

ON THE CENOZOIC GEOLOGY OF ITU, CHANGLO AND LINCHÜ
DISTRICTS (SHANTUNG)*

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INTRODUCTION

Since many years the occurrence of Early Pleistocene fossiliferous red loam (wrongly interpreted generally as "loess") was known, north of the Taishan range, along the Tsinan-Tsingtao railway. Chiefly in the Itu district several fossiliferous localities had been reported, and an appreciable number of fossils described, for instance by Zdansky¹ and Matsumoto². No earlier Cenozoic formation however was supposed to have been found in that area.

Therefore it was a surprise to Mr. M. N. Bien and myself when visiting, in the fall of 1934, the geological department of the Cheloo University (Tsinan) under the direction of Prof. Scott, to see among other interesting specimens, a series of remarkably well preserved fossil plants and fishes, evidently of Tertiary age, reported as having been found near Linchü in North Shantung³.

Later on (spring 1935) Dr. W. H. Wong was informed that some "dragon bones" had been recently unearthed in Changlo which is approximately in the same area.

* Received for publication in March 1936.

1 Zdansky, O. 1925, Fossile Hirsche Chinas. Pal. Sin., Ser. C, Vol. 2, Fasc. 3, P. 48.

2 Matsumoto, A. 1926. On some fossil Cervids from Shantung, China. Sc. rep. Tohoku Imp. Univ. Sendai, Japan. Vol. X, No. 2, P. 27.

1926. On a new fossil race of Big-horn sheep from Shantung, China. *ibid.* P. 39.

3 This collection was given to Prof. Scott by Dr. Hayes, at Tenghsien. According to Dr. Hayes the fossils had been collected by Dr. Paul Bergen in December 1909.

A closer examination of the region was evidently necessary, and I carried it out in May 1935. The aim of the present note is to give a short preliminary account of the results of this survey, which resulted not only in collecting a rich Cenozoic flora, but also in gathering several other important data bearing on the Cenozoic history of Shantung.

It is my pleasure to express here my deepest gratitude to Prof. Scott; and to P. Fakart and P. Feng for their kind and valuable help during my journey.

1 THE CRETACEOUS BEDS OF N. SHANTUNG (CHINGSHAN SERIES)

The general geology of northern Shantung has already been reported on elsewhere, chiefly by H. C. Tan¹. It is not the aim to discuss this subject in detail here. But before I start in the description of the Cenozoic sediments with which this paper is chiefly concerned, I feel it is necessary to say a few words on the Cretaceous beds which form mostly the floor of the younger deposit in the area.

All the outcrops of Cretaceous beds observed by me in the Changlo-Linchü district belong to the Lower Cretaceous *Chingshan series* of Tan, a formation consisting chiefly of tuff-conglomerates and tuffs interbedded with andesitic lavas and clays. In the vicinity of Fangshan and west of Changlo (N. of Lingshan), the beds are almost horizontal, slightly dipping towards the plain (north). But in the place W. of Shangling, where the Chingshan series lie on the Sinian strata, it dips about 30° N.E.

Physiographically speaking, the Cretaceous beds usually form a series of low ranges, or rather a mature plain, which represents most probably the Tanghsien surface as already noticed by us in the Ssushui-Wenho area². This mature surface is especially well developed in S.

1 H. C. Tan, Explanation to the Geological Map of China, Peking Tsinan Sheet. 1924. and

——— New researches on the Mesozoic and Early Tertiary Geology in Shantung. Bull. Geol. Surv. China. No. 5, Part II, 1923.

2 Young and Bien. Cenozoic geology of the Wenho-Ssushui District of Central Shantung. Bull. Geol. Soc. China, Vol. XIV, No. 2. 1935.

