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寒武紀下界問題

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摘要

寒武紀下界是國際上爭論問題，並已列入第20屆國際地質會議討論問題之一。著者認為結合古生物和地層方法是解決寒武紀下界的唯一途徑，決不應強調任何一種方法。

中國震旦、寒武紀情況和西歐、美國西部地質情況相同，二系間的不整合具有頭等重要的意義。

因此，著者完全贊同 Walcott 的見解，並着重批判 Wheeler 專以 *Olenellus* 帶去確定寒武紀下界的片面的看法。

我們的初步結論是：

(1) 中國震旦-寒武紀間不整合的存在，也同西歐、美國西部一樣，具有相當普遍性及其重要的意義，並且在中國各處（昆陽、冀東、襄陽、淮南、遼東）已經不斷地發現了。

(2) 中國寒武紀海浸系從南來，海浸到達華北時期只是在下寒武紀後期（饅頭期），所以華北震旦-寒武紀分界是在饅頭層和下面景兒峪灰岩（狹義的）中間，並且有底礫岩的存在。與其說寒武紀下界是在饅頭期以前，不如說在景兒峪期之後為妥。

(3) 中國震旦、寒武紀間不整合的規模雖不及前震旦紀呂梁運動之大，但盛產三葉蟲化石的寒武系和震旦系有別，似應仍按照國際用法仍列為古生代第一紀。

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ON THE BASE OF CAMBRIAN SYSTEM

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I. INTRODUCTION

Studies on the Cambrian faunas made by Walcott, Sun, Endo, Kobayashi, and Chang have laid down the foundation for the classification of Cambrian system in China. In 1922, Sun first demonstrated the upper boundary of the Cambrian and a paper on the Cambrian, Ordovician and Silurian of China was presented before the 14th International Geological Congress at Madrid in Spain, 1926. Owing to the lack of Palaeontological evidence at the base of Lower Cambrian and general neglect of Cambrian hiatus by geologists, the lower boundary of the Cambrian has hitherto remained as a conflicting problem in Cambrian stratigraphy.

The Cambrian of British Wales is structurally complicated and also lacking of fossils; that of Baltic region (Sweden and Norway) is rather regular but developed incompletely; neither of them can be used for the solution of the base of Cambrian. Only the Cambrian of China and western part of North America are well developed and possess a rich fauna. Furthermore, the Cambrian and the Precambrian of Western N. America are very much similar to those of China, and therefore this correlation might serve the purpose to answer this question not only

important in Chinese geology but also in the world geology. During the past thirty years, particularly in the eight years after Liberation, Chinese geologists have collected abundant materials from new regions and made detailed and careful observations, owing to the large increase of geological works, thus enabling them to have enough data at hand to solve this problem—the base of Cambrian.

II. Relative Values of Criteria Used in Drawing

The Sinian-Cambrian Boundary

Grabau first considered the trilobite zone as the division between the Sinian and the Cambrian. Because of the Characteristic *Redlichia* fauna the Mantou formation has been put in the Cambrian. The unfossiliferous rocks below the *Redlichia* zone were all designated as Sinian. Subsequently, as soon as *Redlichia nobilis* and two new species of *Corynexochus* were found in the Chingeryu formation, the lower limit of the Cambrian was shifted downward. This was the case both in the Western Hills of Peking, and in Sungshan in Honan Province. However, this simple application of the palaeontological method is still unsatisfactory.

In the same way, W. E. Wheeler of America suggested in 1947 the *Olenellus* zone as the base of the lower Cambrian, thus putting the upper part of the Wood Canyon formation and the strata above it as Cambrian, and putting all the middle and lower parts of the same formation and the Prospect Mountain formation to be of Cambrian age. Disregarding of the principle of the cycle of sedimentation, this undoubtedly fell into the same error.

