

POST PALÆOZOIC FORMATIONS OF THE MÊN YIN AND LAI WU VALLEYS OF SHANTUNG.

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INTRODUCTION.

I was appointed to accompany Dr. J. G. Andersson to take a trip in central Shantung, especially in Mên Yin (蒙陰) and Lai Wu (萊蕪) valleys, for the purpose of collecting fossils and observing the post-Palæozoic formations. We came back to Peking in December, 1922. The conclusion obtained from this trip makes the geology of Shantung clearer than before, though we spent only three weeks in the field. I shall try to state the formations observed, and the important points concerning the geology of Shantung.

FORMATIONS.

During this trip we have not paid any attention to the formations prior to the Mesozoic. The formations observed are Red Sandstone, Mênying Series and the Eocene Series.

Red Sandstone:—In the Mên Yin Valley this formation is in fault contact with the Ordovician limestone and Palæozoic coal series. It consists chiefly of red sandstones, and of conglomerate in the uppermost part. The pebbles contained in the latter are mostly made of quartzite and occasionally of limestone. The sandstone is frequently cross-bedded, compact and not coarse. In the Lai Wu Valley it rests upon the yellowish white, coarse sandstone which may correspond to the quartzose sandstone usually overlying the Palæozoic coal series. In Shantung the real contact between these two sandstones so far has not yet been clearly observed. The lower red sandstone is also cross-bedded, without conglomerate in the upper part, but invaded by syenite dykes. The thickness of this formation is indeterminable in the Mên Yin Valley on account of its incomplete exposure; but in the Lai Wu Valley the thickness is estimated at about 700 meters. No fossils were found in this sandstone, so that its age cannot be determined. But according to its position it may be regarded as Permian or Triassic, and especially the latter suits the case better than the former.

The Mênying Series:—This series overlies the Red Sandstone likely in disconformable contact. It is largely composed of green sandstone, and

somewhere the tuff-conglomerate plays an important role in this formation. In the northwestern part of the Mên Yin district the lower part of this series comprises yellow or green conglomeratic sandstone, yellow or greenish sandstone and shale, somewhere being cross-bedded. The middle part contains green shale, sandstone and greenish sandy shale. The upper part embraces green sandstone and violet and brown shale. In the vicinity of the Mên Yin City the lower part consists of gray, greenish and brownish shaly sandstone, and green, hard, coarse sandstone. The middle part consists of green tuff-conglomerate, tuff interbedded with yellowish gray sandy shale and green shaly sandstone. The upper part includes green, yellow and violet shales; sandstone interbedded with reddish, yellowish, and grayish clay; grayish, loose sandstone and tuff-conglomerate. In the Lai Wu Valley this series is composed of gray and green shaly sandstone, sometimes being brownish and including numerous igneous intrusions. But somewhere it comprises only volcanic materials, such as green tuff conglomerate, breccia, tuff and lava flow, without any sandstone. The thickness of this series is variable. It is estimated at 830 meters in the northwestern part of the Mên Yin district; 1240 meters in the vicinity of the Mên Yin City. In the Lai Wu Valley it amounts to 260 meters, but that part which contains volcanic materials has considerable thickness.

This series bears an abundance of fossils, both animals and plants. The animal fossils are Dinosauria, turtles, fishes and mussels. The plant fossils are represented by wood-trunk and various leaves. They will be described and published in near future after being properly studied. The bones of *Dinosauria* are contained in the lower and middle parts of the Mên-yin Series, found in the neighbourhood of Ning Chia Kou, a small village 35 li N. W. from the Mên Yin City. The turtles and fishes were obtained mostly from the middle part of this series occurring in the vicinity of Ning Chia Kou. The mussels occur in the vicinities of Ning Chia Kou and the Mên Ying City and are also contained in the middle part. The plant fossils were found from the middle and upper parts of this series. So far as we know from the fossils contained, it is nearly confirmable that this series can be referred to the Jurassic and a part of it may extend to early Cretaceous.

The Eocene:—This series rests disconformably upon the Mên-yin

Series; the name, Wenho Conglomerate called by B. Willis, in fact, denotes only the uppermost part of this series. It is chiefly composed of red sands, clay and conglomerate, containing yellow, gray sandstone, marl and limestone, occasionally with dark-gray shale which seems to be carbonaceous. In the Mên Yin Valley the lower part of the series consists of red sands and loose conglomerate, the pebbles of which are of red quartzite, limestone and igneous rocks such as syenite and diorite. The middle part comprises red sands, yellow, gray and greenish sandstone, grayish clay, dark-gray shale, white-gray paper shales, gray-greenish marl and gray-white limestone, including a plenty of calcareous concretions, the marl and limestone are represented in several beds which are from less than half meter to about two meters in thickness. The upper part includes conglomerate and red sands, the pebbles of the former are mostly of limestone and of igneous rocks such as porphyry and diabase, and mostly larger than those contained in the lower part. In the Lai Wu Valley the lower part consists of red sands and clay with loose conglomerate beds, the pebbles of which are mostly made of limestone. In the vicinity of the diorite beds, north of the Lai Wu City, the red sands contain abundance of feldspar grains, and the pebbles of the conglomerate beds are partly composed of diorite which is the same as what constitutes the main intrusive body. The middle part contains red sands interbedded with yellow, gray, greenish and white-gray sandstone, including numerous beds of grayish white limestone. The upper part is a conglomerate occasionally with red sands. Along the border between the Lai Wu and T'ai An districts we met with some outcrops of yellow, green sandstone and white limestone which may also be referred to the same series. The thickness of this series is variable, from 600-1100 meters in the Mên Yin Valley; in the Lai Wu Valley the thickest part is estimated at 1670 meters, but some parts being not more than 200 meters.

