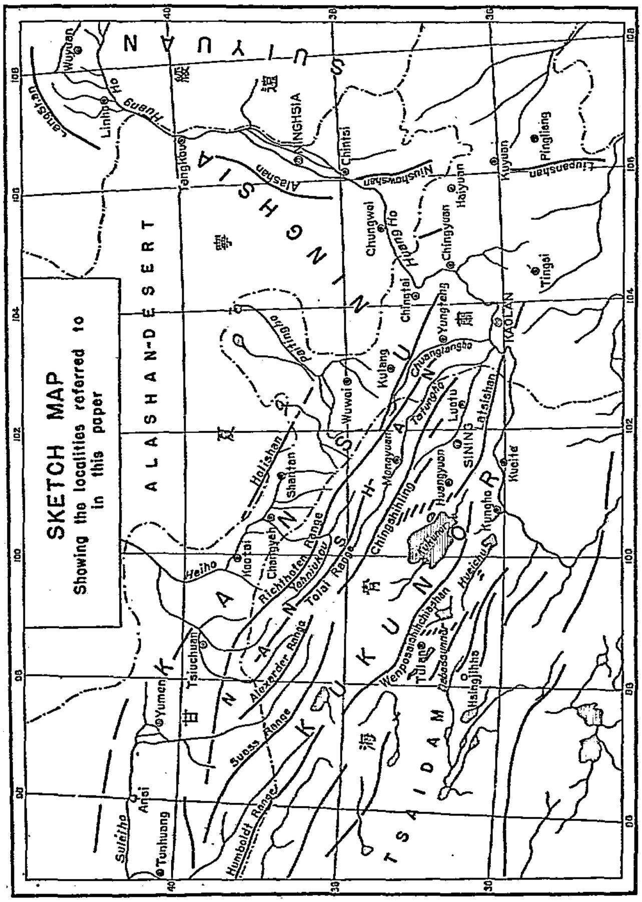


Fig. 1. Sketch map showing the location of the regions visited by the author.

through Tsiuchuan (or Suchow) (酒泉), Changyeh (or Kanchow) (張掖) and Wuwei (or Liangchow) (武威) to Kaolan at the end of October. Thus the geological formations of the Upper Huangho and Nanshan regions became gradually better known.

The fossils collected during these trips have not yet been examined in detail. Only some[1] of the marine fossils have been provisionally studied by Messrs. C. C. Young and Y. S. Chi of the Geological Survey. The geological maps and sections are in preparation. This paper will give only a rough idea of the sequence of the important formations in the Upper Huangho and Nanshan regions.

In the territory studied, the geological formations are represented chiefly by the continental deposits but some of them are developed in marine facies. These formations are separated by several rather pronounced stratigraphical breaks. In descending order they are as follows:

Pleistocene	Loess	about 200 M
	Gravel	" 10 M
Pliocene	Kungho Series	" 500 M
Mio-Pliocene	Sining Series	" 1000 M
Eocene	Ssuk'ou Series	" 1000 M
Upper Cretaceous	Liyuankou Series	" 800 M
Lower Cretaceous	Hungkou sandstone	" 1000 M
Upper Jurassic	Yaochieh Series	" 200 M
Lower Jurassic	Lungfengshan Series	" 400 M
Permian-Triassic	Sitakou Series	" 1000 M
Upper Permian	Yaokou sandstone	" 900 M
Middle Permian	Taihuangkou Series	" 300 M
Lower Permian	Opo Series	" 300 M
Midlle Carboniferous	Yanghukou Series	" 50 M
Lower Carboniferous	Chouriukou Limestone	" 150 M

1 Aseptate Corals and Hybodus; Bull. Geol, Soc. China, Vol. XIV, No. 1. 1935.

Devonian	Chingshihling Series	about 700 M
Devono-Silurian	Kulang Series	" 2000 M
Lower Palæozoic?	Kaolan Series	

The Kaolan Series consists of well bedded gneiss with interbedded mica-schist and occasional marble, all being of sedimentary origin. This series of rock has been invaded and soaked by the reddish or grey biotite-granite. Exposures of this group are seen near Kaolan, Luotu (樂都), Huangyuan (湟源), Tulan etc. The age of this series is still a question. In south Shensi there occurs a group of crystalline rocks, wth granite-gneiss and mica-schist interbedded with bands of marble. The age of these rocks was thought by Y. T. Chao[1] & T. K. Huang to be Wutaian by comparing their lithological character with the metamorphic series in the Yangtze valley. In Suiyuan there is another series of ancient rocks, mainly gneiss, schist and marble, which unconformably underlies the Wutai system. This series has been considered by C. C. Sun[2] as a type intermediate between the Taishan and Wutai systems. Petrographically the Kaolan Series, therefore, is surely comparable with the groups of crystalline rocks in the provinces mentioned above. The Kaolan Series is not a true stratigraphical unit. It, in some cases, passes imperceptibly into the Kulang series whose age ranges from Devonian to Silurian. It is possible that the Kaolan Series is one part of the Kulang Series in a strongly metamorphosed state.[3]

The Kulang Series[4] occurs in Kulang (古浪), Tulan, and Yungteng districts and is often associated with the Kaolan Series as stated above. The

1 Y. T. Chao & T. K. Huang, Geology of the Tsinlingshan and Szechuan, Mem. Geol. Surv. China, Ser. A, No. 9, 1931.

2 Geology of Suiyuan and SW. Chahar, Mem. Geol. Surv. China, Ser. A, No. 12, 1934.

3 Formerly the Kaolan Series was thought to be of Archæan age in Bull. Geol. Soc. China, Vol. XIV, No. 1.

4 During his survey of Kansu (1880), the Australian geologist. L. von Loczy was struck by the frequent presence of a very thick graywacke and phyllite formation intercalated by a few marine limestone layers. To this series, extensively occurring in Nanshan, the name of Nanshan sandstein was given, and it was considered to be Wutaian, or partly early Palæozoic.

total thickness is estimated at about 2000 meters. Dark green graywackes and phyllites predominate. Thin limestones are intercalated in it, chiefly in its upper part. The limestone beds yield tabulate corals (*Pachypora*, *Favosites* etc.), which are, according to Mr. Y. S. Chi. of Devonian age. If this is true the upper part of the series is Devonian, and the lower part may be considered to be Silurian or still older.[1]

The Chingshihling Series: Upon the Kulang Series lies conformably the younger Chingshihling series of purely continental origin. A tolerably complete and continuous sequence of this series, consisting of alternating beds of green and red slates and graywackes in the lower part and massive, green and red graywackes and conglomerates with slaty intercalations in the upper part, has been observed at Chingshihling and in the Richthofen Range which latter is separated from the former by the Tatungho valley. The series, being underlain by the Kulang Series as mentioned above and being followed, with a hiatus, by the Chouniukou Limestone of Lower Carboniferous age, is surely not older than Devonian and younger than early Carboniferous. It is probably upper Devonain in age.

The Chouniukou Limestone: At Chouniukou (臭牛溝), (on the NE slope of the Richthofen Range) the limestone is blue or grey in colour and fine in texture, frequently intercalated with grey and blach shales. From the limestone fossils were collected by Prof. P. L. Yuan[2], indicating a Visean age.

Twelve years later (1892), V. A. Obrutchef paid a visit to the said province and got a collection of Devonian fauna (*Spirifer anossofi*, *Sp. elegans*, *Rhynchonella aliensis* etc.) from the Nanshan Sandstein in the Western Richthofen Range.

In 1934-35, in the course of a journey across the upper Huangho and Nanshan regions, the writer noticed the same series from which the Devonian fossils were also found in the eastern Richthofen Range. He is of the opinion that this series, in fact, may be divided into two geological units, one being of marine origin, which is named Kulang Series, and the other, purely continental Chingshihling Series.

1 Detailed descriptions of this are to be found in Bull. Geol. Soc. China, Vol. XIV, No. 1, 1935.

2 P. L. Yuan, Carboniferous Stratigraphy of NW. Kansu, Bull. Geol. Soc. China, Vol. 4, No. 1, 1925.

The fossil list includes *Productus giganteus* Martin var. *Maximus* M'Coy *Spirifer striatus* Mart., *Orthotetes crenistria* Phillips, *Leptæna analoga* Phillips, *Schizophoria resupinata* Martin, *Lithostrotion portlocki* etc. The formation is also well developed in Yehniukou (野牛溝), Chingyangkou (青羊溝), Opokou (俄博溝), Kuankou (關溝) etc. (in the western Richthofen Range) where it consists of thick bedded, fine textured greyish blue limestone (sometimes interstratified with black shale) with more or less rounded nodules of black flint. Through the whole formation fossils are abundant[1]. The same limestone in Chingshihling, Wenposaishihchiashan etc. is almost wholely metamorphosed and is converted into crystalline, sometimes silicified greyish white limestone which only yields very poorly preserved fossils.

In the Alashan, Niushoushan etc. a greyish black, thick and thin bedded limestone, sometimes with more or less irregular layers of chert, underlies the Opo Series of Lower Permian age. Both on a stratigraphic and lithologic basis, this limestone seems to be equivalent to the Chouniukou Limestone.

The Yanghukou Series: The Series lies immediately above the Chouniukou Limestone or above the Chingshihling Series and is followed by the Opo Series of Lower Permian age. It measures at about 50 meters. The lower part of the series, exposed in Yanghukou (in N. slope of the Richthofen Range), consists of sandstones and thin beds of shale. In the upper part, dark grey shale predominates, containing beds of limestone which yields the typical Penchi fauna.

At Lichiachuan (李家泉), Mokou (墨溝), Yaokou (窯溝) and Hungshanyao (紅山窰) (on the N. slope of the Richthofen Range), the series is again composed of shales and sandstones with layers of richly fossiliferous, grey or yellow limestone.

At Chouniukou, according to Prof. P. L. Yuan, the lower part of the series comprises greenish grey, micaceous, thin bedded sandstone with fossil plants. This is followed by fossiliferous shale and limestone carrying a middle Carboniferous fauna. Here the Opo Series, however, is not observed.

1 From this limestone, T. C. Chow & the writer got a large collection of fossil.

The Opo Series: Lying disconformably on the Yanghukou Series, the Chouniukou limestone, the Chingshihling Series or the Kulang Series is the Opo Series which is observed in the Alashan, Niushowshan, Holishan, Tolaishan, the Richthofen Range and the Alexander Range. In this series, comparatively coarse-grained sandstone and sandy or argillaceous shale with workable coal-seams occur frequently in alternation with beds of marine limestone. They probably are of late Palæozoic age. Among the marine fossils, there occur some forms of brachiopods and fusulinids, which appear to indicate both the Taiyuan Series and the Shansi Series that are well developed in northeastern China and recently considered by paleontologists to be better classified as Lower Permian.

The Taihuangkou Series: The Opo Series is conformably overlain by the Taihuangkou Series which is well developed in the Nanshan region, but becomes very thin in the upper Huangho territory. The prevailing rocks are here dark green sandstone and shale which sometimes contain workable coal-seams or else are somewhat bituminous. As considered by G. Bexell[1], this series corresponds to the Shihhotsu Series of Shansi, probably belonging to the Middle Permian age. From certain horizons of the formation, plant-fossils were collected by Bexell in the Richthofen Range. According to Dr. T. G. Halle they are: *Annularia stellata* (Schloth) Wood, *Sphenophyllum emarginatum* Brongn, *Sphenopteris pseudogermaniea* Halle, *Pecopteris* cf. *orientalis* (Schenk) Pot., *Callipteris* sp.; *Alethopteris Norinii* Halle, *Neuropteris pseudorata* Gothan & Sze, *Protoblechnum wongii* Halle, *Lepidodendron oculus felis* (Abbado) Zeill., *Walchia* cf. *hypnoides* Brongn, *Cordaites* sp., etc. From the same place the writer made another collection of the same flora.

The Yaokou Sandstone: Proceeding upward the Taihuangkou Series in the Nanshan region becomes so pure that the bituminous beds are very scarce. However, toward the top intercalations of red sandstone appear more and more numerous, and by gradual transition the rock becomes a coarse-grained reddish sandstone for which the writer proposed the name of *Yaokou Sandstone*. Going

1 G. Bexell, On the Stratigraphy of the plant-bearing deposits of late Palæozoic and Mesozoic age in the Nanshan Region, Geograeiska Annaler, 1935.

eastward, the sandstone becomes more fine-grained, usually with intercalations of shale.

As no fossils have been found in the formation, its exact age can not be asserted. It may be either the upper portion of the Taihuangkou Series, also of middle Permian age, or of upper Permian age.

The Sitakou Series: Continually overlying the Yaokou sandstone is the Sitakou Series, about 1000 meters in thickness. It consists of green sandstone and shale usually with intercalations of red beds. The plant-bearing beds are not frequently observed. In the western Richthofen Range, in the lower part of the series, Bexell found *Phyllotheca deliquacens* Zal., *Callipteris* sp., *linopteris sibirica* Zal., *Brongiartites salicifolius* Zal., *Rhipidopteris ginkyoides* Schmalh, etc. According to Dr. Halle[1], these forms seem to be late Permian in character. Thus the higher beds may be assumed to correspond to the lower and upper Triassic.