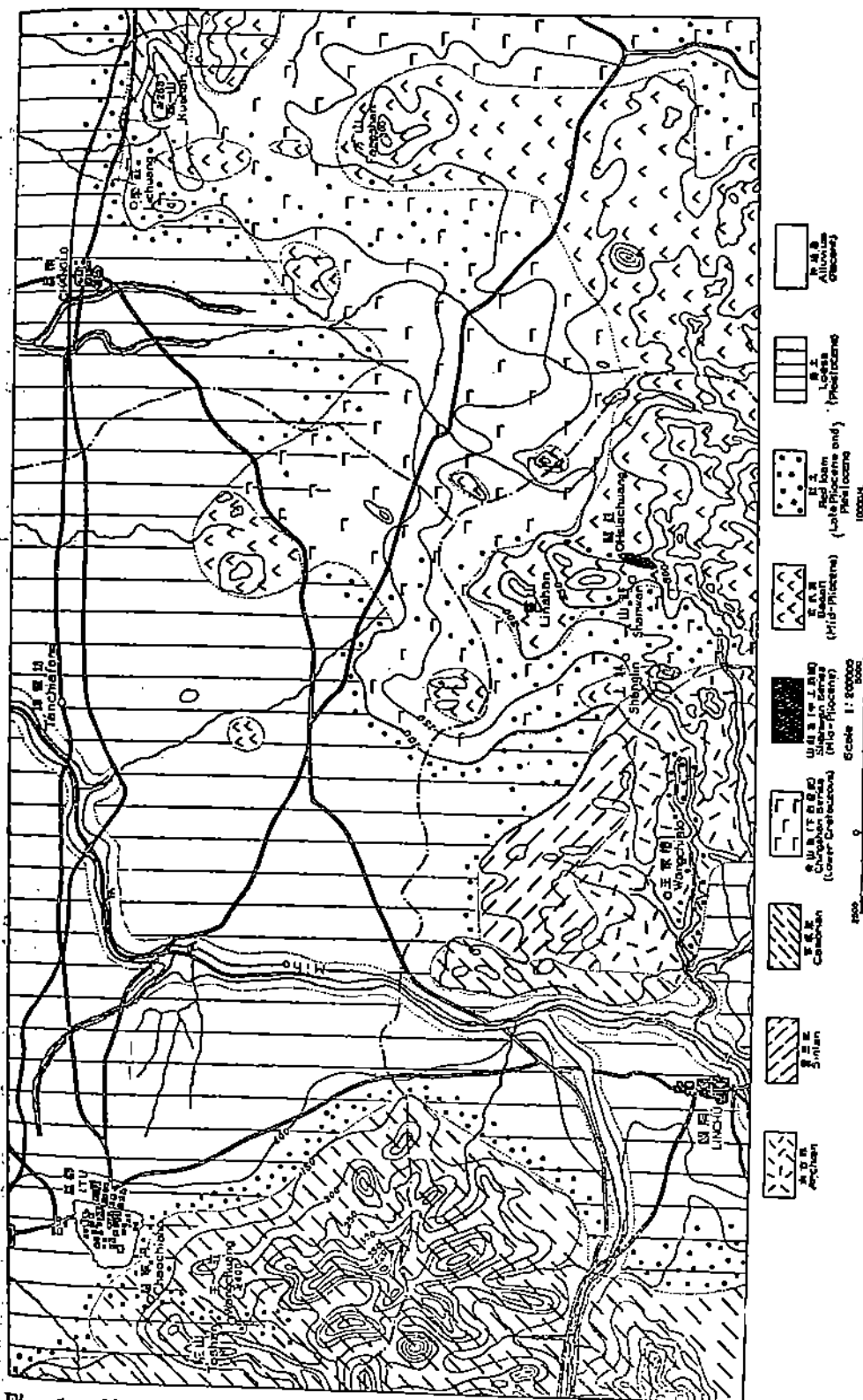


Fig. 1. Sketch map showing the general distribution of the Cretaceous and Cenozoic formations in the Itu-Changlo-Linchü area.

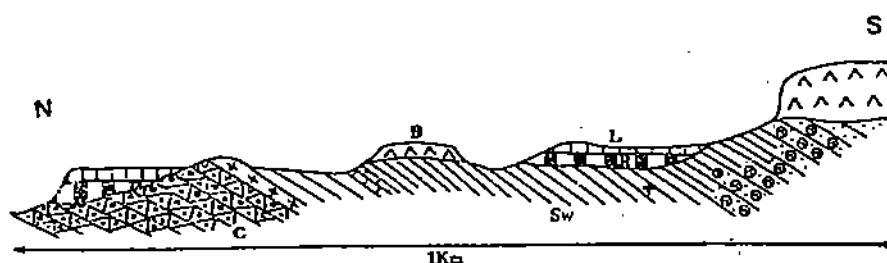


Fig. 3. A section along the right bank of the Chiehchiaho Valley (abbreviations as in fig. 2). T. Place where fossil plants and fishes etc. were mostly collected.