The Eocene contains a plenty of fossils, such as gastropoda, reptiles, mammals and fish-bones. The Gastropoda were found from the grayish white limestone in the middle part of this series at many localities, especially in the Mên Yin Valley and Li Chia Chên in the Lai Wu Valley. Among them *Helix* and *Planorbis* are the prevailing types. The mammals and reptiles are contained in the grayish white and greenish marl and sandstone in the middle

part of this series, occurring in the vicinities of Hsin T'ai and Kuan Chuang in the Mên Ying Valley (and Li Chia Chen in the Lai Wu Valley). They are represented by a mandible with teeth and various kinds of molars and tusks. The fish-bones are frequently associated with mammals and reptiles, mostly found from the grayish white limestone in the neighbourhood of Li Chia Chen.

CONCLUSION!

After taking this trip three important geological questions become fairly settled.

(1) *The Eocene beds are well developed and wide-spread in Shantung:*

Most of the formations prior to the Cenozoic were observed and studied by the geologists who have been in Shantung. But they knew very little about the Cenozoic deposits except the Wenho Conglomerate which was observed and referred to the Tertiary by Bailey Willis. The Eocene beds which we found in this trip are very thick and spread in most part of the Mên Yin and Lai Wu valleys. The Wenho Conglomerate is only the uppermost part of the Eocene. Moreover, taking these beds to compare with what was met with in Shantung during the last few years, the identical strata and resembled formation seem to occur in many places. In the big valley, south of Mêng Shan range, from Lin Yi (臨沂) to Ning Yang (甯陽), some strata are exactly the same as the Eocene beds occurring in the Mên Yin and Lai Wu valleys and they spread widely. In eastern Shantung occurs a formation which overlies the tuff-conglomerate and comprises red, loose sandstone interbedded with conglomerate, variegated clay and shales, including calcareous concretions similar to those contained in the Eocene beds. I believe that this formation can be referred to Eocene. Thus the Eocene beds, which have not been taken into account before will play an important role in the stratigraphy of Shantung hereafter.

(2) *The horizons of the post-Palaeozoic formations are mostly determined:*

The age of the formations older than Mesozoic has been precisely determined by the geologists who have worked in Shantung. But they have not accurately studied the post-Palaeozoic beds. Bailey Willis grouped the uppermost part of the Eocene under the name of Wenho Conglomerate and applied the name Sint'ai Formation to cover the Permo-Triassic red sandstone, the

Ményin series, and the lower and middle parts of the Eocene, and regarded the whole group as Permo-Mesozoic. Between the two groups an unconformity is thought to occur. Now the geological ages of these formation mostly become clear and we may say that there is no unconformity below the Wenho Conglomerate.

However, between the Red Sandstone and the Ményin Series here seems to exist a disconformity, though they have nearly the same strike and dipping angles. The uppermost part of the Red Sandstone of the Mén Yin Valley is a coarse conglomerate, but in the Lai Wu Valley it is not. This may show that the Red Sandstone had undergone erosion before the Ményin Series deposited. And, between the Ményin Series and the Eocene there is a real disconformity which can be confirmed by the fact that in the Lai Wu Valley the lower part of the Eocene contains diorite body and its pebbles, which may be contemporaneous with or little later than the Ményin Series. This shows that the diorite body and the Ményin Series have been eroded before the Eocene deposits were formed.

(3) *The age of principal faults of central Shantung should be modified:*

There are many big faults in central Shantung, which made the strata faulted downwards to form big valleys, Ményin and Lai Wu are but two examples of such kind of valleys. The down-throw-sides of these faults are usually composed of the Red Sandstone, the Ményin Series and the Eocene, on the northern upthrow-sides are the Cambro-Ordovician and the Palaeozoic Coal Series. Somewhere, the throw can be estimated at not less than 4000 m. Bailey Willis inferred that the faulting occurred during the early Tertiary and thought the Wenho Conglomerate is later than the faulting and the material contained in the conglomerate was derived from the upthrow-sides of the big faults. But so far as it is mentioned above, the Wenho Conglomerate has been brought in contact with the Archean gneiss and somewhere breccia exists along the fault-line. Hence it is undoubted that the Wenho Conglomerate is older than the faulting. And the Wenho Conglomerate is but a part of the Eocene. So the faulting might be dated to Oligocene or Miocene, but it can not be later than Miocene because in northern China the Pliocene red clay has not been affected by folding and faulting.