The Lungfengshan Series: In the Upper Huangho region, the Sitakou Series is often succeeded by another coal series, the Lungfengshan Series, in which fine or coarse-grained greenish grey sandstone and grey or black shale, as a rule, predominate, with coal seams from 1 ft. to 15 ft. in thickness. From the formation the writer has found Lower Jurassic plant fossils[2] at Lungfengshan (龍鳳山), Shihkoupu (石溝堡), Sitakou (西大溝) etc. In the Nanshan region the same series occurs not infrequently, conformably overlying the Sitakou Series. At Chienlikouting (千里溝頂), Peitapan (北大坂) and Hsiaoshihmenkou (小石門溝), Wuweihsien (武威縣), it is composed of greenish grey sandstone with beds of black shale and coal seams. The shale is highly carbonaceous and yields some plant-remains including *Cladophlebis* sp., *Hausmannia* cf. *ussuriensis* Kryshtofovich, *Ginkgo* cf. *lepida* Heer, *Podozamites lanceolatus* (L. & H.) etc.

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1 T. G. Halle. On the distribution of the late Palæozoic floras in Asia, Geograciska Annaler, 1935.

2 T. F. Hou & C. C. Sun, A Geological Section NW of Lanchow, Bull. Geol. Soc. China, Vol. XIV, No. 1.

The Yaochieh Series: In the Nanshan region, the deposition of the Jurassic sediments was followed by a period of violent orogenic movement and subsequent wide-spread denudation when the great part of the Jurassic sediments was removed. At Yaochieh (窰街), Tiehmeikou (鐵麥溝), Hungkou (紅溝), the Permian or Permo-Triassic beds are unconformably overlain by probably upper Jurassic strata for which the writer proposes the name of Yaochieh Series. Petrographically, this series may be subdivided into two parts. The upper part is formed of fine-grained red sandstone with intercalated shale which bears poorly preserved *Podozamites lanceolatus*. The lower part mainly consists of dark paper-shale with coal seams and earthy limestone nolules in which fragmentary remains of shark[1] of Mesozoic age have been found.

The Hungkou sandstone: This occurs in Hungkou (in the western Richthofen Range), Tiehmeikou, Yehniukou, Akanchenkou, Talapaikou, etc.; and rests either disconformably upon the Yaochieh Series or unconformably overlies formations ranging from Devonian to Lower Jurassic in age. The total thickness is estimated at about 1000 meters. Cross-bedded red sandstones predominate. Conglomeratic sandstone is usually intercalated in it. This formation shows characters of the Cretaceous red sandstones on the Shensi-Kansu border anl is, in all probability, Cretaceous in age.

The Liyuankou Series: At Liyuankou (梨園溝), SW. of Changyeh, the Hungkou red sandstone is succeeded by a transition zone of green and red sediments. These transition beds are finally replaced by green sandstone and shale, sometimes containing bluish grey earthy limestone layers. This series is very probably equivalent to the formation from which P. L. Yuan has found Cretaceous fossils[2] in the Liupanshan region of E. Kansu.

The Ssukou Series: In 1921, C. Y. Hsieh found, at Ssukoutzu N. of Kuyuan, a thick sedimentary series conformably overlying a series of grey shale

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1 C. C. Young, On a Dorsal Fin-spine of Hypodus. Bull. Geol. Soc. China, Vol. XIV. No. 1.

2 P. L. Yuan, Geological notes on eastern Kansu. Bull. Geol. Soc. China, Vol. IV, No. 1.

and oolitic limestone[1] (probably equivalent to Liyuankou Series of the writer), which is composed of shale and sandstone alternately bedded and with limestone beds and gypsum. The limestone has yielded shells and opercula of a small gastropod, which up to present have not yet been examined by specialists.

The same series was recently discovered by the writer at Shihhsienkou (石峽口), a little northwest of Ssukoutzu. Here the lower part of the series is built up by conglomerate and sandstone. In the middle part, red and green clay-shale predominates, containing gypsum and occasional limestone layers. In the upper part there occurs red sandstone, alternating with clay-shale, which latter unconformably underlies the Sining Series of Miocene-Pliocene age (see below).

The age of the formation in question was thought by J. G. Andersson[2] to be Miocene-Pliocene. However, from the indications given above it seems beyond doubt that the series belongs to the older Tertiary, very probably Eocene.

The Sining Series[3]: In the region of Sining, Kueite, Kaolan and Shihhsiakou, there occurs a red series lying unconformably upon the Ssukou formation and older strata. It consists chiefly of soft red sandstone and clay, sometimes with thin beds of green sediments intercalated with layers of gypsum and rock salt, Chilisaltpeter being not infrequently interbedded in it. In the regions of Sining and Kueite, J. G. Andersson found numerous mammalian bones among which a *Mastodon* is very common, showing more probably that the red beds under consideration belong to Miocene-Pliocene.

The Kungho Series: In the territory from Kueite to Kungho there occurs a formation of reddish fine clay merging upward into yellow sand with layers of gravel, yielding fresh water shells possibly of late Pliocene age. This

1 C. Y. Hsieh, Preliminary Notes on the Topography and Geology of Northern Kansu. Science, Vol. 9, No. 10 1934 (in Chinese) and Geological Notes from Kansu. Bull. Geol. Soc. China, Vol. IV, No. 1, 1925.

2 J. G. Andersson, Geological Notes from Kansu. Bull, Geol. Soc. China, Vol. IV, No. 1.

3 L. Loczy first saw the red beds in Upper Huangho region, he named it the Kueite Series, in view of its typical developement in Kueite basin, which almost includes both the Sining Series and the Kungho Series in this paper.

series of strata was apparently not affected by any deformation of profound character. In the vicinity of Kueite it horizontally overlies the folded Sining Series.

The Gravel: In central Kansu, where the base of the Loess is exposed, it is marked by a gravel deposit of some 10 m. in thickness. The pebbles of the gravel, all of rounded shape, consist almost entirely of metamorphic rocks. Though no fossils have been found the age of the gravel is thought to be lower Pleistocene for it occupies the same stratigraphical position as the Sanmen Gravel of the lower Huangho region.

The Loess: The loess is well-developed in the territory traversed. It is frequently found in valleys, forming cliffs and terraces, and showing the characteristic columnar jointing. From Chingyuan to Kaolan and from Kaolan to Kulang the loess forms a continuous plateau with incised canyons showing the rock floor of older formations.

THE RHODONITE VEINS OF HSIHUTSUN, CHANGPING DISTRICT, NORTH OF PEIPING.*

BY C. C. WANG (王竹泉)

(*Geological Survey of China*)

CONTENTS

INTRODUCTION

The maganese deposit of Hsihutsun was first visited by Dr. V. K. Ting[1] in 1922. During the spring of 1932 while directing students of the Geological Department of the Peking University in the field, the writer had an opportunity to study the deposit. A detailed geologic map has been prepared, but in writing this paper it has been found that field observations were still inadequate for some facts. As the writer was occupied with other works, no report in any form was written until present. It is the writer's pleasure to express his obligations to the kind assistance of Mr. S. Y. Yu and to the students who helped him in the mapping work.

* Received for publication on January, 1936.

1 V. K. Ting: The manganese deposits of Hsi Hu Tsun, Changping Hsien, Chihli. Bull. Geol. Surv. China. No. 4, 1922.

Geological Features

Hsihutsun is situated in a hilly region about 30 li from the margin of the Peiping plain and 80 li from Peiping (Fig. 1). In its vicinity one notices a wide area of granite, consisting dominantly of feldspar and mica and usually exhibiting a profoundly weathered surface (Pl. II, Fig. 1) of loose sands. On the southwest of the granite body siliceous limestone of pre-Cambrian age occurs in a narrow belt (Pl. I), trending from N. W. to S. E. and generally dipping toward S. W. at about 40°-60°. The length of the belt is only about 820 m.

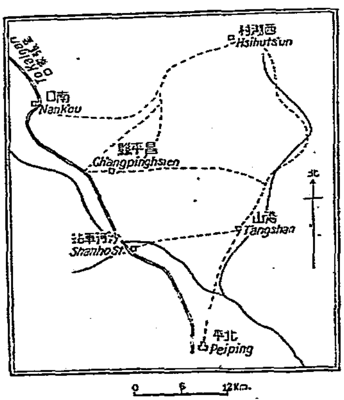

Fig. 1. A map showing the location of Hsihutsun rhodonite veins.

while its width varies from 10 to 150 m. Further, on the S. W. of the limestone there is a plagiaplite series of complicated origin. It is at the contact between the limestone and the plagiaplite series that the rhodonite veins appear. Dr. Ting formerly considered the plagiaplite series to be mainly Pre-Cambrian sandstone and a fault was drawn by him between this sandstone and the siliceous limestone. The writer cannot agree with such consideration, though the partial presence of sandstone in the plagiaplite series is not impossible.

DESCRIPTION OF INTRUSIVE IGNEOUS ROCKS.

In the plagiaplite series there are a great many dykes of varying mineralogical composition intruded in different epoches. The following only treats of a few of them. The nomenclature of the rocks is chiefly according to Prof. A. N. Winchell[1].

Before describing the plagiaplite series the main intrusion in the vicinity of Hsihutsun should be stated first. The rock as shown by handspecimens is gray in color with abundant feldspar and biotite. Under the microscope, the feldspar is composed mainly of orthoclase with a small amount of albite. The latter exhibits finely repeated twinning laminæ with a little higher refractive indices than the former. Quartz occurs only in subordinate quantity. Tabular sections of brown biotite are frequently met with, with marked pleochroism. Green hornblende is present, but partly altered to epidote. The alteration usually begins in the central part and works outward, constituting the so-called "centrifugal" replacement. Long prisms of apatite are often observed as an accessory mineral.

The rock is granular in texture and is considered as *biotite granite*. This granite intrusion constitutes the main part of the range north of Peiping and is perhaps connected with the granite of Pataling, the longest tunnel of the Peiping-Suiyuan Railway, about 60 li northwest of Hsihutsun.

(1) *Plagiaplite*. There are numerous plagiaplite dykes on the southwest of the rhodonite veins, which may not have the same mineral composition, but only one will be mentioned here. Megascopically the rock is light-colored and fine-grained. Microscopically it is composed mainly of tabular crystals or microlites of albite in felsitic texture (Pl. III, Fig. 2). A few phenoscrysts are sometimes scattered in the microlitic groundmass, but they are subordinate in comparison with the latter.

Groundmass—It consists of albite, quartz and hornblende. *Albite*: It generally occurs in microlites. Nm < 1.54 but > 1.525. Optically biaxial and positive. Albite twinning distinct in some less altered crystals but mostly obscure due to alteration. The maximum extinction angle in crystals elongated

1 A. N. Winchell: Journ. Geol. Vol. XXI, No. 3, 1913.

parallel to a is about 16°. Graphic intergrowth with quartz is common. Treated with mineral powder mixed with gypsum, it gives sodium flame before the blow-pipe. *Quartz*: A few quartz grains often fill the interstices of albite microlites They can be recognised in thin sections by their smooth surfaces and higher birefringence. *Hornblende*: It is only occasionally observed with marked pleochroism. Its color is green.

Phenocrysts—They are generally composed of felspar, probably orthoclase. Carlsbad twinning is sometimes visible. Refractive indices are distinctly lower than those of albite microlites. Optically biaxial and negative.

(2) *Alkali granite*. This occurs as a dyke about 80 m. S. of Heitseitzu. It consists mainly of orthoclase and quartz with some biotite in granular texture. Other accessory minerals are exceedingly rare. *Orthoclase*: Cleavage parallel to (001) usually distinct. Twinning is not observed. Mean refractive index is between 1.525 and 1.515. Optically biaxial and negative. *Quartz:* Primary and secondary quartz sections are both present. The latter are usually in small rounded grains or in a series of grains, while the former are generally in big angular fragments. *Biotite*: This occurs only as fragments with distinct basal cleavages. Parallel extinction. Pleochroism strong. In a section normal to Y, X=colorless, and Z=yellow brown. $X < Z$.

(3) *Kersantite*. This is represented by a dyke exposed on the southern slope of Heitseitzu. As shown in figures 2 and 3 the dyke transversely cuts a rhodonite vein or is included in it. Its intrusion is, thus, later than the formation of the vein. The rock is gray and porphyritic and is really a diorite porphyry. But as biotite is especially abundant, it seems better to designate it as kersantite.

Groundmass—*Albite*: It occurs in felsitic tabular crystals and constitutes the main component of the ground mass. Its mean refractive index is generally < 1.54 but > 1.525. Albite twinning is scarcely visible due to alteration. *Quartz*: A few quartz grains fill some interspaces of albite microlites but they are subordinate.

Phenocrysts—*Oligoclase-andesine* (*andeclase*): This forms the chief component of the phenocrysts. Albite twinning is common. The mean refractive index is between 1.540 and 1.550. In a section normal to X, $Z \wedge (001)$ is about 18° and the mineral is, therefore, oligoclase-andesine in a composition of about $Ab_{68}An_{32}$. Optically negative. The mineral is sometimes altered into quartz and orthoclase, resulting in a vermicular texture. *Orthoclase*: Only a few fragments are observed. As the mean refractive index is < 1.54, orthoclase can be easily distinguished from oligoclase-andesine when immersed in liquid. Carlsbad twinning occasionally present. Generally speaking, both plagioclase and

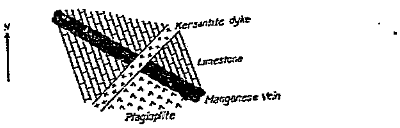

Fig. 2. A rhodonite vein cut by a kersantite dyke at Heitseitzu.