the insects and the impression of flowers are most beautifully indicated. Most of the fossils are plants (leaves), amongst which no less than 21 genera, including 47 species have already been recognised by Dr. H.H. Hu, in charge of the description:

- Salix* spp. (two species)
- Carya* spp. (4 species)
- Quercus* spp. (5 species)
- Carpinus* spp. (5 species)
- Zelkova* spp. (2 species)
- Morus* spp. (2 species)
- Ulmus* sp.
- Sassafras* sp.
- Lindera* spp. (2 species)
- Spiraea* sp.
- Sorbus?* spp. (2 species)
- Leguminosites* spp. (4 species)
- Alchornea* spp. (3 species)
- Pistacia* spp. (2 species)
- Ilex* sp.
- Acer* spp. (4 species)
- Tilia* sp.
- Firmiana* sp.
- Catalpa* spp. (2 species)

Ceratophyllum sp.

Antholithis sp.

As a conclusion of his preliminary study, Dr. Hu draws attention to the fact that this collection represents a subtropical flora, not unlike that found at the present day in the Yangtze Valley, this likeness being specially indicated by the presence of *Sassafras*, *Carya*, *Lindera*, *Ilex*, *Zelkova* and *Alchornea*. After careful comparison, Hu believes that the age of the flora is probably Miocene in age, which is in full accord with both our geological and palæontological observations.

In addition to the plants, several animal remains were recovered from the shales:

Insects:

Cycad sp.

Amphibia:

Rana basaltica Young (sp. nov.)

Pisces:

Leuciscus miocenicus Young and Tchang

Barbus linchuensis Young and Tchang

Barbus scotti Young and Tchang

Pseudorasbora macrocephala Young and Tchang

All these forms are now being studied and will shortly be described.

2. *The sandy part.* A short distance away from both sides of the river, the shaly series is no longer to be seen but instead is replaced by a yellow gravel mixed with rather consolidated sands. The pebbles are sometimes as large as a fist. Both the pebbles and the sands consist chiefly of granitic or metamorphosed rock, a fact suggesting that during the deposition of this series outcrops of archæan rocks were exposed nearby. In fact, a large archæan mass is still observable only a few li W. from Shanwang. Another marked feature is the presence of abundant basaltic boulders throughout many parts of the series. This shows clearly that during the deposition of the beds, the volcanic activity had already started, preceding the faulting of the beds and the spreading

of the big basaltic flow. Along the west side of the valley pits were made by natives several years ago for searching peat in the sandy beds, but without definite result. It is of course possible that, as told by the local people, a small amount of coal is found. But we were not able to collect any piece of it ourselves, as most of the pits are now destroyed and covered by cultivation.

Just as the shales, the sandy-gravel of Shanwang is fossiliferous, but instead of plants and smaller animals, it contains rich remains of large mammals. Many highly mineralized bones can be collected along the small gullies and slopes of the hills. A preliminary determination of the fossils so far recovered by us is given in the following list:

Carnivora:

A large Amphicyonid.

Perissodactyla:

A tetradactyle *Aceratherium*.

Artiodactyla:

Two primitive Cervids, one of them resembling closely a Tung Gur form (*Platybelodon* beds of Inner Mongolia), the other one is decidedly of antilocaprin affinity.

Testudinata:

A very big turtle (perhaps two species).

This fauna as well as the plants distinctly point to a Miocene age of the deposits.

Stratigraphical relations between the shaly and the sandy part.

Between the shaly and the sandy parts of the Shanwang series, the relations are mostly obscured by a cap of later sediments and by minor local dislocations. On the whole, the shales seem to underlie the sands. Yet, in the SE exposures of the formation, the two formations seem to grade distinctly one into the other. Both of them in addition contain basaltic elements, and both are referable by their fossils to the same Miocene age. Our impression is therefore that they correspond merely to two successive stages in a single sedimentary sequence. They form a single stratigraphical unit.

