

THE NATURE AND EXTENT OF A STRATIGRAPHICAL
BREAK IN THE CAMBRO-ORDOVICIAN LIMESTONES
OF NORTHERN ANHUI, AND ITS BEARING UPON THE
SYSTEMATIC CLASSIFICATION OF THE CAMBRO-ORDOVICIAN
STRATA

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Those who have followed the historical development of the systematic classification of the old Palaeozoic rocks in Europe would undoubtedly well remember how the Ordovician became recognized as a well-defined, independent system. Here in this country, geological exploration has only begun in comparatively recent years. One might easily suppose that we have had the full opportunity to apply directly the system of classification as to the larger groups of strata already well-established elsewhere in the world,—that is, if our development justifies such a procedure. But stratigraphical geology has yet to go through a sort of evolution as it had done in the West. To illustrate what is involved in this statement, it would be best to trace the various and varying designation attributed to the term "Sinian" since it was introduced into Chinese geology.

Back in the time of Pumpelly, a system of folds was observed by this pioneer-explorer to prevail over wide areas in eastern Asia. They run from N.E. to S.W., and apparently affect the strata which are not younger than the Carboniferous. Pumpelly rightly judged that it merited a special tectonic name, and proposed to call this type of fold the "Sinian system of folding". Placing aside the question of strict chronology, the term, Sinian, in the sense of its founder, is therefore not incomparable with the term, Caledonian, in European geology; for the latter likewise denotes an important group of folds running N.E. and controlling, to a large extent, the structure of northwestern Europe.

Richthofen, during his extensive exploration in China, particularly in northern China, found a mighty sequence of unaltered strata, chiefly composed of limestone, covering wide areas between the northern foot of the Tsing-

ling Range and Manchuria. This limestone and its associated strata are often folded in the Sinian type, which fact had probably induced Richthofen to apply the term, Sinian or Sinisch, to this mighty sequence of old sedimentary rocks. Thus the term, Sinian, was made to migrate, so to speak, from the domain of tectonic geology to that of stratigraphy. As a consequence, it frequently appeared in geological literature, and soon won a firm standing as if it were a closely defined stratigraphical term. But the fact was otherwise.

as a result of the Carnegie Expedition (1903-4), Willis and Blackwelder found it desirable to revise the denotation of Richthofen's term, Sinisch. Blackwelder states that a number of instances was found in the Chihli-Shansi area showing a remarkable stratigraphical break within the lower part of Richthofen's Sinian Formation. The plane of the unconformity, according to this author, generally coincides with the base of a red shaly series known as the Manto Formation or its equivalent. It was then decided by Willis and Blackwelder to shift the lower boundary of the "Sinian System" on to the place of the said unconformity. From the Manto Series upward to the coal-bearing Anthracolithic Formation which generally overlies the Cambro-Ordovician of northern China, not the slightest evidence of a stratigraphical break was observed by Blackwelder in Shantung. Nor does Lorenz who has indeed made valuable contribution on the geology of the same province, report any fact that may be regarded as indication of the existence of an unconformity or disconformity within the upper part of this mighty sequence of the Cambro-Ordovician strata.

In attempting to establish a complete system of Sinian in this revised sense, Willis and Blackwelder include in it a limestone formation well-developed in several regions of northeastern China, described and mapped by Richthofen, in the early days, as "Kohlenkalk." These American writers evidently believed that the "Kohlenkalk" of Richthofen as developed in northeastern China was but the uppermost representative of their Sinian System being conformable with what it overlies. But now we know that it is not always the case.

Prof. A. W. Grabau was the first to discover a physical break in the Cambro-Ordovician rocks of the Tang Shan coal basin. He states that, there, the irregular surface of the Cambrian rock is followed upward by a basal conglomerate made up by the pebbles of the underlying series indicating a considerable period of exposure before the deposition of the Ordovician rocks. This eminent palaeontologist further points out that the Lower Ordovician with a fauna closely related to that of the Beekmantown of north America is characterized by *Archeocyathus*, *Opheteta*, *Piloceras* etc, while the upper part of the Ordovician or the Actinoceras limestone yields a fauna comparable with that of the Black River Group. No transitional types are found in between the two. The break in life sequence is therefore, according to the same professor, "profound and absolute".

About 500 miles south of the Tang-Shan basin, the present writer quite independently and more or less accidentally found another break in the upper part of the Cambro-Ordovician Limestone. In the plain between Hwai-Yuan and Hsü Hsien, northern An-hui, two isolated hill ranges rise to an average height of about 300 m. They arrange themselves after the fashion of the Chinese character 八 (eight) or a truncated Greek letter λ and are tectonically disposed with a remarkable similarity or symmetry; namely, a simple fold over-turned towards the plain extending between the two.