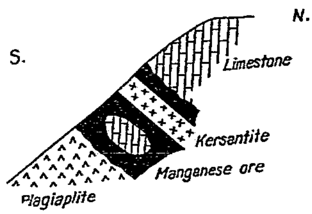

Fig. 3. Section through Heitseitzu showing the intrusion of kersantite in the rhodonite vein.

orthoclase have been much altered and mostly broken into many parallel cracks, indicating that the phenocrysts were once under great pressure before the cystallization of the goundmass. *Biotite*: This occurs abundantly. Some altered six-sided hexagonal basal section shows distinct acute bisectrix figure. In such a section, $2E = 21°$. Pleochroism: Y=yellow, and Z = brownish yellow. In unaltered sections, however, the optic angle is nearly equal to zero and $Y = Z$ = deep reddish brown, X=yellow. Absorption is $X < Y < Z$. Some fragments are cracked and bent, while others are sometimes decomposed into a greenish substance which is nearly isotropic under crossed-nicols, and is probably chlorite. *Hornblende*: It is only represented in a few fragments. The color is bluish green with distinct pleochroism. The extinction angle ($Z \wedge C$) is about 20°.

Besides, there are numerous calcite veins (Pl. III, Fig. 3), crossing both phenocrysts and groundmass. They are probably supergene in origin.

(4) *Grano-diorite*. The exact locality of the rock is not known, but it certainly occurs as a dyke in the neighborhood of Heitseitzu. Under the microscope it is granular in texture. The lime-soda-felspar is more abundant than alkali-felspars. The latter is represented by orthoclase while the former, chiefly oligoclase, is hardly discernible since subsequent alteration obliterated the twinning laminæ.

Oligoclase: The mean refractive index is above 1.525 and very near to 1.54. Albite twinning is common but usually obscure in strongly altered crysals. Optically biaxial and negative. In a section normal to X, $Z \wedge (010)$ is 86°, indicating that the composition is nearly $Ab_{76}An_{24}$.

Orthoclase. It occurs in a few fragments and can be distinguished from oligoclase by its mean refractive index which is less than 1.525 when immersed in liquid.

Biotite: It is generally in tabular fragments with marked pleochoism. X=Yellow, Y=deep yellow and Z=dark brown. Absorption is $X < Y < Z$. Z is nearly parallel to cleavage (001). The optic angle is very small though biaxial character is still clear.

Hornblende: Pleochroism distinct with X=yellow, Y=brownish green, and Z= green. Positive elongation. Optically negative. 2V=large.

Apatite: Generally in prismatic crystals or in irregular grains. Parallel extinction. Negative elongation. Refringence high. Birefringence weak.

MANGANESE VEINS

FORM OF THE VEINS

The rhodonite veins generally exist in the contact zone between the siliceous limestone and the plagiaplite series (Fig. 4) and their width varies from

0.3 m to 2 m. but is most commonly about 1 m. Seven veins may be recognised though they are possibly continuous in depth since they are arranged in the same line.

Vein I. Exposed south of Heitseitzu in contact with the alkali granite dyke (Fig. 5). It has a length of about 18 m. and a width of about 1 m.

Vein II. Situated north of vein I and separated from the latter by the dyke just mentioned. It is about 6 m. long and 1 m. wide.

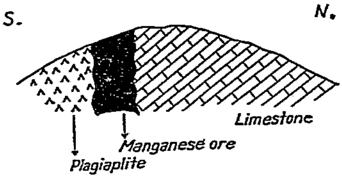

Fig. 4. Section southeast of Yikeshu, showing the occurrence of rhodonite vein between siliceous limestone and plagiaplite.

Fig. 5. Section south of Heitseitzu, showing the contact of alkali granite with manganese ore.

Vein III and IV. Exposed on the south slope of the top of Heitseitzu (Pl. II, Figs. 2 and 3). They trend in a parallel N.-S. direction and are combined into one at their northern ends. They have the same length of about 40 m. with a width varying from 0.5 to 3 m.

Vein V. This lies between Heitzeitzu and Yikeshu, with a length of about 104 m. and a width of 1-2 m.

Vein VI. Situated northwest of Toutaokou. Its length is about 300 m. and its width varies from 0.1 m. to 0.3 m.

Vein VII. Exposed at Sanchiaokou. Nearly 26 m. long and 0.3. m. wide.

DESCRIPTION OF THE MINERALS

The minerals in the veins may be generally distinguished into two groups; one is of hypogene origin or primary minerals and the other is supergene or secondary minerals. The former can only be found in depth and so far as we know it consists only of two mineral species, while the latter is mostly exposed on the surface of the veins.

Hypogene Minerals

Quartz: It is the earliest mineral in the veins. Usually occurring in a considerable quantity in certain specimens. Generally coarse-grained.

Rhodonite: It is much abundant in association with quartz and thus makes the veins a beautiful pinkish color in deep zones. In thin sections it is colorless with distinct (110) and ($1\bar{1}0$) cleavages. Its refractive indices: Np=1.7174, Nm=1.728, and Ng=1.7313. In a section normal to one optic axis, Z makes about 40° with (110) and ($1\bar{1}0$) cleavages. 2 V=80° ± as estimated from the curvature of the isogyre. The extinction angle between Z and prismatic cleavages in a section normal to Y is about 30°. Most crystals show optically positive property but a few give also negative sign. According to A. N. Winchell[1] the former should be called fowlerite and the latter rhodonite. The chemical analysis as shown below contains no zinc but a considerable amount of magnesium, while another analysis gives about 4% zinc. From a pure chemical standpoint the mineral under study does not agree in composition either with fowlerite ($Ca(Mn, Fe, Zn)_5(SiO_3)_6$?) or with rhodonite ($CaMn_5(SiO_3)_6$) and might be termed in a new name "*Hsihutsunite*". Its chemical composition, as analysed by Mr. S. C. Liang, chemist of the Geological Survey, is as follows:—

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1 A. N. Winchell: Elements of Optical Mineralogy, Part II, Sec. edition, pp. 195-196.

SiO_2	44.30%
Fe_2O_3	1.79%
Al_2O_3	0.78%
MnO	42.18%
CaO	4.31%
MgO	6.24%
Moisture	0.10%
Ignition loss	0.21%
Total	99.91%

It generally replaces quartz when it is in contact with the latter (Pl. III, fig. 1). Residual grains of quartz are not infrequently met with.

Supergene Minerals

Psilomelane: It occurs in great quantity near the outcrop of the veins. Under the microscope it shows grayish white color. Its hardness varies from high to medium. All etching reagents as suggested by C. M. Farnham[1] are negative. Colloform structure (Pl. IV, fig. 3) is distinct in some specimens. Under crossed nicols it is isotropic. Two generations of crystals can be observed: residual grains of one generation are commonly included in the other. Psilomelane veinlets are usually found in rhodonite (Pl. IV, fig. 1) or plagiaplite (Pl. IV, fig. 2) and thus replace them. The alteration of rhodonite into psilomelane generally begins with the formation of dark or black masses which are subsequently traversed by numerous psilomelane veinlets.

Manganite: This also occurs in an appreciable amount. Its presence indicates that the deposition of the supergene minerals at least partly took place in a considerable depth.

Megascopic examination: Handspecimens generally show granular, crystalline masses. Giving much water in closed tube. Hardness about 2½. Streak brownish black.

Microscopic examination: Color grayish white. Brittle when scratched with the needle. Reflecting pleochroism strong. Cleavages distinct. All etching reagents are negative. Strongly anisotropic with bluish gray and creamy white colors. Powder yellowish brown. Generally showing intergrowth struc-

1 C. M. Farnham: Determination of the opaque minerals, 1931.

ture (Pl. IV, fig. 4). Replacement of psilomelane by manganite gashes is common. Sometimes residual grains of the former are scattered in the latter.

The chemical composition of manganite as analysed by Mr. T. T. Chang of the Geological Survey, is given below:—

Mn 47.69% (MnO_2	75.47%)
Fe	0.90%
SiO_2	0.39%
Zn	0.16%
Moisture	3.75%

Loss on ignition at 900° C for 1½ hour. 15.88% (Mainly H_2O)

Pyrolusite: It may be present but usually too little to be definitely identified in the writer's collection.

Wad: It is sometimes present in a notable amount in certain localities. Generally occurring as soft blackish earthy masses and occassionally showing cellular texture. Easily crushed into powder when touched with fingers. Mostly altered from psilomelane on its exposed surface.

Calcite: Carbonatization is the last phase of deposition occurring in the zone of the rhodonite veins. Calcite veinlets and coatings are not only frequently found in the manganese ores but also in certain dykes such as kersantite (Pl. III, Fig. 3).

The paragenesis of the hypogene and supergene minerals mentioned is summarized in the following table:—

	Hypogene	Supergene
Quartz	——	
Rhodonite	————	
Psilomelane		————
Manganite		———
Pyrolusite		———
Wad		———
Calcite		———

METASOMATIC PROCESSES OF THE COUNTRY ROCKS

The country rocks of the rhodonite veins are composed mainly of siliceous limestone and plagiaplite. The former generally shows recrystallization only. As an exception one handspecimen in the writer's collection has been found to contain some isotropic mineral showing high refractive index and being thus probably garnet which is the only silicate we found in the limestone. In connection with the alteration of plagiaplite it is exceedingly interesting to note the occurrence of a great amount of sillimanite and andalusite, minerals rarely connected with ore deposits in general. One interpretation is that such minerals are not the product of the metasomatic action of the rhodonite veins but are the result of some general metamorphism caused by other igneous rocks. It is strange, however, that these minerals are scarcely found at a distance from the contact zone of the veins. The minerals in the metasomatic rocks of plagiaplite are mentioned below in some detail.

Sillimanite: This occurs in fibres (Pl. III, fig. 4) or prismatic crystals and may be really termed fibrolites. Its mean refractive index is nearly 1.645. Cross fractures common. Parallel extinction. Positive elongation. (010) cleavage distinct in some sections. Birefringence strong. The optic sign is not easily determinable, since transverse sections are rarely obtained. In one optic normal figure, the color in the direction of the acute bisectrix is orange red while in the obtuse bisectrix it is bluish green. The acute bisectrix is, thus, the slow ray and parallel to elongation. The mineral is then positive.

Andalusite: This is represented by some rounded or irregular grains, with birefringence similar to apatite, but always gives biaxial interference figure. The optical sign is probably negative though not decisive as the interference figure is very feeble. The mean refractive index is higher than muscovite but lower than sillimanite and probably also higher than 1.60 and lower than 1.635. The mineral is provisionally assigned to andulusite though still with some doubt.

Fe-phengite: Occurs as tabular crystals with distinct (001) cleavage. Colorless in thin sections. The optic angle (2V) is very small. Optically negative. Birefringence strong.

Pyrite: This occurs only in a few grains and is partially or wholly altered into hematite.

Secondary quartz: This is characterized by its rounded forms, often replacing feldspar or muscovite. Brownish inclusions common.

Penninite: When the powder of the rock is immersed in liquids, a colorless or yellowish mineral is often found with refractive index about 1.585 and weak birefringence. Optically negative and biaxial with small optic angle. It is probably penninite.

GENESIS AND ECONOMIC SIGNIFICANCE

Though there is a great variety of igneous dykes in the neighborhood of the rhodonite veins, *plagiaplite seems to be the only rock in genetic relation with the veins.* This is shown not only by the common occurrence of plagiaplite in contact with the veins but also by the included ore body in the former as indicated in figure 6.

W. E.

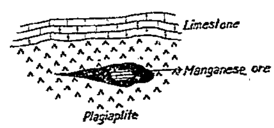


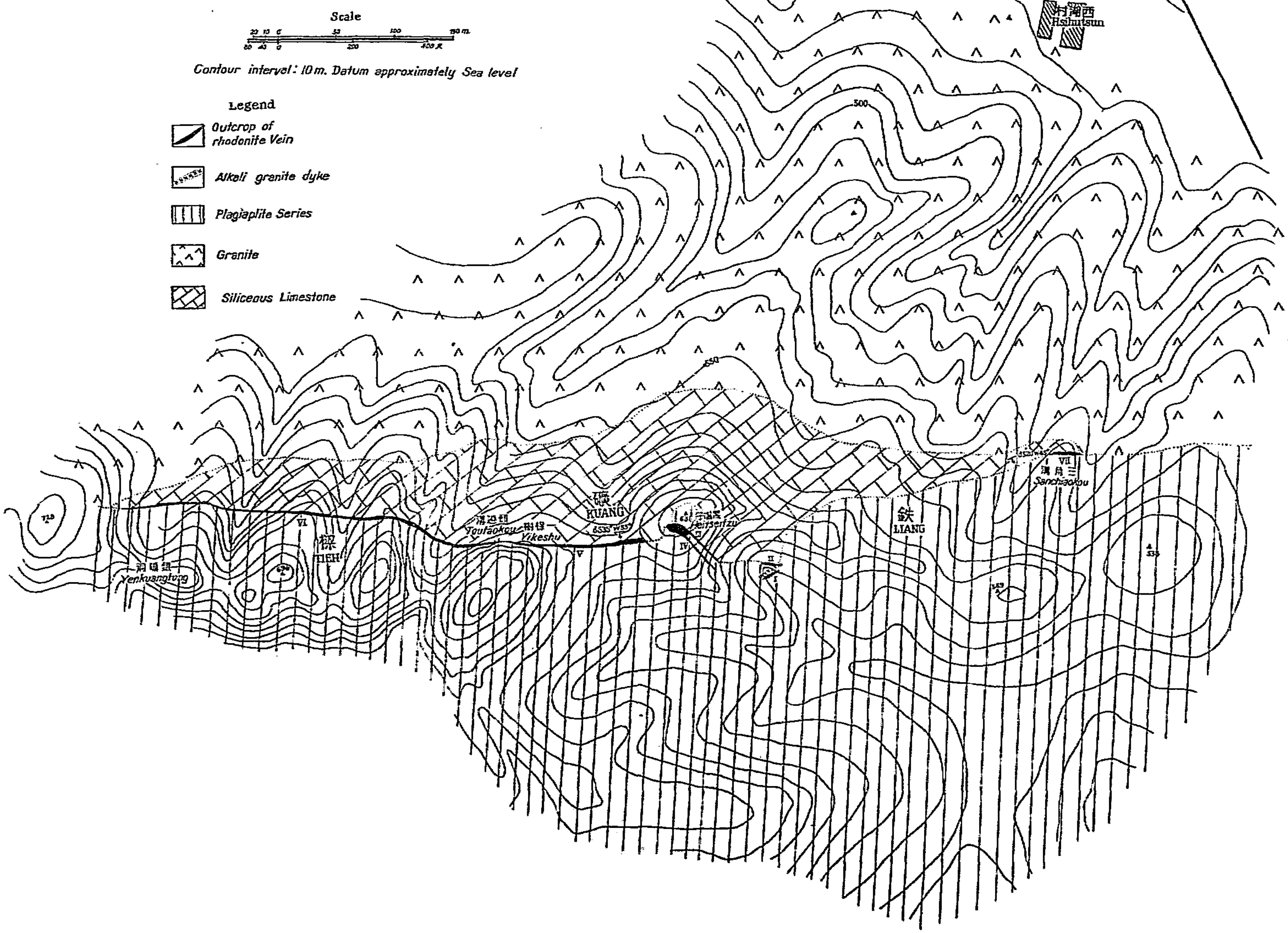
Fig. 6. Section through Heitseitzu, showing the included manganese ore and limestone in plagiaplite.

