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STRATIGRAPHY, PALAEONTOLOGY AND PALAEO-GEOGRAPHY OF THE AMMONITE FAUNA OF THE CLYMENEENKALK FROM GREAT KHINGAN WITH SPECIAL REFERENCE TO THE POST DEVONIAN BREAK (HIATUS) OF SOUTH CHINA

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I. INTRODUCTION

The Devonian has been known in China since 1920 through the work of Grabau and C. C. Tien (on brachipods), Y. C. Sun and K. K. Chao (on ammonites), Y. C. Sun, Y. S. Chi, C. C. Yu and H. C. Wang (on corals), but the Upper Devonian stratigraphy of China remains obscure.

Grabau first pointed out the fact that the *Clymenia* fauna originated in the Boreal Sea and widely distributed in Northern Europe such as Southern England, Western France, Poland, and also the Pyrenees, and the Alps. This can be clearly indicated by the fact that the *Clymenia* fauna is well developed in the rocks of the Ural geosyncline, and Southern Russia appears to be the only possible line of their connection. Thus, the Boreal sea was connected with both the Caledonian and Uralian Geosynclines, which laid along the periphery

of the growing fan of river deposits that were spread from the Atlantic over the Russian plain. The presence of the *Clymenia* fauna in the Ural Geosyncline like its precursor *Intumescens* fauna which was probably pelagic, might suggest that it was first developed also in the Boreal realm, whence it spread mainly over northern Europe. However this fauna is absent in China as well as in the Southern Hemisphere.

The so-called Famennian Hsikwangshan formation of Hunan has been a conflicting problem between Tien and other geologists owing to the fact that this formation is underlain by the Shetienschiao formation of Frasnian age and characterized by *Yunnanellina*, *Yunnanella*, *Tenticospirifer* together with *Camartoechia hsiwangshanensis* on the one hand, but up to now none of the European Famennian index forms has ever been found in that formation and the two formations are conformable on the other hand.

Y. C. Sun was the first one to point out that the Famennian (D_3^2) was entirely absent in Eastern Yunnan, where the Frasnian Itate formation of Poshu area is certainly disconformably overlain by the Kolaoho formation, and characterized by a typical Frasnian form *Manticoceras wedekindi* Sun, *Camartoechia* and *Yunnanellina uniplicata*. Certainly a hiatus occurs between Itate formation (D_3^1) and Kolaoho formation (C_1^1).

Again, T. F. Hou reported that in Szechuan the Chungchangkou formation of Tournasian age overlays directly upon the Tangwangchai formation of Frasnian age. This hiatus is due to the uplifting which is equivalent to the Liukiang movement of S. Chu. It is widespread in South China and clearly indicates that there the Frasnian sea was rather widespread whereas the Famennian sea dwindled and was marked by continental deposits.

Evidently the existence of the Famennian in South China has been in dispute for fifteen years among our palaeontologists and stratigraphers. It is hoped that the present article will help to settle this dispute through detailed study of the biostratigraphy of the Upper Devonian formations of South China together with the new discovery of the Clymeneenkalk in Great Khingan.

Finally the writer wishes to express his thanks to the Soviet specialists, Yegolova and Wustalisen, and he is also indebted to Prof. Sun under whose direction the present paper is made.

II. NEW DISCOVERY OF THE CLYMENEENKALK FROM GREAT KHINGAN

Recently Y. Wang and C. S. Ning discovered the Upper Devonian in Suhuho area and classified the Upper Devonian into the Lower Suhuho and the Upper Suhuho formations. These two formations representing both the Frasnian and Famennian formations of Europe respectively are separated by a great hiatus.

The Lower Suhuho formation is characterized by the Hsikwangshan fauna probably of Frasnian age, while the Upper Suhuho formation yields *Phacops granulatus** Münster, *Cyclocyclicus* cf. *veericocus* Gelt., *Plicochonetes exginanus* (Verr), *Favosites gasimuricus* var., *Cyclocyclicus* ex gr. *conideus* Gelt., *Pen-*

*Identified by Soviet specialist Yegolova.

tagonocyclicus ex gr. *uastus* Gelt. The discovery of *Phacops granulatus* suggests the presence of the Famennian rocks in China, however further work is still required before a final settlement could be reached.