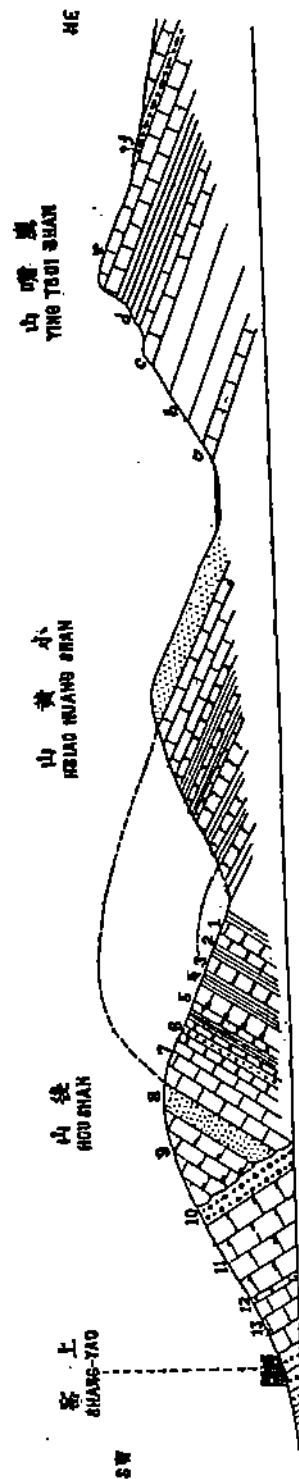
The southwestern range is generally known as the Shun-Ken-Shan, part of which is already mapped by the geological Survey of China. The northeastern range possesses a number of local names, such as Li-shan, Ma-shan, Huang-lung-shan, etc. For convenience, we may name them collectively as the Li-Shan range. It is in this range that an unconformity in the upper part of the Cambro-Ordovician was discovered.

The general geology of the country conforms with the development of northern China; viz, the prevailing formations are the Cambro-Ordovician and the coal-bearing Anthracolithic, the former being overlain by the latter with a marked disconformity. The lithology of these two groups of rocks can hardly be distinguished from that of the typical Cambro-Ordovician and Anthracolithic rocks occurring in Sbantung, Chibli and further northeast.

The Li-shan range is about 15 li or 7 km. long, and extends N.W.-S.E. This is also the trend of its tectonic axis. Not far from the southeastern end of the Li-shan range, there is situated a small town, named Shang-yao. A section taken from Shang-yao to the northeast reveals the complete succession of the strata in an over-turned fold.

In the southwestern limb of the above-said fold, the sequence of the strata ranging from the Anthracolithic to the Cambro-Ordovician is as follows:—

Anthracolithic	Sandstone.	
	A band of buff limestone.	
	Coal-bearing Sandstone.	
	Buff sandstone	
	Sandstone intercalated with soft shale.	
	Disconformity	
Cambro-Ordovician.	13 Light blue limestone.....	50 meters
	12 Red limestone.....	0 8 "
	11 Massive blue limestone.....	15 "
	10 Coarse red conglomerate with water-worn pebbles, 2 to 3 inches in diameter..	10-30 "
	Unconformity	
	9 Well bedded dark blue limestone.....	20 "
	8 Medium grained red sandstone.....	20 "
	7 Blue limestone.....	80 "
	6 Brown sandy Shale intercalated with numerous beds of light blue limestone.....	14 "
	5 Well bedded blue limestone intercalated with sandy shale.....	14 "
	4 Limestone in the form of pseudo-conglomerate.....	20 "
	3 Well-laminated, yellow and purple limestone.....	17 "
	2 bedded limestone	48 "
	1 An alternation of limestone and shale.....	128 "



In the above sequence of rocks the disconformity between the Anthracolithic and the Cambro-Ordovician can be easily recognized in the field. For, the enduring nature of the Ordovician limestone in contradistinction to the softer material that forms the Anthracolithic coal-bearing series together with the salient weather-beaten surface of the limestone presents a striking illustration of the typical topographic features characterizing this disconformity.