As to the physical conditions during the formation of the veins, besides the indication by the altered products in the country rock, the rhodonite itself is a high temperature mineral. *Consequently the veins should be classified as a hypothermal type.*

Being situated near Peiping and being not far from the iron ores of Lungkuan, Chahar, their economic value is worthy of paying attention. According to the writer's observation, however, the manganese oxide ores are only superficial and should merge into manganese silicate in the depth. By rough estimation the oxide ores hardly exist 20 feet below the surface, though variations may happen in some localities. The reserve of the ore is, thus, not to be expected in great amount and its economic value becomes doubtful. On the other hand, as Peiping is the centre of precious stone industry, the rhodonite veins may be mined for the purpose of ornamental use rather than for manganese ore.

GEOLOGICAL MAP OF THE RHODONITE VEINS OF HSIHUTSUN (村湖西), NORTH OF PEKING

By C. C. Wang



Explanation of

Plate II

PLATE II

Fig. 1. A distant view of Yinshan (銀山), showing the granite topography. looking north from Heitseitzu.

Fig. 2. Outcrop of manganese ore at Heitseitzu.

Fig. 3. Abandoned pits for manganese prospecting on the southern slope of Heitseitzu.

1

2

3

Explanation of Plate III

PLATE III

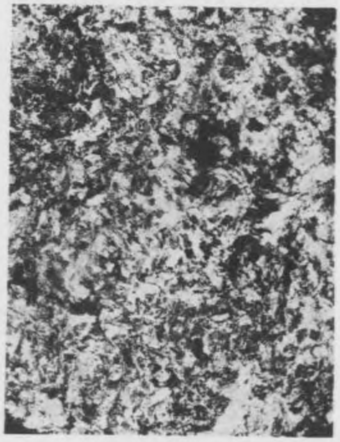
Fig. 1. Replacement of quartz by rhodonite. × 46, parallel nicols. Notice the residual grain of quartz included in rhodonite in the central portion of the picture.

Fig. 2. Felsitic texture of plagiaplite × 45, crossed nicols.

Fig. 3. Calcite veins in kersantite. × 46, parallel nicols.

Fig. 4. Aggregates of sillimanite fibers in plagiaplite. × 50, parallel nicols.

1



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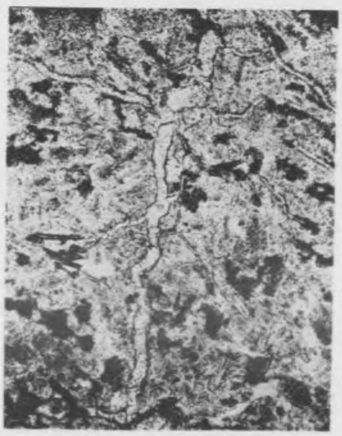

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Explanation of

Plate IV

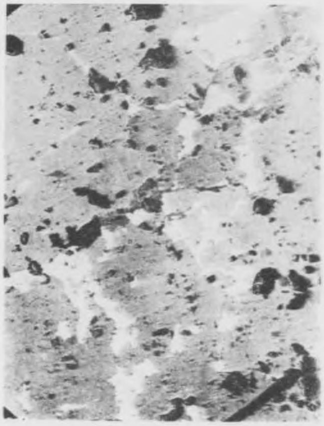
PLATE IV

Fig. 1. Psilomelane veinlets and gashes replacing rhodonite. × 150, parallel nicols.

Fig. 2. Veinlets of psilomelane in plagiaplite. × 42, parallel nicols.

Fig. 3. Colloform structure of psilomelane, × 150, parallel nicols.

Fig. 4. Intergrowth texture of manganite, × 120, crossed nicols.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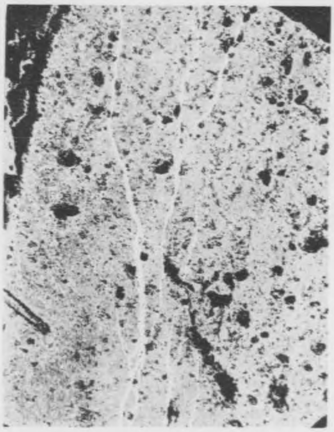
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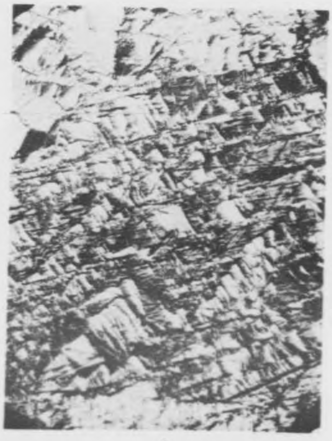
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THE TREMADOCIAN IN SOUTH ANHUI*

By Singwu C. Hsü (許傑)

(National Research Institute of Geology, Academia Sinica)

For a long time I have been doubtful of the age of a nearly homogeneous group of greenish shales which was repeatedly found to lie below the Ningkou Shale, a graptolite-bearing shale of Arenigian age, so familiar and widely distributed in N. Kiangsi, S. Anhui and S. W. Chekiang. Wherever we met the Ningkuo Shale in these provinces, we met the underlying greenish shales too.

In the years 1931-32, while collecting graptolites from the Ningkuo Shale at Hulossu (胡樂司), S. Anhui[1], both Mr. Y. Y. Lee and I observed that below the graptolite-bearing Ningkou Shale there is a considerable thickness of shales from which we failed to find any kind of fossils except one or two indeterminable fragments of trilobites. In the winter of 1934, while studying the so-called Yinchupu Series[2] at Yüchien (於潛), W. Chekiang, I again noticed that the same shales lie below the yellowish, phyllitic *Phyllograptus* shale (equivalent of the Ningkuo Shale) in the middle part of the Yinchupu Series. A similar case was also observed by Mr. Lee at Wuning, (武寧), N. Kiangsi[3], where the Arenigian graptolite shale is underlain by the greenish calcareous shales with a few trilobite fragments.

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* Received for publication on January, 1936.

1 S. C. Hsü: Graptolites of Lower Yangtze Valley, Monograph of National Research Institute of Geology, Academia Sinica, Ser. A, Vol. IV, 1934, p. 4.

2 For Yingchupu Series, see C. C. Liu & Y. T. Chao, Geology of S. W. Chekiang, Bull. Geol. Surv. China, No. 9, 1927, pp. 14-17.

3 Y. Y. Lee: Geology of the Neighbouring Districts of Suishui, N. Kiangsi, Contributions from the National Research Institute of Geology, Academia Sinica, 1933, No. 3, p. 43.I

In the winter of 1935, for the purpose of studying the lower Palæozoic formations in South Anhui, Mr. Lee and I went to Tanchiachiao (譚家橋), a small town about 15 kilometers to the south of the city of Taiping District (太平縣). Here, at the low hills near the town, we again met already the familiar rocks, *i.e.*, the Ningkuo Shale containing the typical Arenigian graptolites and that group of shales lying below it and furnishing, as former experience shows, no fossils except some poorly preserved fragments of trilobite. This time, however, we made up our mind to make a thorough search for trilobites from these shales with a view to get some knowledge about their geological age. One evening, while we were nearly disappointed after a long search in vain and were just on the point of leaving the spot,—a certain spot on the southern slope of a small hill called Lo-to-pei-pao (駱駝背寶) or "The Camel Carrying Precious Stones", about ½ km. to the northeast of the town—one stroke of the hammer, however, brought us a beautifully preserved multi-ramous graptolite on the surface of a slab. The new excitement made us to commence our work anew, and several more pieces of graptolites were obtained. In addition to these, some specimens of trilobites were also found from the same horizon. The graptolites, as well as the trilobites, were later found to belong to a single species. These are *Clonograptus tenellus* var. *callavei* Lapworth[1] and *Asaphus ovatus* Sheng[2].

The graptolite is known to be characteristic of the Shineton shales of Great Britain, while the trilobite is a species newly established by Mr. Sheng and has been first collected by him from the shale below the Arenigian graptolite beds in the Yinchupu Series. It is no wonder that *Asaphus* comes from the same horizon with Clonograptus, since the former may appear as early as in the Tremadocian time though it is characteristic of the Ordovician. Thus the two fossils in association tell us definitely that we are dealing with a Tremadocian formation.

The formation has a thickness of about 230 meters. It is entirely composed of more or less calcareous, slabby and fissile shales generally yellowish

1 Elles & Wood: Monograph of British Graptolites, Part II, 1902, p. 84.

2 S. F. Sheng: Lower Ordovician Trilobite Fauna of Chekiang. Palæon. Sinica, Ser. B, Vol. III, Fasc. 1, 1934, p. 9.

green or bluish gray in color. In its upper part, however, there are purple shales alternating with greenish ones. Its basal part becomes more calcareous and darker in color. To distinguish it from the Ningkuo Shale lying above, I propose the name Tanchiachiao Shale for this group of shales which, in fact, differ very little from one another in lithologic characters and form a rather homogeneous unit. The best outcrop of the upper part (beds 3-7 in the following list) of the Tanchiachiao Shale and the overlying Ningkuo Shale is found at Lo-tö-pei-pao, a small hill mentioned above, whereas the lower part (beds 1-2) of the Tanchiachiao Shale and the underlying impure limestones are best exposed at the highway near Shangchangyüan (上長源), a village about 4 km. to the north of Tanchiachiao. By combining the two sections at the two localities a probably complete succession of the beds of the Tanchiachiao Shale may be obtained. This is shown as follows:

Arenigian, Ningkuo Shale:

Blue and yellowish brown shale containing *Phyllograptus*, *Tetragraptus* and *Didymograptus*, etc.

Tremadocian, Tanchiachiao Shale:

7.	Greenish shale without fossil	10 m.
6.	Yellowish green shale containing *Clonograptus* and *Asaphus*	6 m.
5.	Greenish blue shale containing limestone nodules	2 m.
4.	Greenish gray, fine, calcareous shale containing *Asaphus* and traces of *Clonograptus*	7 m.
3.	Purplish red, soft, clayey shales alternating with greenish calcareous ones, containing *Asaphus ovatus* Sheng	59 m.
2.	Bluish gray to greenish gray, slightly calcareous shale, easily weathered to clay, containing very sparingly small forms of *Asaphus*	121 m.
1.	Bluish gray to dark gray, finely laminated shaly limestone	33 m.

Disconformity

Sinian (?), impure limestones:

Thin-bedded limestones alternating with thick-bedded ones, containing carbonaceous shales especially in the lower part. 500 m.

The section begins with a series of dark gray limestones with black carbonaceous shales in its lower part. Most of the limestones are thin-bedded and containing impure, argillaceous bands at close intervals. In these respects they are similar to the limestone in the lower part of the Yinchupu Series of western Chekiang. The limestone series is correlated with the Töngying Limestone of the Yangtze Gorge by Messrs. Lee[1] and Yü[2]. It is disconformably overlain by the Tanchiachiao Shale which is in turn conformably overlain by the Ningkuo Shale.

The finding of the Tremadocian fauna in the Tanchiachiao Shale in South Anhui show us that the shale which furnishes *Asaphus ovatus* Sheng in the Yinchupu Series of western Chekiang should, on both palæontological and stratigraphical grounds, also belong to Tremadocian. Rocks of the same age probably also occur in Wuning, N. Kiangsi, since, as mentioned above, from the shale below the *Tetragraptus* beds (Arenigian) at Wuning, several trilobite fragments suggestive of the genus *Asaphus* were collected by Mr. Lee. Future discoveries might testify that the Tremadocian has a distribution in Cenrtal China much wider than what we know now.