3. THE BASALT

Immediately above the Shanwang series extends the protecting cap of baslt, actually observable in angular unconformity, either with the shaly or with the sandy part of the sediments below. Unquestionably the "Miocene" sediments have been warped and planned before the out-pouring of the basaltic flow.

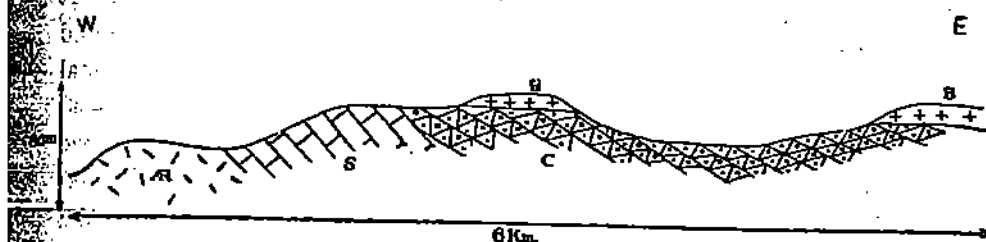


Fig. 4. A section from E. of Wangchiao from Shanglin to Shanwang showing the general geological formations. Ar. Archaean, B. Basalt, C. Cretaceous, S. Sinian limestone.

Mineralogically, the basalt of Shanwang (an olivine basalt)¹ has the same composition as the other basalts found along the coast, either in N. Shantung (Fangshan), or in Central Shantung, south of the Taishan range², or in Kiangsu³. The general dip of the basaltic flow is gently towards N.E. As shown by our fig. 1, the rock is widely distributed in the S.E. part of the here described area, a fact suggesting the vicinity of a line of fracture. Wherever the Shanwang series is absent, the basalt lies directly over the Chingshan series of Lower Cretaceous age. Its age might well be Lower Pliocene.

- 1 The writer is indebted to Mr. C. C. Chang for examining the specimens of basalts collected in the locality.
- 2 Young and Bien. Cenozoic Geology of the Wenhö-Ssushui Districts of Central Shantung. 1935. Bull. Geol. China, Vol. XIV, No. 2.
- 3 Teilhard and Young. The Cenozoic Sequence in the Yangtze Valley. 1935. *ibid.* P. 163.

4. THE REDDISH LOAM

The reddish loam is well developed along the foot of the hilly ranges of the district as shown roughly in our map. Three places are of special interest:—

1. *Lichuang near Changlo*. S. E. of Changlo, along the slope of the range the reddish loam, sometimes very sandy, remains as patches left by erosion. In one of the gullies dissecting the formation, a short distance E. of Lichuang, a beautifully preserved skull of Bovid was found by the natives some time ago, and is now kept in the Public Educational Bureau in the city. This is the very specimen which was mentioned in 1935 to Dr. W. H. Wong as a "dragon bone". At first glance we recognised it as belonging to a most characteristic type of Water-Buffer (horn-cores short and sharply trihedral) already found a year ago by the

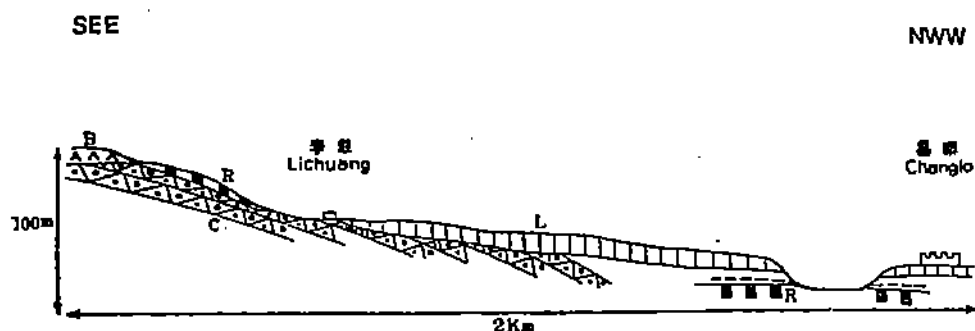


Fig. 5. Section S.E. of Changlo city. B, Basalt, C, Cretaceous. R, Reddish loam. L, Loess. The dotted line indicates a concretionary layer below Loess.