More recently from the uppermost *Wunerl* series (Upper Suhuho formation) at Taminshan, Great Khingan, a rich Clymeneen-fauna was discovered by L. Lee and M. L. Chang under the direction of speciliasit Wustalisgen. This fauna* represents certainly the ammonite assemblages of the Clymeneenkalk of Europe, and comprise 5 Families, 11 genera and 30 species of Ammonites together with other group of fossils.

Our fauna of Taminshan belongs to the *Sporadoceras-Prolobites* beds and corresponds to the Lower and Middle Famennian of Rhine region of which the Ammonites zones were established by Wedekind and Schindewolf.

The stratigraphy of the Great Khingan may be summarized as follows (modified after Wang and Ning see table 3):

Surperformation: Lower Carboniferous sandstone
— disconformity —

Suhuho Series: (Upper Devonian)

Upper Suhuho formation (=Famennian D₃)

Classic sediments in Suhuho area and represented by conglomerats, sandstones, shales and limestones; but the type Clymeneenkalk predominating near Taminshan area and represented by pinkish limestones with the following species:

Cheiloceras subpartitum Münster
C. globosum Münster
Sporadoceras pompecky Wedekind
S. biferum Phill.
S. rotundum Wedekind
S. subbilobatum Münster
S. latilobatum Correns
S. several sp. nov.
Pseudoclymenia weissii Wedekind
P. several sp. nov.
Postprolobites frechi Wedekind
P. several sp. nov.
Platyclymenia annulata Münster

— disconformity —

Lower Suhuho formation (=Frasnian D₂):

Brownish and greyish-green sandstones and shales only found in Suhuho area, sandstones and shale in the Lower, limestone in the upper, yielding the following species (identified by Prof. K. Y. Chang):

Cyrtospirifer (Sinospirifer) cf. *sinensis* (Grabau)
Camarotoechia cf. *hsiwangshanensis* Tien
Yunnanella sp.?
Schizophoria cf. *macfarlanii* var.
Atrypa desquamata

Middle Devonian: Halahaho formation (Givetion D₂).

The faunal assemblage of the Lower Suhuho formation is represented by several Hsiwangshan forms, although the material is poorly preserved and further systematic collecting of fossils in that area is urgently needed.

Except *Phacops granulatus* which is common in both areas, all the other

* Ammonite faunas there will be fully described by the writer in a separate paper.

Ammonite fauna of Clymeneenkalk was collected from one single bed of 1 m thick.

This fauna is rather complex, comprising the characteristic zone fossils from *Cheiloceras* beds to *Postprolobites* beds. It is probably due to the high development of the organism in the great center of evolution—the Boreal sea.

It is quite possible that our fauna, characterized by the predominance of *Sporadoceras* and *Prolobites*, might represent the *Sporadoceras-Prolobites* zone of the boreal province together with a few relic (*Cheiloceras*) and early appearing genera (*Postprolobites* etc.).

III. DISCUSSION ON THE UPPER DEVONIAN STRATIGRAPHY OF SOUTH CHINA AND ITS STRATIGRAPHICAL SIGNIFICANCE (BREAK)

It is obvious that the late Upper Devonian formation is absent in South China and the Devonian is directly overlain by the Lower Carboniferous formation with a pronounced hiatus. Such a relation may be briefly reviewed in the following:

(I) Eastern Yunnan (After C. W. Ku and Y. C. Sun).

The Upper Devonian of Eastern Yunnan is subdivided by Ku and Sun as follows:

Superformation: Lower Carboniferous impure crystalline limestone
— disconformity —

Iate formation: Black and deep grey marly limestone with *Manticoceras wedekindi* Sun, *Yunnanellina uniplicata* Grabau, *Tenticospirifer* sp., *Camarotoechia* sp., *Schizophoria* cf. *macfarlanii* (Meek), *Amphipora* sp., *Atrypa desquamata* Sow., *Hypothyridina parallelepipedum* (Bronn) etc.

The Iate formation characterized by *Manticoceras wedekindi* Sun, *Yunnanellina uniplicata* and *Tenticospirifer* has been considered by Sun and Ku to be of Frasnian age, the Famennian being entirely absent.

(II) Kueichow (After S. S. Yoh).