1 Y. Y. Lee: Sinian Glaciation in the Lower Yangtze Valley (published in this Volume).

2 T. Y. Yü: Sinian Stratigraphy of the Yangtze Valley (Manuscript to be published in this bulletin).

ÜBER EINEN BAUMFÖRMIGEN LEPIDOPHYTEN-REST IN DER TIAOMACHIEN SERIE IN HUNAN*

VON H. C. SZE (斯行健)

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Anfangs 1934 zeigte Dr. Y. C. Sun dem Verfasser einen *Knorria-ähnlichen* Stammrest (Taf. 2, Fig. 7), den er als *Psilophyton* dachte. Der Stamm wurde in den mittel-devonischen Schichten aus dem Fundort Tiaomachien etwa 35 li südöstlich von der Hauptstadt Changsha der Prov. Hunan gesammelt. Dadurch wurde die Aufmerksamkeit des Verfassers darauf gerichtet, dass dort irgendwelche lepidodendroiden Pflanzen vorhanden sein müssen. Ein Jahr später (Jan. 1935), als der Verfasser zufälligerweise in Changsha Herrn K. K. Chao traf, sagte er, dass er ebenfalls ähnliche Reste gefunden hatte (Taf. I, Fig. 6). So ging der Verfasser gleich an den Fundort hin und fand mehrere, interessante, gut erhaltene Lepidophyten-Stämme.

Die Blattpolster sind durchaus lepidodendroid, langspindelförmig (Taf. I, Fig. 4), breitspindelförmig (Taf. I, Fig. 5) bis eiförmig (Taf. I, Fig. 3). Auch die Polster an jüngeren oder kleinen Exemplaren kommen deutlich nur als spindelförmig (Taf. I, Fig. 1,2) vor. Die sigillarioide-syringodendroide Skulpturen sind an unseren Exemplaren durchaus nicht bemerkbar. Die Polster sind in der Mitte eingesenkt (Taf. I, Fig. 3,4,5), weshalb sie auf den Gegendrücken konvex hervortreten (Taf. II, Fig. 4). In der Mitte der Polster findet sich ein Eindruck (Närbchen) von kreisförmiger (Taf. I, Fig. 1,2) oder länglicher (Taf. I, Fig. 3; Taf. II, Fig. 1,2) Form. Die Närbchen sind ebenfalls in der Mitte eingesenkt (Taf. II, Fig. 1,2). Die Ligulargrube und parichnosnärbchen sind nicht nachzuweisen. Die Polster sind speziell an älteren Exemplaren in Schrägzeilen, oder spiralig angeordnet, stark reliefartig vorspringend, die sich meist direckt berühren (Taf. I, Fig. 1-5).

Dass die vorliegende Form eine baumförmige Pflanze ist, geht aus unseren grossen Stammfragmenten hervor (Taf. I, Fig. 3-5; Taf. 2; Fig. 1,2;

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* Received for publication on January, 1936.

4). Es erhebt sich nun die Frage, ob unsere Form zu *Archæosigillaria* oder zu *Protolepidodendron* gehört. Was die Form der Blattpolster angbelangt, schliessen sich die Stämme mehr an *Protolepidodendron scharyanum* Krejci aus dem oberen Mittel-devon von Böhmen, Elberfeld etc. an, doch soll diese Art oder überhaupt die Gattung nach Kräusel und Weyland eine krautige Pflanze sein (Vgl. Wiederherstellungsversuch 1932, b. S. 398). Auch hat Hirmer früher gemeint, dass *Protolepidodendron scharyanum* "möglicherweise eine krautige Pflanze" gewesen ist (1927, S. 319). Da auch die für diese Art charakteristischen einzelnen Sporangien und gegabelte Blätter bei unseren Stämmen nicht nachgewiesen werden können, wöllen wir die Zugehörigkeit derselben zu der Gattung *Protolepidodendron* offen lassen.

Was die Zugehörigkeit unserer Form zu der Gattung *Archæosigillaria* betrifft, so ist hervorzuheben, dass dies ebenfalls zweifelhaft ist, wegen der Form der Blattpolster. Kidstons Diagnosis (1899) von *Archæosigillaria vanuxemi* aus dem Oberdevon von New York und Unterkarbon von Westeuropa und Spitzbergen lautet folgendermassen: "Leaf-scars contiguous, broadly fusiform on younger branches, hexagonal on older stems having a single vascular circatrice." Über die Stellung zu anderen Gattungen werden folgende Bemerkungen beigefügt: "*Archæosigillaria* is distinguished from *Lycopodites* by the contiguous and distinct leaf-scars, which become hexagonal on the older stem by mutual pressure, and the apparently much larger growth of the plant, from *Lepidodendron* by the absence of a leaf-cushion and lateral circatricular (Parichnos) of the leaf-scar, and from *Sigillaria* by its single central vascular-scar, unaccompanied by the two lateral lunate parichnos. The small deltoid lanceolate leaf agrees with that of some species of *Lycopodites*, but not with the leaves of *Lepidodendron* or *Sigillaria*. *Archæosigillaria* forms, therefore, a genus clearly separated from all the other genera of Palæozoic Lycopods."

Da aber die Polsterbildung an den Exemplaren von Hunan durchaus spindelförmig (lepidodendroid) ist, ist die Zugehörikeit zu der Gattung *Archæosigillaria* ebenfalls fraglich, obwohl die "single vascular cicatrice" vorhanden sind (Taf. I, Fig. 1, 2).

Ein anderer merkwürdiger Stamm ist von White aus dem Oberdevon Nordamerikas (unweit Naples, New York) bekannt gemacht worden und als

Archæosigillaria primæva bezeichnet worden (N.Y. St. Mus. Bull. 107, 1907, S. 327). Derselbe zeigt am oberen Ende mehr lepidodendroide, nach unten zu mehr sigillarioide-syringodendroide Skulpturen von mässiger Erhaltung. Die Zugehörigkeit dieses Stamms zu der typischen Gattung *Archæosigillaria* (d. h. typus *A. vanuxemi*) wurde wohl von verschiedenen Authoren bezweifelt (Gothan 1923, S. 224; Pia 1926, S. 240; Hirmer 1927, S. 311). Knowlton (1927, S.64) und Berry (1920) bezeichnen diese Form als *Protolepidodendron*, und so bezeichnet sie auch Seward (1933, S. 142). Kräusel und Weyland[1] neigten aber dahin die nordamerikanische Form von *Protolepidodendron* zu entfernen (1932, S. 188.) Man sieht hieraus, das eine grosse Verwirrung der beiden Gattungen noch herrscht. Der Grösse nach, stimmt unser Stamm wohl gut mit der nordamerikanichen Art überein, doch fehlt die charackteristische sigillarioide-syringodendroide Skulptur. Die Identifizierung der beiden Formen ist daher zweifelhaft. Da aber weder unsere noch die nordamerikanische[2] Form zu den bereits bekannten beiden Gattungen *Protolepidodendron* und *Archæosigillaria* gebracht werden könnte, würde es doch richtiger sein noch zwei neue Gattungen aufzustellen um die herrschende Konfusion klar zu machen. Vorläufig bezeichnet der Verfasser die vorliegende Form mit ? zu *Protolepidodendron* wegen der Ähnlichkeit der Polsterbildung mit der typischen Form *P. scharyanum* Krejci, dabei muss man bedenken, dass unter den Resten von *Protolepidodendron* im Sinne von *P. scharyanum* nicht absolut baumörmige Formen unvorhanden sein dürften. Die Art werde als *arborescens* bezeichnet werden: *Protolepidodendron*(?) *arborescens* sp. nov.

Beiläufig sei noch einen gegabelten Rest (Taf. II, Fig. 8) zu erwähnen, der aus demselben Fundort vorkommt. Ob dieser Rest als Blätter von unseren

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1 Kräusel u. Weyland 1932 a, S. 188, ... Bisher schien *Protolepidodendron* (die zuweilen dazu gestellten "Archæosigillarien" des nordamerikanischen Oberdevons haben damit nichts zu tun) auf das Mitteldevon beschränkt zu sein.

2 Zalessky hat versucht die nordamerikanische Form mit seinen beiden neuen Gattungen: *Helenia* und *Heleniella* zu vergleichen (1931. S. 561......"Alors se poserait la question de rattacher le tronc américain à deux de nos genres à la fois: d'après la partie inférieure du tronc au genre *Helenia* et d'après sa partie supérieure au genre *Heleniella*.)

Protolepidodendron? zu deuten ist, ist nicht zu entscheiden. Die Gabeläste sind so lang oder fast so lang wie der unverzweigte Teil des "Battes" und weisen schräg nach oben. Diese Erscheinung ähnelt besonders die Blätter von *Protolepidodendron wahnbachense* Kräusel u. Weyland aus den Wahnbachschichten (Unter Devon) des Wahnbachtales bei Siegburg in Deutschland. Die Blätter der letzteren Art sind aber kleiner, weil sie wahrscheinlich von der kleineren Dimension des Stamms herrühren. Ausserdem ist noch ein merkwürdiger Fossilrest gefunden worden, dieser ist schlank, langlineal-förmig (ca. 7 mm breit) mit sehr kleinen Narbenzeilen an der Oberfläche. Die Natur dieses Fossils ist unklar und wird vorläufig als Problematica bezeichnet werden (Taf. 2, Fig. 9).

Protolepidodron scharyanum Krejci wurde neuerlich von Prof. Halle in der Prov. Yunnan angegeben (1936, Pal. Sinica. jetzt im Druck). Dass die Identifizierung kaum richtig ist, geht aus der merkwürdigen Skulptur an die Polsterbildung seiner Stämme hervor. (Halle's Text-fig. 1 und Taf. 2, 3). Die einzelnen Sporangien sind aber auch hier gefunden worden (Halle's Taf. 2, Fig. 13, 14). Auch die gegabelten Blätter sind nachgewiesen worden (Halle's Taf. 2, Fig. 6-7; 10, 11, 13). Es handlet sich hier sicher um eine neue Art. Auch die Zugehörigkeit dieser Stämme zu der Gattung *Protolepidodendron* ist wohl noch fraglich.

Schliesslich sei noch *Protolepidodendron lineare* Walkom, *P. yalwalense* Wal. und *P.* (?) *clarkei* Wal. aus dem Ober-Devon in New South Wales zum Verleich heran gezogen. Von den ersten beiden Arten unterscheidet sich unsere Art durch das Fehlen der längsverlaufenden Furchen zwischen den Blattpolstern und auch durch die Blattpolster selbst, die oben und unten recht gut abgegrenzt sind. Von *Protolepidodendron*? *clarkei* unterscheidet sich unsere Art durch die fast nur spindelförmigen Polsterbildungen und durch das Fehlen von "well-defined wide diagonal grooves" zwischen den Polstern. Man kann vielleicht *P. lineare* mit *P. yalwalense* vereinigen, da wahrscheinlich *P. lineare* die jüngere Stammpartie von *P. yalwalense* ist, wie auch Walkom selbst hervorhebt (1928, S. 312). Die Zugehörigkeit solcher Stämme zu der Gattung *Protolepidodenron,* scheint auch von Kräusel und Weyland kaum bezweifelt zu sein (1930, S. 82. Vgl. auch Seward 1933, S. 143). Auch diese Stämme scheinen dem Verfasser baumfömig gewesen zu sein. Die australischen Arten haben wohl grosse Ähnlichkeit mit den von Zalessky aufgestellten Gattungen *Heleniella* und *Helenia* (jetzt *Heleniodendron*)[1] aus dem Oberdevon vom Donetz-Becken. Ob sie damit identisch sind, sei vorläufig dahingestellt. *P. lineare* und *P. yalwalense* schliessen sich mehr oder weniger an *Heleniella* speziell *H. thesdori* an, und *P*(?) *clarkei* ist wohl mehr *Helenia prisca* ähnlich. Zalessky hat offenbar Walkom's Arbeit übersehen, so dass er die australischen Formen zum Verleichen mit seinen Gattungen nicht erwähnte. Bei den Donetz-Arten sind ausser der zentralen Blattleitbündelsnarbe noch die beiden seitlichen Parichnosnärbchen nachgewiesen worden, die Identifizierung derselben mit den australischen Formen bleibt deshalb zweifelhaft.

1 Nebenbei sei bemerkt, dass die Gattung *Helenia* schon vorher von Walcott (1889) für eine kambrische Pteropoden (*Helenia bella*) gebracht wurde. Für die Zalesskysche Gattung schlägt der Verfasser deshalb den Namen *Heleniodendron* (Sze nom nov.) vor. Obwohl der Verfasser früher die Meinung geäussert hatte, dass Heer den Namen *Torellia* unnötigerweise in *Feildenia* umänderte (1931. Lias. Flora v. China. Mem. Nat. Res. Inst. Geology Nanking. No. 12, S. 61), hält er jetzt doch für richtiger den Namen *Feildenia* beizubehalten, wohl weil der Name *Torellia* schon früher für eine Molluskengattung benutzt worden war. Es ist immerhin besser die Prioritäts regeln aufzuerhalten und nicht dieselben Namen in der Palæobotanik und der Palæozoologie zu gebrauchen.

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BEMERKUNG

Soweit nichts anders angegeben, sind die Figuren in nat. Grösse dargestellt. Die Originale befinden sich in "the National Research Institute of Geology" (Academia Sinica) Nanking.

TAFEL

TAFEL I

Protolepidodendron? arborescens Sze (sp. nov.)

Fig. 1. In nat. Grösse, mit einem kreisförmigen bis eiförmigen Närbchen in der Mitte der Polster. Die Närbchen können als "single vascular cicatrice" zu deuten sein.