Generally speaking, the break between the Sinian and the Cambrian is distinctive. But its magnitude is by far less than those of the Algonkian and the Luliangian. It is sometimes in the form of disconformity or unconformity. I agree with the European geologists in the Continent that the strata can only be divided into conformable and unconformable ones. As a rule, disconformity is nothing but unconformity. Such disconformity between the Sinian and the Cambrian is difficult to be recognized, often making one believe that the Sinian and the Cambrian are conformable and that the Sinian is not metamorphosed. At the same time, it should be pointed out at once that the base of the Cambrian should not be put further downward at the unconformable surface below the Algonkian or the Sinian.

In 1926, E. Licent and Teilhard de Chardin made an expedition to Southwestern part of Shansi, and from their observation the basal beds were found to represent a continuous sequence of sedimentation. However, their idea that the

basal siliceous limestone might represent the basal Cambrian or Upper Sinian is not entirely wrong. Regarding sedimentation they were right, but they retained the old notion that the Sinian and the Cambrian in China were always conformable and thus sometimes erroneously had been once put a part of the basal strata into the Sinian.

In order to answer this question, we must primarily consider the cycle of sedimentation and then differentiate the intraformational sandstone from the basal sandstone, the intraformational conglomerate from the basal conglomerate. In the next, we have to know the facial change of the basal rocks accordingly. Because of the source of sediments, the center of the organic distribution and their way of migration in the different embayment areas can hardly be all the same. Regarding unfossiliferous rocks, we must use the cycle of sedimentation as a main base.

In the past, sometimes we relied upon fossils while in other occasions we did emphasize the importance of unconformity, none of them has yet answered our question at all. The joint use of the following methods might be helpful for the final solution:

- (1) Cycle of sedimentation;
- (2) Palaeontological method;
- (3) Unconformity (including disconformity).

With the methods as mentioned above, it will then be possible to divide the Sinian and the lower part of the Cambrian. If we fail to distinguish the Sinian and the Cambrian strata correctly, it is impossible for us to draw the boundary line between them and understand better their paleogeographic changes.

III. The Cambrian-Sinian Boundary Line

1. *The unconformity between the Sinian and the Cambrian is the key for the base of the Cambrian.*

Researches on the Chinese Sinian and Cambrian strata have been continued for 30 years. Even at the very beginning, many geologists who recognized the fact that the Hsiamaling formation might possibly belong to the basal part of the Lower Cambrian. Owing to the presence of a disconformity at the base of the Hsiamaling formation and the discovery of the *Redlichia* fauna from the Chingeryu limestone of Changping, most of the geologists had considered the basal part of the Hsiamaling formation to be the base of the Lower Cambrian.

Recently, a systematic study on the Cambrian-Sinian boundary line of the Yinshan region was conducted by us in two expeditions. The first party in

Sinian-Cambrian Boundary of Yen Shan Region

L. F. Yih etc (1920)	C. H. Kao etc. (1934)	Y. C. Sun (1953)	S. F. Chiao (1954-56)	Y. C. Sun, Y. L. Wang, C. H. Kao, C. Y. Lee (1956)
Upper Shale Cm ₁ Middle Limestone Cm ₁ Lower Shale Cm ₁	Purple shale Cm ₁ <i>Disconformity</i> Chingeryu limestone	Mantou formation Cm ₁ <i>Conformity</i> Chingeryu limestone	Nanshanpo formation Cm ₂ <i>Conformity</i> Chingeryu Leopard-skin limestone <i>conformity</i>	Changhsia formation Cm ₂ Lower shale <i>Conformity</i> Mantou formation (leopard-skin ls.) <i>Unconformity</i> (Chihstienian) Chingeryu limestone (Middle & lower part of old sense) <i>conformity</i>
<i>Conformity</i> Hsiamaliang formation <i>Disconformity</i> Tiehling limestone	Hsiamaling formation <i>Disconformity</i> Tiehling limestone	Hsiamaling formation <i>Disconformity</i> Tiehling limestone Sn	Changping limestone <i>Conformity</i> Hsiamaling formation <i>Disconformity</i> Tiehling limestone Sn	Hsiamaling formation <i>Disconformity</i> Tiehling limestone

charge of the writer consisted of Drs. C. Y. Lee and K. Yang, Prof. Y. L. Wang and myself, and the second party was in charge of Prof. C. S. Kao.