According to S. S. Yoh, the Upper Devonian of central and southern Kueichow is subdivided as follows:

Superformation: Kolaoho formation of Lower Carboniferous.
— disconformity —

2. Yaoso formation—Grey marly limestone with *Amphipora* sp.

1. Wangchenpo formation—Grey limestone intercalated with shales in the middle and lower parts, containing *Cyrtospirifer* (*Sinospirifer*) *sinensis* (Grabau), *Schizophoria* cf. *macfarlanii*, *Gypidula simplex* Grabau, *Atrypa desquamata* Grabau, *Atrypa aspera* var., *Fasciophyllum brevisseptum* Frech, *Phacellophyllum irregulare* Grabau.

As the Wangchenpo formation characterized by *Cyrtospirifer sinensis* usually passes up into the Yaoso limestone, these two formations form one big unit of sediments of Frasnian age.

(III) Hunan (After C. C. Tien).

The succession of the Upper Devonian of Hunan is as follows:

Superformation: Lower Carboniferous.
—hiatus and disconformity —

Upper Devonian (Human series):

(B) Hsikwangshan formation characterized by *Yunnanella* and *Yunnanellina* faunas.5. Makunao limestone with *Yunnanella* fauna.Zone of *Tenticospirifer hsikwangshanensis*.Zone of *Camarotoechia hsikwangshanensis*.Zone of *Huanospirifer wangi*.Zone of *Yunnanella supersynplicata*.Zone of *Yunnanella synplicata*.4. Tutzutang limestone with *Yunnanellina* fauna.Zone of *Yunnanellina hanburyi* mut. *latiformis*.Zone of *Yunnanellina hanburyi* mut. *uniplicata*.

3. Changlungchich shale, same as Tutzutang limestone.

(A) Shetienchiaio formation characterized by *Cyrtospirifer* fauna.

2. Shetienchiaio beds—limestone with intercalations of shales and sandstones.

Zone of *Atrypa hunanensis*.Zone of *Camarotoechia shetienchiaensis*.Zone of *Hypothyridina cuboides*.

1. Lungkouchung beds—sandstones and shales with two or three intercalations of shaly limestones.

Zone of *Atrypa douvillii* var. *lungkouchungensis*.

— conformity —

Middle Devonian.

The Hsikwangshan formation is put by Tien in the Famennian, but on the contrary it has been considered by Sun to be still of Frasnian age, because *Yunnanella*-*Yunnanellina* fauna is sometimes associated with *Manticoceras* and *Cyrtospirifer* of Frasnian age. It is also probable that the *Yunnanella*-*Yunnanellina* fauna predominates in the high beds of the Frasnian.

(IV) Kwangsi (Modified by Y. C. Sun and T. C. Lu).

Upper Devonian rocks are widely distributed in Kwangsi. Lithologically speaking they may be grouped into two formations: the Yunghsien above and the Liukiang below.

Superformation: Lower Carboniferous.

— disconformity —

2. Yunghsien limestone—with *Yunnanella synplicata* var. *Y. mesoplicata*, *Y. ericksoni* Grabau, *Cyrtospirifer* (*Sinospirifer*) *vilia*, *C. gartoni* Grabau, *Productella subaculeata* mut. *alpha*.1. Liukiang series—shales in the lower and characterized by *Cyrtospirifer* and *Manticoceras* faunas; limestones in the upper member (Kueilin limestone member).*Cyrtospirifer* (*Sinos.*) *sinensis* Grabau.*Amphipora asiatica*.*Manticoceras kwangsiense* Chao.*Manticoceras* cf. *Cordatum* Sandbergers Wedekind.*Lobabactrites kwangsiensis* Chao.*Lobabactrites naningensis* Chao.*Eoboloceras anguisellatum* Chao.*Boloceras acutum* Chao.*Ponticeras regulare* Chao.*Ponticeras kwangsiense* Chao.

— disconformity —

Middle Devonian.

According to K. K. Chao and S. S. Yoh, the Upper Devonian of Kwangsi

is subdivided into the Lower (Liukiang) series, the middle (Kueilin limestone) and upper (Yunghsien limestone). The Liukiang series was put by Lee, Chang and Chao in middle Devonian, but it has been considered by Sun to be of the Frasnian, because both *Manticoceras* and *Cyrtospirifer* faunas are represented in that series which represents a facies-change with its equivalent Kueilin limestone. More recently Chao^[13] corrects its age and puts it in early upper Devonian. Accordingly the overlying Yunghsien limestone might also belong to the late Frasnian.