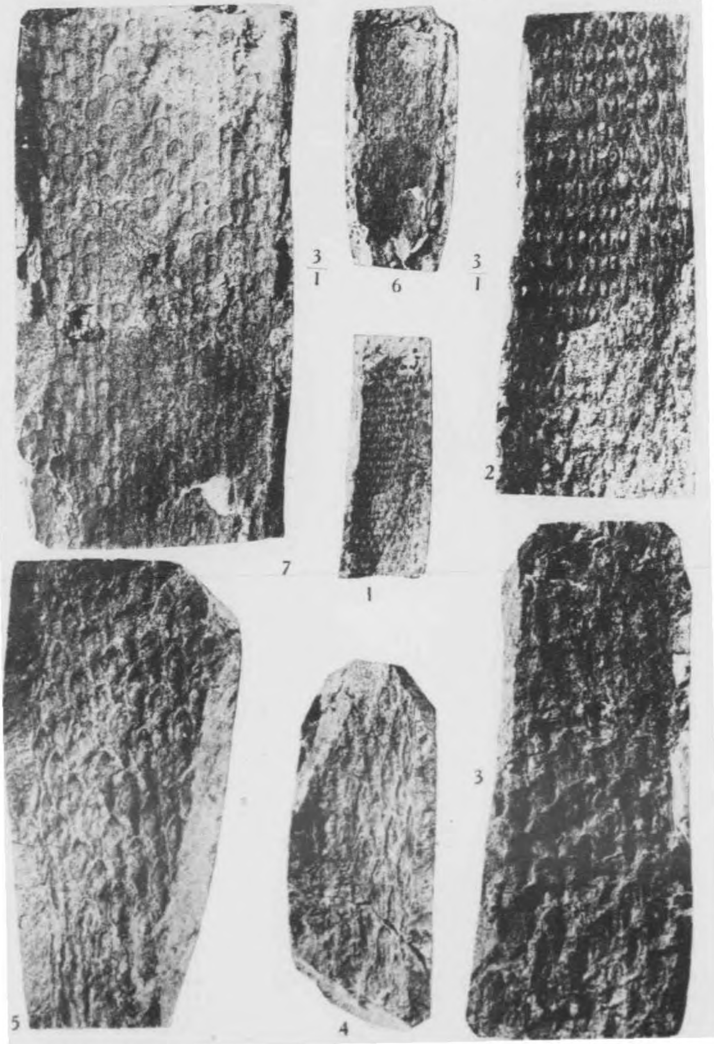
Fig. 2. Dasselbe Stück, dreimal vergrössert.

Fig. 3. In nat. Gr., mit einer ziemlieh grossen, länglichen oder eiförmigen, fast parallel der Aussenkontur der Polster folgenden (oder verlaufenden) Narbe in der Mitte. Die Narben sind ebenfalls in der Mitte eingesenkt.

Fig. 4-5. In nat. Gr., ohne irgendwelche Narben oder Närbchen in der Mitte der Polster, was wohl zufällig und durch den Erhaltungszustand zu erklären ist.

Fig. 6-7. Eine innere und zwar *Knoria*-ähnliche Rindenfläche.

Fig. 6. In nat. Gr., Fig. 7. Partie des vorigen; dreimal vergrössert (Von K. K. Chao gesammelt).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TAFEL II

TAFEL II

Protolepidodendron? *arborescens* Sze (sp. nov.)

Fig. 1. In nat. Gr. Vgl. Taf. I, Fig. 3.

Fig. 2. Dasselbe Stück, dreimal vergrössert.

Fig. 3. In nat. Grösse.

Fig. 4. In nat. Gr. Ein Gegendruck-Exemplar von Taf. I, Fig. 5. Die Polster treaten hier konvex hervor.

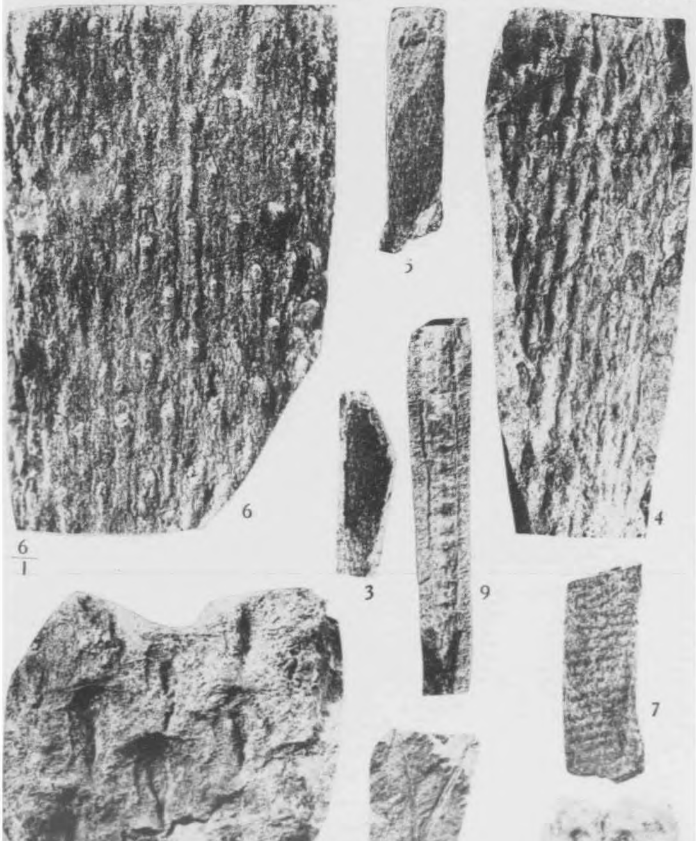
Fig. 5. In nat. Gr. Eine innere und zwar *Knorria*-ähnliche Rindenfläche.

Fig. 6. Partie des vorigen, sechsmal vergrössert.

Fig. 7. In Nat. Gr. Ebenfalls *knorria*-ähnliche Rindenfläche. (Von Y. C Sun Gesammelt).

Fig. 8. In Nat. Gr. Gegabelte "Blatt"-rest von *Protolepidodendron*(?)

Fig. 9. Problematica. In Nat. Gr.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THEORETICAL REFLECTIONS ON THE GEOMORPHOLOGY OF CHINA FROM THE VIEWPOINT OF GLACIO-EUSTATISM.*

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It is quite generally accepted that the growth of the Pleistocene ice-caps demanded world-wide depression of mean sea-level; indeed, as Henri Baulig says, "it expresses a physical necessity." There is striking evidence, moreover, for such a recent depression in the extension of river systems across the continental shelf as submarine trenches of dendritic pattern, a feature met with on most shores of the world and whose localised absence is usually to be explained along simple physiographic lines, such as the lack of streams capable of incising to this extent (e.g. desert shores).

Further, the gradual recession of the ice after each glacial maximum must have entailed a slow rise in sea-level. This is remarkably clear in the case of the last (Würmian) glaciation through such widely spread features as drowned shorelines and river estuaries, the aggradation of river-beds due to the rise in baselevel, and the associated sedimentary infil of the Würmian trenches cut into the continental shelf. The rise in mean sea-level since the commencement of the melting of the Würmian ice will be referred to, for the purposes of this paper, as the post-Würmian transgression.

The purpose of this paper is not, however, to examine the abundant evidence for such eustatic oscillations since this has already been dealt with in numerous papers of which H. Baulig[1] has recently given a critical résumé. The evidence for these movements is so convincing that their actuality will be assumed in this discussion and attention will be concentrated upon China in the light of glacio-eustatism.

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* Received for publication on January, 1936,

1 H. Baulig: "The Changing Sea-Level," Inst. Brit. Geographers, Pub. No. 3., London, 1935.

In the first place the youthful, submerged type of shoreline shown by the 'South China Block' is remarkable.[1] Before seeking what information the eustatic factor can throw on this ria coast it is instructive to consider certain tectonic hypotheses. Perhaps the drowned coast is due to downfaulting on the seaward side together with partial submergence of the landward (upthrow) block. In this case the faulting cannot have taken place in a remote geological period since the shoreline is so youthful; further, two main divisions of such possible faulting may be discussed: a) that in which the fault zone is some distance inland with resultant drowning of the down-faulted region between the fault-zone and the sea. In this case the fault zone should be clearly visible in the field; the majority of rivers should show profile breaks of slope when the faulting has taken place in rocks of high resistance to fluvial erosion; there may even be waterfalls. If in addition there were partial submergence of the landward block then the sub-aequeous profiles of most rivers would be expected to show breaks of slope (unless sedimentation had been very rapid) at that part of their bed crossed by the fault or faults. b) that in which the sea is brought to rest against the fault-face, producing a compound shoreline with partial submergence of the landward block. In such a case the fault-face should be recognizable throughout much of the shoreline affected by faulting, since owing to the reflection of waves from such a face and the initial absence of really effective material for the waves to fling against the cliffs erosion is for some time unusually slow. Moreover the sub-aequeous contours would clearly reveal such faulting if it were of any considerable extent, which is our supposition.[2] However, the irregular pattern shown by this south-east coastal region of China is certainly not characteristic of fault coasts.

In the second place downwarping may have caused the drowning. In this case important river profile modifications must have taken place, and these changes should be clear in the case of rivers that had reached the graded

1 A recent paper dealing with the question is by C. Y. Lee; "Study on the submergence or emergence of the shoreline of China," J. Geog. Soc. China., vol. 2, June 1935.

2 For discussion on fault coasts see particularly, Cotton: "Fault Coasts in New Zealand," Geog. Rev., No. 1., Pgs. 20-47, 1916.

stage before the warping took place, since:—those that flowed seawards at right-angles to the hinge of warping would start downcutting at a rate greatly superior to that they assumed during the graded state, and this increased incision would be greater downstream, where the increase in slope is greatest; those rivers flowing for a part of their courses at right-angles to the hinge of warping, but in a direction away from the sea, would have their slopes decreased and, given identical conditions with regard to load and volume, would start aggrading their beds, (in the case of really violent downwarping their direction of flow might be reversed, etc., conditions which are outside the scope of this paper as regards discussion); rivers flowing parallel to the hinge would probably show a tendency to lateral displacement in a seaward direction.

In all these cases the simplest, symmetrical type of down-warping has been considered; departure from symmetry would naturally demand modifications more or less easily determined. Moreover, the determination of such profile modifications would demand contoured maps of high accuracy, not to mention a knowledge of the geological structure (in its widest sense) and extended field-work, for a critical examination of the warping hypothesis.

If we go beyond simple warping and suggest broad negative (i.e. downward) epeirogenic movement—a possibility that, frankly, must be faced—then difficulties abound, i.e. in the mere determination of the limits of the area affected.

But there is another side to the latter question: there is a youthful shoreline and therefore the supposed epeirogenic movement cannot have taken place in the remote past. If then it took place comparatively recently it can hardly have done so very slowly, for in that case active marine erosion, and sedimentation would have kept pace with the gradual drowning and so prevented the characteristics of a submerged shoreline from obtaining. Thus the movement must have been recent and of no small magnitude; and in that case the limit of the area involved in the downward movement should be clearly defined in that area's peripheral morphology.

It must be stressed that whatever tectonic hypothesis (especially that of faulting) or combination of hypotheses be favoured, a "tangent" shoreline of very great length is here involved, quite apart from the *actual* endlessly ramified shoreline. Should such as hypothesis be proved correct, then the recent activity of such widely-spread tectonic forces will demand an explanation from geophysics.

We have still, however, to consider the eustatic factor. What has been the effect of the Würmian depression plus the post-Würmian transgression? It seems inevitable that, since we are dealing with a shoreline of immense length, unless tectonic movements have so closely simulated eustatic movements as to nullify their effect, traces must abound of a recent downcutting of the rivers into the continental shelf with the later drowning of the coastal region and the development of youthful, submergence type coastal forms such as rias, bay-head beaches, spits, etc. But this is precisely the shoreline type that is observed. The presence of sediment-filled trenches in the continental shelf in continuation of the river systems, and the discovery that most rivers are underfit (i.e. below-grade) and engaged in aggrading their beds seem, to the author, to be expected; it is unreasonable to suppose 'oscillatory' tectonic movements capable of simulating eustatic pulses through such a length of coast. At the same time the length of shoreline is quite immaterial, since the depression of sea level was world-wide.

There is the further point that Pleistocene glaciations earlier than the Würmian must also have had their effect on sea-level, and that the depression at the maximum of those glaciations must have been considerably greater than the Würmian. And furthermore the possibility of tectonic movements locally affecting areas must be allowed for. Before going further the magnitude of these depressions must be briefly discussed.

Ernst Antevs[1], neglecting the effect of downwarp of the glaciated areas due to ice-load, and considering the ice-caps to be plano-convex instead of bi-convex as well as taking no account of the gravitational effect of the ice-masses insisted upon by Daly,[2] gives an estimate based upon the most careful analysis of glacial data of 93 metres for the maximum of the Würmian glaciation (assuming exact contemporaneity of the maximum in each hemisphere), and 88 metres if there were not exact contemporaneity.

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1 Ernst Antevs: "The Last Glaciation," New York, 1928.

2 Daly: "The Changing world of the Ice Age." New York, 1934.

Daly (loc.cit.), allowing for what may be termed deformational and gravitational corrections, gives 75 metres for the Würmian and 90 metres for the maximum depression during the Pleistocene. Moreover he stresses the complicated effects of the earth's elasticity and plasticity on strandline positions in non-glaciated regions, particularly in relation to ocean-bed depression due to increase in post-glacial water-load increase. At the same time it does seem that these estimates are too low; or, in other words, that the applied corrections are too great. It would seem that Daly's depression values are necessary to support his coral-reef theory, rather than that the theory rests upon more generally accepted depression values.

Dubois,[1] neglecting 1) isostatic adjustment of the ocean bed with varying water-load, 2) modifications of the oceanic basins following upon glacial variations themselves, upon the sediments brought by the glacial débâcle, or upon reactionary movements of the continents due to glacial isostatic adjustments, 3) local deformation of the sea-surface caused by variations in the attraction of the glacial masses, gives the following figures:—90 to 100 metres for the Würmian depression, assuming exact contemporaneity in each hemisphere, and 131 metres for the maximum Pleistocene depression, under the same conditions.