Owing to the discovery of an unconformity within Chingeryu limestone and the basal conglomerate of Mantou formation at Chingeryu, Chihsien and the ascertainment of the exact stratigraphical position of the *Redlichia-Corynexochus* fauna from the upper Chingeryu (the Mantou formation) of Changping district, we all agree the above statements and would like to suggest that the Cambrian-Sinian boundary line is at the base of the upper Chingeryu limestone (Mantou formation) instead of the base of Hsiamaling formation of North China. Its relation may be expressed as follows (see Table).

The Lower Cambrian is also well developed in Southwestern China, especially along the borders of the Sikang-Yunnan platform. At the base of Lower Cambrian the apatite deposits was discovered and in several places an erosion interval had been observed. Owing to small magnitude of the conformity, it was considered at that time the apatite-bearing rocks to be of Sinian or a transitional beds. Actually, the erosion surface is very clear and there is angular unconformity in several places.

In the summary of the stratigraphy of Yunnan, the author has put the apatite-bearing rocks at the base of the Lower Cambrian. This has been adopted by Chinese geologists and also by Howell. The basal part of the Lower Cambrian—the apatite-bearing formation—has been proved to occur at Kunyang, Yunnan

Angular unconformity of large magnitude between the Sinian and the Cambrian occurs at Ching-lo in Shansi, the Cambrian overlies the Huto series. Y. L. Wang has proved that the Wutai is partly of the metamorphosed Huto series. The basal conglomerate and the quartzite above the unconformable surface are conformable with the Cambrian. So it makes us to believe that the unconformity is between the Sinian and the Cambrian, but not between the Sinian and the Wutai, as suggested by Licent and Teilhard. This is also known in the Wutai, Liaoning and Huainan regions.

The Cambrian-Sinian unconformity is very conspicuous in the South China platform, such as Chinyang and Linghsiang in Hunan. It is also clear in Tapashan, and the other places.

It is evident that the Cambrian-Sinian unconformity, whether horizontal or angular, is widespread and its existence is unquestionable. Its relation might be separately expressed as follows:

N. China (Sino-Korean Platform)		S. China (Yangtze Platform)	
Mantou formation	Cm	Lungwangmiao formation	} Cm
unconformity		Tsanglongpu formation	
Chingeryu formation (Sense restricted)	} Sn	Chiungchussu formation	
Hsiamaling formation		Apatite-bearing formation (<i>Salterella</i> beds)	
unconformity		Unconformity	
Tiehling Limestone		Tengying Limestone	} Sn
Hungshuichuang shale		Chengkia sandstone	

2. *The cycle of sedimentation is the key for the solution of the base of the Cambrian.*

The Cambrian of China is comparatively complete and rich in fossils. Zones have been established by Sun, Kobayashi, Endo and Lu in the Cambrian of both North and South China. The Sinian of China is well developed and has been studied by J. S. Lee, A. W. Grabau, C. H. Kao, Y. L. Wang, T. Y. Yu and K. C. Tsao. We have a complete Cambrian and Sinian stratigraphical sequence, thus having no difficulty to determine the basal cycle of the Cambrian sedimentation. In case we want to decide whether a formation is present or in lacking, we must base upon the fact on the stratigraphical sequence of the structural unit.

The Wutai region is a part of the Sino-Korean Platform. Either the Cambrian or the Sinian stratigraphical formation can be easily correlated. It is quite regrettable that we usually overlooked the classification of the local change of sedimentation. The author went twice with the students of Peking University to Wutai for field work (1925, 1929) and found the basal part of the Cambrian to represent a cycle of sedimentation. A large collection was made in 1929, but the Cambrian fossils mostly came from the upper part, while materials from the lower one are almost lacking. We may conclude that the basal sandstone and siliceous limestone above the Wutai is of Cambrian age. At the same time, we must also point out that the siliceous limestone has already been known in the Mantou formation of Changhsia district in Shantung and should not be classified as a member of the Sinian.