Cenozoic Laboratory technicians in the Reddish clays of Mienchih (W. Honan) (this form will be shortly described). We visited the site ourselves, but did not find any interesting bone, with the exception of several teeth and vertebrae. One upper molar and a lower jaw with teeth preserved of a Bovid, and fragmentary limb-bones of

Cervids were collected by our technicians about 2 li E. from the same place. The reddish loam is therefore fossiliferous, although rather poor. The *pre-Loessic* age of it we could positively ascertain, taking advantage of the new deep cuttings made along a road close to the city.

At the foot of Fushan, the reddish loam series begins with characteristic basal conglomerates. Most of the boulders and pebbles found are basalt, not much rolled but deeply weathered. A post-basaltic age of the series is quite evident.

2. *Itu area.* S.W. of the city of Itu at Chingshuichian (清水澗) in the reddish loam capping directly the Cambrian limestone, a broken tooth of Elephant was found recently, according to information given us by Bishop Meinzens. The reddish loam is especially well developed over the district extending between Toshan and Yumenshan, and many fossils are reported from this area. With exception of one place, S. of Wangchia-chuan, where a dark red clay is exposed along the river bottom *below*

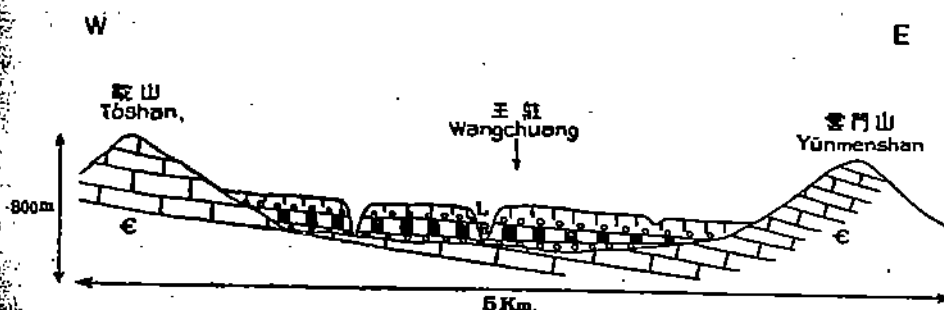


Fig. 6. Section across Toshan and Yunmenshan. C. Cambrian limestone. R. Reddish loam with basal gravel, L. Loess with basal gravel.

the reddish loam and its basal conglomerates, all the exposures we observed correspond to the generalized section given in textfigure 6. This dark red clay may be Lower Pliocene in age, but no fossil has been observed in it. The reddish loam on the contrary, seems to be very fossiliferous.

ferous. All the fossils described by Matsumoto¹, Zdansky² and Pearson³ come from this area. They represent the following forms:

- (Pearson) - *Sus* sp. Yenchiaichuan
- (Zdansky) - *Pseudaxis magnus* (the antler from Loc. 24,
S. Mienchihsan and Kochuan)
- (Matsumoto) { *Cervus* (Sika) *nippon leptodus* (Koken)⁴
 Cervus (Sika) *hortulorum* Swinhoe
 Cervus (Cervus) *canadensis songaricus*
 Ovis ammon shantungensis Mat. (Wanchiagna,
 probably Wanchiaichuan)

That Zdansky's classification of *Pseudaxis magnus* wrongly includes a great number of thick-jawed deer (*Euryceros*), I have already suggested some years ago⁵. The Cervids described by Matsumoto are also described in a confusing way. Matsumoto himself noticed that his *Cervus nippon leptodus*, *C. hortulorum* and *C. canadensis*, correspond to *Pseudaxis grayi*, *Rusa pachygnathus* and *Cervus canadensis* respectively (ibid. P. 37). Using our present knowledge of the fossil Cervidae of China, the faunal list of Itu has to be revised as follows:—

Sus sp.