Baulig (loc. cit.) commenting on Antevs' figures, stresses the fact that the considering of the ice-masses to have been planoconvex lenses instead of biconvex ones, etc., means that there was more ice, by an indefinite amount. than Antevs allowed for, and that therefore, in the case of the Würmian glaciation, the sea-depression must have been greater than his 88-93 metres; similarly comparable figures, or even larger ones, must naturally be accepted for each of the previous glaciations. In support of this statement it is noteworthy that the Würmian bed of the Rhône-Durance, for example, plunging beneath the delta, the Camargue, would indicate a sea-level of from 100 to 140 metres below that of to-day; the continuation of the profile clearly shows this.[2]

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1 Georges Dubois: "Essai statistique sur les états glaciaires quaternaires et les états correspondants du niveau marin," Ann. de Géographie, XL, 1931. pp. 655-658.

2 H. Baulig: "La Crau et la Glaciation Würmienne," Ann. de Geog., XXXVI, 1927, pp. 499-508.

In the light of these figures it is instructive to consider the "geosynclinal" region to the north of the South China block, that is to say, the Yangtze & N. China Plains of G. B. Cressey.

Well logs show beach deposits at Shanghai at 900 feet below ground-level.[1] The deepest Peiping well records 708 feet of deposits, and Dr. W. H. Wong[2], critically examining well-log evidence in the northern 'alluvial' plain, concludes that it is definitely proved that the delta plain is characterized by great depth of sediments.

The generally accepted opinion regarding such deposits is that a typical geosynclinal region is being dealt with; and, indeed, this solution has much to support it, and in the main would appear to be sound. Barbour[3] mentions that poor preservation of fossil content from various horizons makes dating impossible, and judging from the volume of sediments deposited, and general physiographic considerations, he would say that unquestionably subsidence has been the dominant movement in the main delta of the Yangtze since well before the close of the Tertiary, and that this movement may have halted for a time or had its effect negatived by warping early in the Pleistocene, and has proceeded at an extremely slow pace since. Whether it has ceased or not at the moment cannot be determined with certainty.

On applying the conception of glacio-eustatism to the geosynclinal region one has first to countenance an important query: what was the development of the region before, say, the beginning of the onset of the Würmian glaciation compared with the region's present development? It is clear that, in the present state of our knowledge, this question cannot be answered with certainty, and that arguments will have to be based upon reasonable assumptions and simplifications. Let it be supposed, therefore, that the area occupied by the delta during the Riss-Würmian interglacial times was comparable with that occupied to-day.; further let it be supposed that there was some considerable

1 Walker: Pro. Eng. Soc. China, Vol. 25, Paper 7, 1926, p. 14.

2 W. H. Wong; Sediments of the North China rivers and their Geological Significance," Bull. Geol. Soc. China, Vol. 10, 1931.

3 Barbour: "The geomorphology of the Nanking area," Contrib. Nat. Res. Inst. Geol., Acad- Sin., No. 3, 1933.

depth of sediments—say 150 metres in the thicker, seaward part. Finally, for the purpose of initial simplification, suppose all purely tectonic movements of the area under consideration to be non-existent. Then with the onset of Würmian glacial times there would be a gradual eustatic depression to a maximum of some 100+ metres. This would lead to:

a) The shifting of the strandline very far to the East. The present 100 metre isobath extends, very roughly, from Quelpart Island in the north to Formosa in the South, with an eastward bulge half-way simulating the general curve of the coast. It seems to the author, therefore, that during the maximum of this glaciation the Gulfs of Pechihli and Liaotung, Korea Bay and the Yellow Sea must have been above sea-level; indeed, to take but 100 metres depression for the Würmian is almost certainly too low a figure, so that the strandline must have been even further east, whilst during the maximum Pleistocene glaciation it must have been even further east still. It may be objected in this connection that no allowance has been made for deposition during and since the Würmian recession, and that therefore during the Würmian Maximum the 100 metre isobath must have been much further to the west than it is to-day. On the other hand the sea area considered is so vast that it does not seem to the author that the shift can have been of a magnitude likely to affect the major question. Also, with regard to the shore-forms developed during the maximum depression, the bearing on the present discussion is so slight that reference to these emergence shoreline forms will be omitted.

b) A greatly increased land surface now available for aeolian deposition, such as loess.

c) A probable change in the volume of river water owing to climatic change.

d) The extension of the river systems over what was the submarine delta. Rivers formerly sub-parallel may even become tributaries the one of the other.

e) Owing to base-level depression the rivers will steadily incise their beds, and a wave of retrogressive erosion will pass upstream. Given the low resistance of the sediments to erosion it would appear that this retrogressive wave must have moved rapidly, a point to which we shall later return. Further, it is significant that during this phase of incision there will be the smallest possible tendency for rivers to change their courses.

It is unlikely that during the period of maximum sea-level depression the shoreline would be very greatly pushed back towards the west; certainly not far enough to be worth considering its effect on present conditions in the Great Plain.

With the waning of the ice-sheets the sea-level gradually rose—the post-Würmian transgression. This would lead to:

a) The gradual submergence of land consisting of deltaic sediments formed beneath the sea during the Riss-Würm interglacial epoch, incised by the continuation of mainland rivers, and probably by little developed consequent streams, and probably covered by aeolian deposits whose thickness increases westward.

b) Drowning of the incised river valleys.

c) Sedimentary infil of the now submarine trenches, and the initiation of fresh deltaic deposits at river mouths.

d) The passage upstream of a wave of retrogressive aggradation in the river system due to the rise in base-level.

e) Change in volume of water in the rivers due to climatic change.

f) Finally present-day conditions are reached, with overladen rivers, flooding, and consequent immense river migrations, as in the case of the Hwang-ho; also a tendency to delta extension.

Now it would appear[1], empirically, that a graded river in flood can shift alluvium to a depth below the low-water plane equal to the height of the river at flood above that plane. . .and this is but a minimum value, and it is at flood that the great migrations take place. It follows, therefore, that the depth to which such a great river as the Hwangho can shift alluvium at flood must be very great, and so a great depth of material must have been "refashioned" as well as removed during these wanderings. It is therefore clear that, considering solely the period from Riss-Würm times till to-day, the variety of horizons through which any boring might conceivably pass is not small. . . . even under geological conditions intentionally simplified. It might pass through:

1 H. Baulig: "The Changing Sea-Level", p. 11, footnote.

1) Sediments of Rissian and pre-Rissian age, 2) Riss-Würm interglacial material, 3) Würmian æolian material; (4) Post-Würmian infil of Würmian trenches, 5) Silt of more recent times, 6) Early post-Würmian transgression beach material now covered by more recent delta alluvium due to delta advance; there is even a seventh division if "refashioned" material, due to river migrations, be counted.

Is it to be wondered, therefore, that there is very great difficulty in correlating horizons between wells that are even relatively close to each other?. . . . .and this quite apart from the varied facies characteristic of any single horizon.

If one goes back to earlier Pleistocene times it is logical to ask if there may not also be found evidence for the Günz, Mindel or Riss glaciationsr or even for all three. If so then such record as here is much be preserved in division 1) above; and when one considers that the eustatic depression during the maximum Pleistocene glaciation was much greater than during the Würmian, and further that the series of events outlined for the Würmian would be repeated for each of the earlier glaciations, the complexity the existing record must have is certainly not encouraging to the investigator.

And it is less encouraging still if the conclusions of Maurice Gignoux[1] and other investigators be valid, namely that the mean sea-level at each inter-glacial stage was progressively lower than at the previous inter-glacial stage. Moreover, we have purposely neglected negative or positive epeirogenic or warping movements accompanying the glacial cycles sketched above; but it would seem to the author that such movements are unlikely to have been of such magnitude and contemporaneity that the effects of the glacial cycles could have been nullified.

But there is another line of investigation: it has already been stressed that eustatic depression has as a corollary the origination of waves of retrogressive erosion passing up the river systems. Now the waves initiated by a base-level depression of considerably more than 100 metres during the Würmian, and of even more than that during the maximum Pleistocene glaciation, can have been by no means insignificant, and given at first unresistant deposits to pass through

1 M. Gignoux: "La Géologie Stratigraphique", Paris, 1926 (giving the results of his own work and of that of others).

they must rapidly have moved upstream and so reached the delta hinterland of more resistant rock in which river trenches had already been cut.

Now in a very great number of papers recently published in China and dealing with more or less large regions attention has been drawn to recent downcutting of the rivers followed by aggradation. Further, it has been natural to infer that such similarity of action probably occurred more or less contemporaneously, and so an attempt has been made to view synchronically such stages as the Yangtze of Willis, Chao and Huang[1], the Pukiang of Barbour[2]; the North China Panchiao of Willis, Andersson, Barbour and Teilhard[3]; etc. In each case the main reason for increased downcutting is given as "warping"; and the wider the observations are extended the more synchronous cases of warping we seem likely to be presented with.

It would seem to the writer that the Würmian eustatic depression with the associated retrogressive erosion might very well account for this increased and ubiquitous incision; and do so, moreover, in a very simple and "expected" way. And besides, should this suggestion be proved correct, a date has been found for the period of the downcutting. Similarly the aggradation would be a consequence of the eustatic rise since the beginning of the recession of the Würmian ice-sheets.

And further, it is to be expected that previous waves of retrogressive erosion occurring during pre-Würmian Pleistocene glacial maxima must have left their mark in the same way—that during the greatest ice-extension should be conspicuous, considering the depth of the eustatic depression—and each followed by an aggradational wave. Is it possible that such stages as, e. g., the Chingshui [3,4,5] have some such origin?

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1 Chao & Huang: "Geology of Tsinlingshan & Szechuan", Geol. Sur. China Mem. A. 9.

2 Barbour: "Geology of the Nanking Area", (loc. cit.)

3 Barbour: "Geology of the Kalgan Area", G. Sur. C. Mem. A. 6.

4 C. C. Sun: "Geol. of Suiyuan & S.W. Chahar", G. Sur. C. Mem. A. 12.

5 Teilhard & Young: "Some Correlations between the Geol. of China and the Geol. of Mongolia", B.G.S.C., vol. 9, no. 2.

At the same time it is quite within the realms of possibility that such general downcutting in, say, Würmian times has been locally hindered or aided by crustal movement. In any case the investigator must be prepared for this probability.

No attempt has been made in this paper to solve problems; indeed, its aim has been to be suggestive rather than conclusive. Attention has been directed upon those world-wide eustatic movements of Pleistocene times which much necessarily have left their trace on Chinese morphology. In addition, certain probable results of these movements have been suggested, and certain major lines of attack have been touched upon.

THE SINIAN GLACIATION IN THE LOWER YANGTZE VALLEY*

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In 1919, while on a visit to Wuning, Kiangsi, I happened to cross a rock exposure along the northern slope of Shuangchiaoshan (雙橋山) 1 mile and half SSE. of Honlu (橫路). My attention was immediately attracted by the presence of a peculiar bed, which consists of a fine, gray clay mixed up with sands of various sizes and sub-angular pebbles and which has a thickness of about 5 m.[2]

One year later Mr. C. Li and I noticed again a bed of a similar description in Lantien (藍田), Siuning Hsien (休寧縣), Anhui.

Last winter, Mr. S. C. Hsü and I paid another visit to Lantien and made a close investigation of the bed exposed on the northern slope of the Chinyinshan (金銀山), Lantien. It consists chiefly clay usually mixed up with sands and pebbles or boulders and possesses precisely the same characteristics as those which we saw in Honlu, Kiangsi. The clay is extremely fine, pure and greenish gray when fresh, but turns yellowish gray after exposure. The sands range from the size of rice up to that of a pea, while the pebbles or boulders are ½″ up to 5″ in diameter; they are more or less sub-angular. The large boulders seem to be very few in number, but it is believed that in a better outcrop more large boulders might be obtainable. Owing to deep weathering, striations on the boulder-surface are naturally not preserved. The sands and pebbles are usually derived from quartzite or sometimes from sandstones. The large boulders are composed of various silicified material but more usually of granites and mica schists both of which, however, are not to be found in the vicinity. This being so, it may be reasonably suggested that the source of the granite and mica schist boulders must be sought somewhere else, anyway, it must be very far away from Lantien.

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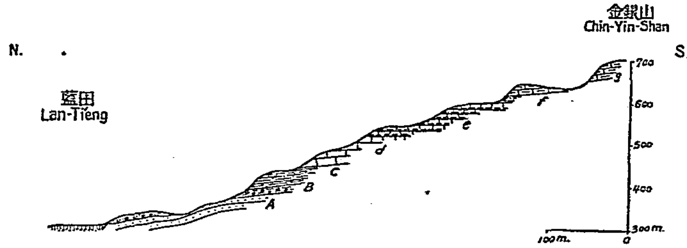
The clays, sands and boulders are usually mixed up in an irregular manner, but sometimes do show some sign of bedding, the pebbles or boulders lying flat. In Honlu, Kiangsi, the bed, however, does not show the slightest sign of bedding.