Now, I would like to say something about (1) facial changes and (2) metamorphism of strata. Are the facial changes of the Cambrian sedimentation considerable? Is there any Sinian metamorphosed? With regard to the first question, there are some facial changes, especially in the basal sediments. Viewed from the Cambrian and Sinian paleogeography, the Sino-Korean Platform was first

formed during the time of the Pre-Sinian Luliang movement. Later on, the platform was formed as large basins and troughs, thus allowing the shallow transgressive sea from the south to come in. At late Sinian time, the entire platform was uplifted and the Sinian rocks were slightly folded and exposed to erosion. The platform again sank and was quickly invaded by the Cambrian sea, the extent of which was about the same as before. Local and regional studies of the sediments reveal the fact that the period of erosion was long and extensive but that the magnitude of the unconformity is not the same everywhere. In some places, the unconformity is angular but in others it is nearly horizontal. During Cambrian paleogeography, China still retained the whole Sino-Korean Platform, but on the platform there were positive and negative elements. The former, such as Tsingling and Huaiyang, were arranged in a E-W direction, thus preventing communication between the North and the South. As a result, the sediments of the Sino-Korean and Sikang-Yunnan platforms are different.

According to the observations given by Y. L. Wang and others in Shansi, the basal part of the Cambrian of Wutaishan may be a red sandstone unconformably overlying the Wutai (Northwestern part of Wutaishan), a sandstone or a siliceous limestone unconformably overlying the Wutai, (northeastern part), a basal conglomerate unconformably overlying the Wutai or the Huto (southwestern part), or a basal conglomerate unconformably overlying the Archaeozoic (northern part). Although the Shansi region was a part of the platform, facial changes of the basal sediments can be seen everywhere. The gradual disappearance of the siliceous limestone in Shansi is also quite evident.

Again, The St. John Quartzite of Northwestern America was considered by Matthew as the basal sandstone and the so-called Pre-Cambrian Etchemining series was established. Later, C. D. Walcott found the trilobite *Olenellus* in the same series, thus his error can be corrected.

The Cambrian of the northwestern part of North America was carefully worked out by Walcott. From his description of that region, he said: **"In Pre-Cambrian time the belt rocks were elevated a little above the sea and at the same time were slightly folded, so as to form low ridges....."** We must agree to put the dividing line between the Cambrian and the Sinian at an unconformity or a disconformity (erosion surface) but not at that within the Cambrian system.

Secondly, we must also make sure of whether the Sinian rocks are metamorphosed or not. The answer is thus: As a whole, the Sinian rocks are not metamorphosed, but only under special conditions they might be metamorphosed by intrusion of granite of later age. For example, the Huto Series of Shansi has been

announced by Y. L. Wang to be the metamorphosed Sinian series which has been considered by Grabau and others in majority to be the equivalent of the Nankou limestone (the Sinian), but some geologists do not agree with this viewpoint and so this question is still in dispute. Recently we have recognized the unconformity between the Cambrian and the Sinian at Chingeryu, and so the question of the base of Cambrian can be solved in this way.

IV. Conclusion

1. Studies of the sections from different regions in North and South China have vividly pointed out the existence of a period of an erosion interval between the Cambrian and the Sinian. Hence, we propose the Mantou formation of North China and the apatite-bearing formation of South China as the bases of the Cambrian.

2. If we could draw the natural boundary between the Cambrian and the Sinian as it should be, a good foundation would be laid down for further studies on the Pre-Cambrian rocks rich in black metals.

3. The Cambrian and Sinian of China and those of Northwestern America are very much alike. The trilobite zones are evident and the erosion surface between them is rather distinct. Thus, we have no reason to say at all that the Cambrian represents the second period and that the Sinian is the first period of the Paleozoic Era respectively.

The Cambrian question was discussed at the 14th International Geological Congress at Madrid in Spain, 1926. Now, the question of Cambrian paleogeography and lower boundary has been brought up again for discussion. It is hoped that the 20th Congress will pay more attention to this widespread unconformity interval between the Cambrian and the Sinian and finally a definite conclusion can be drawn with regard to the base of the Cambrian.