(V) Lungmenshan of Szechuan (After Y. T. Chao, T. K. Huang, S. Chu).

The Devonian stratigraphy of Lungmenshan area was first studied by Chao, Huang and later by Chu. Recently S. S. Yoh has worked out more sections of the Lungmenshan area, and subdivided them as follows:

Superformation: Lower Carboniferous.

— disconformity and hiatus —

Upper Devonian: Tangwangchai series.

2. Mao-pa Limestone (D_3^{-2}): Chiefly light grey and whitish grey pure limestone with oolitic structure in the top part, fossils rare.....300 m.

Camartoechia hsikwangshanensis Tien,

Hunanspirifer cf. *ninghsiangensis* Tien.

1. Shawotze Dolomite (D_3^{-1}): mainly whitish to brownish grey crystalline dolomites intercalated with rather pure limestones, richly fossiliferous350—550m.

Tabulophyllum gorskyi kuanwushanense Yoh,

Peneckiella shawotzeensis Yoh,

Keriophyllum temeniophylloides Wang,

Syringopora sp.,

Cyrtospirifer (*Sinos.*) *sinensis* (Grabau),

Cyrtiopsis spiriferoides Grabau,

Cyrtiopsis shawotzeensis Yoh,

Cyrtospirifer (*Sinos.*) *subextensus* (Grabau),

Atrypa douillii Mausuy,

Meristella kutzingensis Grabau,

Camartoechia cf. *shetienchiaensis* var. *beta* Tien,

Athyris chitzechiaoensis Tien,

Campophyllum crypophylloides Yoh,

Campophyllum pasi Yoh,

Temeniophyllum ovaliforme var. *minor* Yoh,

Middle Devonian: Peshihpu series.

The two formations of Tangwangchai series mentioned above might belong to one unit of Frasnian age.

On the basis of the analysis of faunas, cycle of sedimentation and of the stratigraphical hiatus of the Upper Devonian of South China, we have not sufficient reason to prove the existence of the Famennian in South China. Hence, it is better to place the Upper Devonian (Hsikwangshan formation) of South China within the Frasnian.

IV. CONCLUSION AND PROBLEM ON THE ORIGIN OF THE *Clymenia* FAUNA

FROM THE CLYMENEENKALK OF GREAT KHINGAN

The discovery of the *Clymenia* fauna from Great Khingan is of special significance. The fauna was obtained from a limestone bed (1 m. thick) of

the Upper Suhuho formation of Famennian age which lies directly upon the Lower Suhuho formation of Frasnian age with a pronounced hiatus.

The Upper Suhuho formation at Taminshan is represented by a rather thick series, usually over 1000 m in thickness and rich in *Ammonites* and *Clymenia*. As the lithological character of the Clymeneenkalk is rather similar to the Clymeneenkalk of West Europe, the age of this formation is certainly of Famennian first known in China. Palaeogeographically, the *Clymenia* fauna is restricted to the Clymeneenkalk of the Upper Suhuho formation of 1000 m thick in Taminshan area, while the same Trilobite fauna (*Phacops granulatus*) was also found from the same formation of another locality at Suhuho, with a thickness of 600—800 m. This clearly shows that the boreal invasion came from the Northeast and that the old land mass was in the Southwestern area—the Suhuho area.

The clymeneenkalk is an essential member of the Upper Suhuho formation deposited in the Mongolian Geosyncline which was separated by the Sino-korea Plateform on the Southwest. That is, the Boreal Sea transgression entered the Mongolian Geosyncline, but never went further to the Southwest. This can be further proved by the absence of Famennian formations in North and South China.

Palaeontologically, the *Clymenia* fauna was considered by Grabau and others to be of Boreal origin. The succession of the section from Suhuho to Taminshan in Great Khingan might serve to support his view. Moreover, the *Clymenia* fauna of Taminshan is also represented by *Sporadoceras-prolobites* zone of European classification, but it is of complex nature, both relic and early appearing forms being present. The only explanation is that the Great Khingan region is near to the Boreal Sea, a main center of the organic evolution of the *Clymenia* fauna.