From the above data, we may conclude that the beds consisting of clay, sands and pebbles or boulders in Lantien, Anhui, and in Honlu, Kiangsi, are of glacial origin. The presence of the sign of bedding might perhaps be due to pressure from the overlying strata or due to subsequent orogenic movement in the case of Lantien. The "tillite", in the case of Honlu, lies below a series of shales and limestones of about 500-800 m. in thickness[9]; which again disconformably underlie Cambrian shales. Below the tillite occurs a hard, white quartzitic sandstone of 100 m. thickness. This is the Tungmen sandstone[2] which rests unconformably on the Honlu series. Both the Tungmen Sandstone and the series of shales and limestones mentioned above are supposed to be of Sinian age. The "tillite" of Lantien is in the same stratigraphical position as that of Honlu, it underlies a series of shales and limestones, with more



g. Silicified Limestones or silicified bed, consisting of alternating white and black layers, each layer 1/10"1-/50".
f. Dark to gray calc. shale. C—f Thickness 120 m.
e. Light gray, pure and thin bedded Limestone interbedded with cacl. sha e; each bed 1"-2".
d. Carbonaceous, thin bedded Limestone interbedded with calcareous shale; each bed 1"-2".
c. Brittle, thin gray shale.
b. Yellowish to bluish gray clay or shale mixed up with round and Subangular bouders3"-5" in diameter, and sandy grains 5-10 m. thick (tillite)
a. Fine purple sandstone (Siuning sandstone)

limestones in the upper and more shales in the lower part. The limestones are again succeeded by a silicified limestone.

The section of the Chinyinshan at Lantien, Siuning, is shown in Fig 1.

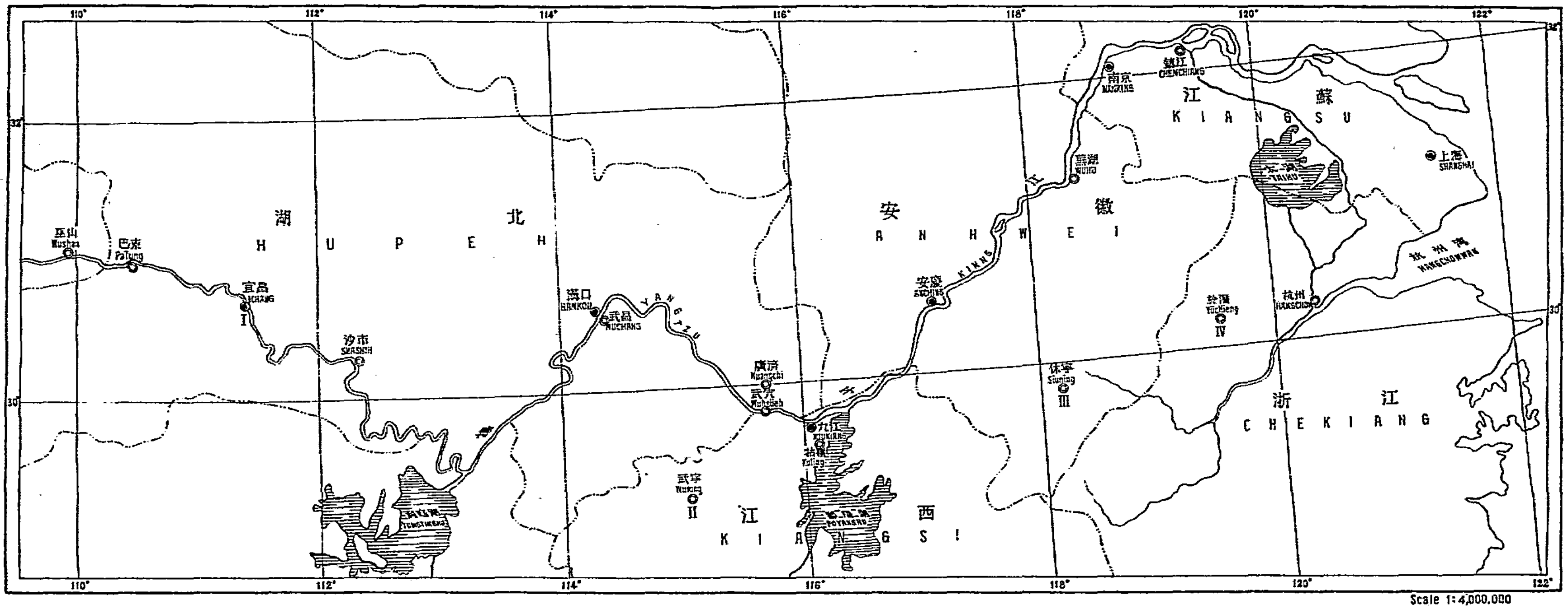
Although the purple sandstone (A in Fig. 1) is poorly exposed in Chinyinshan, a continuous exposure of 8 miles is met with in the SE. The strata show a gentle dip and form hills some 400 m. above the stream bed This sandstone is also found in the N. about 5 li from Lantien and extends farther north for 2 miles, dipping 30°-70° towards south. It consists either of purple fine sandstone or green sandstone or both. Occasionally it contains a soft yellowish brown argillaceous sandstone, with a basal conglomerate of about 40 m. thick. The total thickness of the sandstone, judging by the area occupied and by its dip angle, attains at least more than 500 m. . We may propose the name "Siuning sandstone" for this very thick unit.

The Siuning sandstone rests unconformably on a series of phyllitic shale etc., for the former strikes N. 70° E. and dips 70° to S. whereas the latter strikes N. 70°-85° at the place known as Ihushui (一壺水), 5 miles north of Lantien.

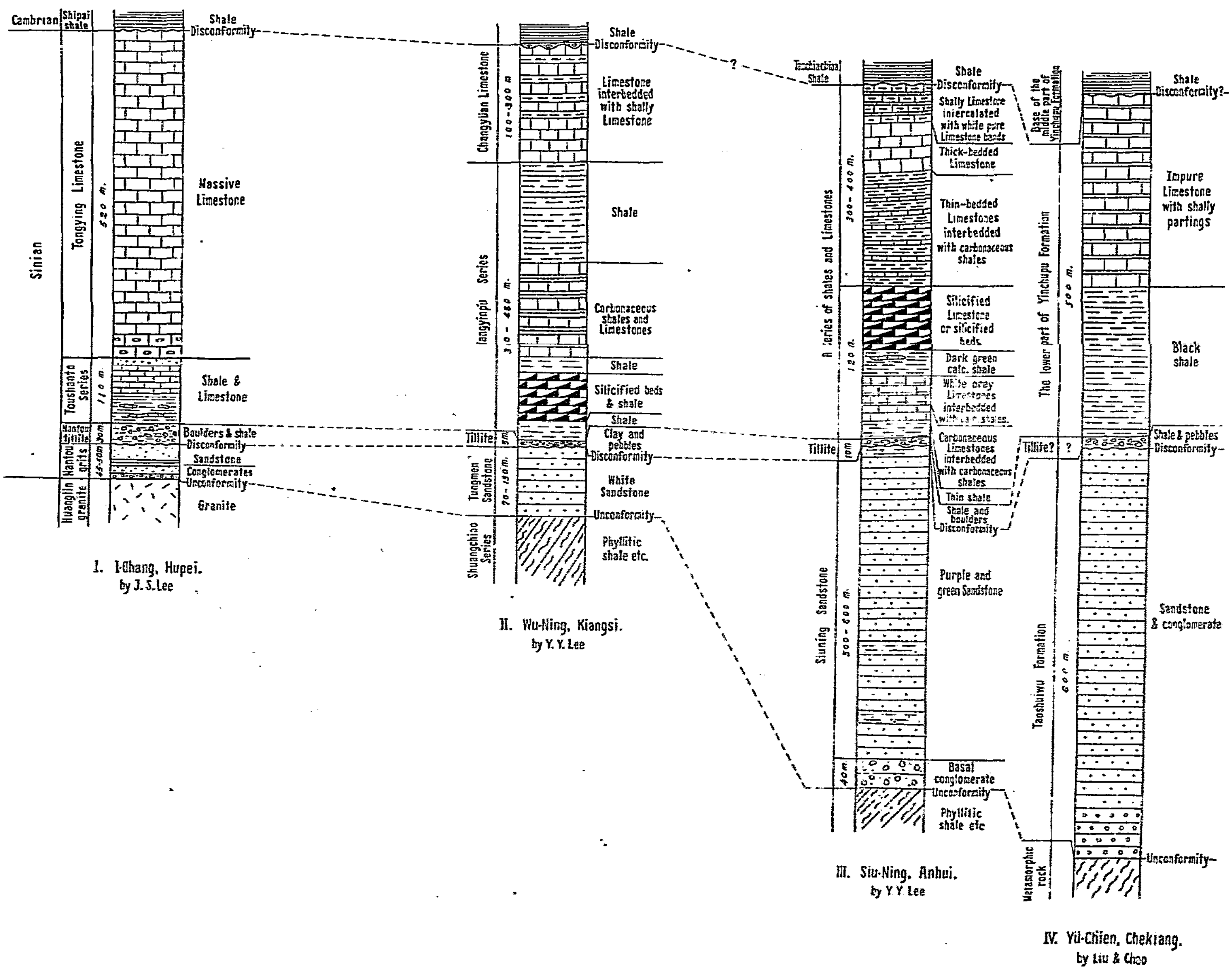
Lithologically and stratigraphically the Hsiuning sandstone can be correlated with the Nantou Grit[1] of Poof. J. S. Lee and with the Tungmen (洞門) sandstone[2] of the writer.

The series of shales and limestones above the tillite is already described in the section, but the silicified limestone (g) is also exposed at about 1 km. N. of Lantien forming a gorge where it has a thickness of more than 100 m. Above the silicified bed comes a series of carbonaceous shales intercalated again with silicified limestone, the top of which cannot be seen here, but the typical carbonaceous shale is unmistakably found at T'anchiachiao (譚家橋), Taiping Hsien (太平縣), (about 25 miles NE. of Lantien), where it gradually passes up into a very thick sequence of gray limestone intercalated with shaly limestone and white gray thin-bedded limestone towards the top. This sequence is again disconformably overlain by a uniformly gray, calcareous shale containing Upper Cambrian trilobites and graptolites (Tremadoc)[3].

The series of shales and limestones above the "tillite" and below the Cambrian shale can be correlated with the T'ushant'o (陡山沱) Series and Tungying (燈影) Limestone of the Yangtze Gorge[1] and with the Wongyinp'u



110°
112°
114°
116°
118°
120°
122°
32°
30°
湖 北
H U P E H
安 徽
A N H W E I
江 蘇
K I A N G S U
浙 江
C H E K I A N G
江 西
K I A N G S I
巫山 Wushan
巴東 Patung
宜昌 ICHANG
I
沙市 SHASHIH
漢口 HANKOW
武昌 WUCHANG
YANGTZU
廣濟 Kuangchi
武穴 Wuhsueh
九江 KIUKIANG
姑塘 Kuling
武寧 Wuning
II
安慶 ANKING
KIANG
蕪湖 WUHU
南京 NANKING
鎮江 CHINKIANG
上海 SHANGHAI
休寧 Siuning
III
於潛 Yuchien
IV
杭州 HANGCHOW
杭州灣 HANGCHOWWAN
Scale 1: 4,000,000



Cambrian
Shipai shale
Shale
Disconformity
Sinian
Tongying Limestone
520 m.
Massive Limestone
Toushantо Series
110 m
Shale & Limestone
Nanto tillite
30m
Boulders & shale
Disconformity
Nantou grits
Sandstone
Conglomerates
Unconformity
Huanglin granite
Granite
I. I-Chang, Hupei.
by J. S. Lee
Shale
Disconformity
Changyüan Limestone
100-300 m
Limestone interbedded with shally Limestone
Iangyinpu Series
310-460 m.
Shale
Carbonaceous shales and Limestones
Shale
Silicified beds & shale
Shale
Tillite
5m
Clay and pebbles
Disconformity
Tungmen Sandstone
70-130 m.
White Sandstone
Unconformity
Shuangchiao Series
Phyllitic shale etc.
II. Wu-Ning, Kiangsi.
by Y. Y. Lee
?
Shale
Shale
Disconformity
Shally Limestone intercalated with white pure Limestone bands
Thick-bedded Limestone
A series of shales and Limestones
300-400 m.
Thin-bedded Limestones interbedded with carbonaceous shales
Silicified Limestone or silicified beds
120 m.
Dark green calc. shale
White gray Limestones interbedded with ... shales
Tillite
10m
Carbonaceous Limestones interbedded with carbonaceous shales
Thin shale
Shale and boulders
Disconformity
Siuning Sandstone
500-600 m.
Purple and green Sandstone
40m
Basal conglomerate
Unconformity
Phyllitic shale etc
III. Siu-Ning, Anhui.
by Y Y Lee
Base of the middle part of Yinchupu Formation
Shale
Disconformity?
The lower part of Yinchupu Formation
500 m.
Impure Limestone with shally partings
Black shale
Tillite?
?
Shale & pebbles
Disconformity
Taoshuiwu Formation
600 m.
Sandstone & conglomerate
Unconformity
Metamorphic rock
IV. Yü-Chien, Chekiang.
by Liu & Chao

(王晉舖) series and the lower part of the Changyuan (章源) limestone of Wuning, Kiangsi.

If the above correlation holds good the tillites both in Lantien and in Honlu would fall exactly in the horizon of the Nantou Tillite.

With reference to Chekiang; farther E. in the Lower Yangtze Valley, the Hsiuning sandstone may be compared with the Taoshuiwu (倒水塢) sandstone[4] and the series above the tillite with the lower part of the Yinchüp'u formation (印渚埠層)[3,5]. Thus it might be worth while to look for similar tillites at the base of the Yinchüp'u formation[7].

With the knowledge already obtained from the 3 localities, Ichang (宜昌); Wuning, and Siuning; we may reasonably conclude that the Sinian glaciation had an already known extension of 800 km. from W. to E. (See Plate I). Further research will undoubtedly throw more light on this very interesting subject.

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8. Singwu C. Hsü: The Tremadocian in South Anhui (See p. 105-108 of this Bulletin).

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