From the town, Shang-Yao, I made a traverse across the Anthracolithic and Ordovician strata. They dip into the hill in regular succession but in reversed order until a series of massive conglomerate (No. 10 in the above sequence) appeared in the scene. This conglomerate is almost exclusively composed of well-rounded, water-worn, pebbles of blue limestone set in a blood-red, sandy and calcareous cement. The pebbles are clearly derived from the underlying rocks. The conglomerate and its overlying strata dip steeply into the hill as already mentioned, but those below the conglomerate dip away from the hill at 40° or less. The discordant contact between the conglomerate and its underlying strata can be directly observed in the field. Here, then, we have unequivocal evidence of an unconformity within the upper part of the Cambro-Ordovician strata.

In crossing the hill further southeast, the same conglomerate was met with. It is therefore not improbable that the conglomerate persists throughout the Li-Shan range, or at least through a large part of it.

In the northeast limb of the fold, the several series of rocks succeed one another in the following descending order:—

Orthoceras Limestone.

Concretionary limestone..... about 7 meters.

Ashy looking limestone divided by numerous vertical joints

into long prisms or columns.....about 4 meters.

(Large fragments and chunks of a red conglomerate found
along or near the outcrop of the above series).

Cliff-forming, massive blue limestone weathered to a red-
dish colour; about 8 m. thick.

Purple shale.

Siliceous limestone, full of large holes and cavities.

about

Alternating beds of sandstone, shale and limestone.

Blue limestone containing, in places, numerous peculiar spheroidal or ellipsoidal bodies made up by concentric layers of the same material as that of the rest of the limestone. These round bodies sometimes reach one inch in diameter.

More limestone follows, then there appear the red sandstone and its underlying strata as exposed in the other limb of the fold.

70 meters.

In this limb no continuous outcrop of the red conglomerate can be seen, but large fragments and chunks of the same rock occur immediately below or closely associated with the *Orthoceras* Limestone containing a large number of this fossil. Judging from the distribution of the fragments of conglomerate, it appears likely that the conglomerate is less regularly developed on this side of the anticline, but not altogether absent. In all probability, it forms the basement of the *Orthoceras* Limestone. Thus we are enabled to conclude that the unconformity below the red conglomerate, is either a break within the Ordovician or marks the boundary between the Ordovician and the Cambrian. The case must yet be decided by fossil evidence.

Granting that the red conglomerate or its equivalent is thus correctly located in the northeastern limb of the fold, as one is forced to do if all the field evidence be taken into consideration; it would at once become evident that the unconformity must represent a long period of erosion; for nearly all the beds above the red sandstone had, in all probability, been denuded away before the deposition of the conglomerate. About 20-30 or 10-15 km. west, the Cambro-Ordovician strata are again magnificently exposed in the Shun-Ken-Shan range. No trace of the conglomerate or the discordance was observed, although the general succession and character of the rocks are otherwise essentially similar to those of the Li-shan range. It should be perhaps mentioned by way of comparison that there is a series of brown sandstone about 20 m. thick intercalated in the upper part of the Cambro-Ordovician strata forming the back bone of the Shun-Ken-Shan range. We have some reason to believe that this sandstone belongs to the Ordovician, but

no means, as yet, to ascertain the stratigraphical relation with the conglomerate of the Li-shan range. Apart from this series which may have some genetic connection with the physical break further northeast, I failed to trace any other sign in the Ordovician formation, that can be interpreted as indication of a notable change of physical conditions during that part of Cambro-Ordovician time which is there represented by a sequence of sedimentary rocks. In these bare hill ranges each individual bed of rock is exposed on the surface. One cannot possibly overlook such remarkable features as a discordance or a band of conglomerate if they do exist. It is therefore safe to say that the unconformity of the Li-shan type is absent in the Shun-Ken-Shan Range.

If the upper Cambrian of Shantung merges into the Ordovician by insensible gradation as maintained by Blackwelder, it would appear, that the sea floor was fairly stable in that region during the Cambro-Ordovician time, whereas earth movements of appreciable magnitude, but probably not of sweeping nature, took place in the surrounding areas. Such a local break is indeed also reported by Deprat from eastern Yunnan.

With these facts in view, it seems neither precise nor convenient to regard the Cambro-Ordovician of China as a single system. We may now, or shall be forced to invite the universal systemic terms, Cambrian and Ordovician, into Chinese geology. This obviously implies that the term Sinian would sooner or later have to die its natural death unless a suitable place in Chinese geology be found, therein its existence may be justifiably continued. Prof. Grabau after a careful review of Riethofen's and Willis and Blackwelder's work, finds reason to propose that the Sinian should now be employed to represent the upper part of the pre-Cambrian rocks. As these rocks are developed in China *par excellence*, the term, Sinian, though hitherto held a precarious office, has probably at last found a most appropriate and therefore lasting position.