?*Pseudaxis magnus* Zd. (the antler of local. 24. S. only)

Pseudaxis grayi Zd. (*Cervus nippon leptodus*)

- 1 Matsumoto, H. On some fossil Cervids from Shantung, China. Sc. Rep. Tohoku Imp. Univ. Sendai, Japan. Vol. X, No. 2, 1926 and On a new fossil race of Big-horn Sheep from Shantung, China. ibid.
- 2 Zdansky, O. Fossile Hirsche Chinas. Pal. Sin., Ser. C, Vol. II, Fasc. 3, 1925, P. 46.
- 3 Pearson, H.S. Fossil Suidae from China. Pal. Sin., Ser. C, Vol. V, Fasc. 5, 1928,
- 4 Some isolated teeth of Hipparion were also described by Matsumoto, (on *Hipparion richthofeni* Koken) SC. Rep. Tohoku Imp. Univ., Vol. X, No. 4, 1927. But the localities are all uncertain. Some were purchased from Chinchou (Itu). They are therefore not included in this list.
- 5 Young, C.C. On the Artiodactyla from the *Sinanthropus* site at Choukoutien. Pal. Sin., Ser. C, Vol. VIII, Fasc. 2, 1932, P. 62.

Euryceros pachyosteus Young (part of *Pseudaxis magnus* and *Cervus canadensis*)

Euryceros flabellatus Young (type of Locality 13 of Choukoutien)

Ovis shantungensis Mats.

In addition, the *Bubalus* skull of Changlo belongs without any doubt to the same faunistical block. The relations are obvious with the upper red clays (*Siphneus tingi* beds) of other parts of North China. With the exception of *Ovis shantungensis* all these forms are found in Choukoutien. The reddish loam of Shantung is probably therefore for the most part of a "Choukoutien age", a small lower part representing possibly somewhat older beds if *Ovis shantungensis* proves to be really an index form for the Nihowan beds.

3. *The sandy beds of Wangchialou area.* Along the road from Linchü to Shanwang also, the reddish loam is well developed over the slopes we passed, although most of it has been already washed away. Along the valley near Wangchialou we found however a markedly different facies of deposits below the loess and above the archæan mass (fig 7). At this

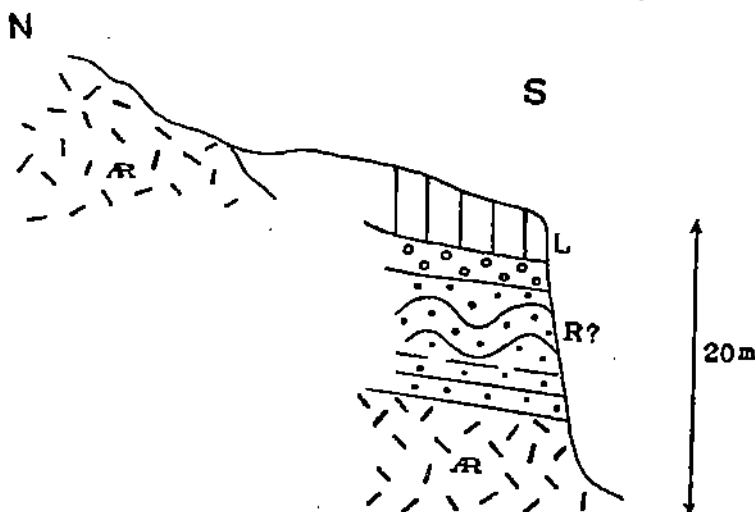


Fig. 7. Section E. of Wangchialou. Ar. Archæan, L. Loess with basal gravel, R? Sands and gravel (locally contorted), probably a river-facies of the reddish loam.

place, the formation is composed mainly of small gravels and sands of a white grayish coloration. Most of the elements are of igneous origin, evidently derived from the archæan rocks. In the middle zone these sandy beds look somewhat contorted. Owing to the smallness of the exposure, I could not decide whether this disposition is simply due to local compression, or to cross-bedding appearance, or whether on the contrary it should be considered as an indication of tilting.

No fossil was found at this very exposure; but some remains of a decidedly Late Cenozoic looking *Ovis* (lower jaw) and fragments of other undeterminable mammal bones have been collected by our technicians from Chunchiaho in Shaling a few li S. from there. I regard this series therefore as the lake or river facies of the reddish loam, although the possibility of it being equivalent to the Shanwang series is not absolutely excluded.

4. *Shanwang area.* In the Shanwang area the reddish loam is extensively developed, and less destructed by erosion. In its thickest part the formation may reach 20 meters or even more. But in the

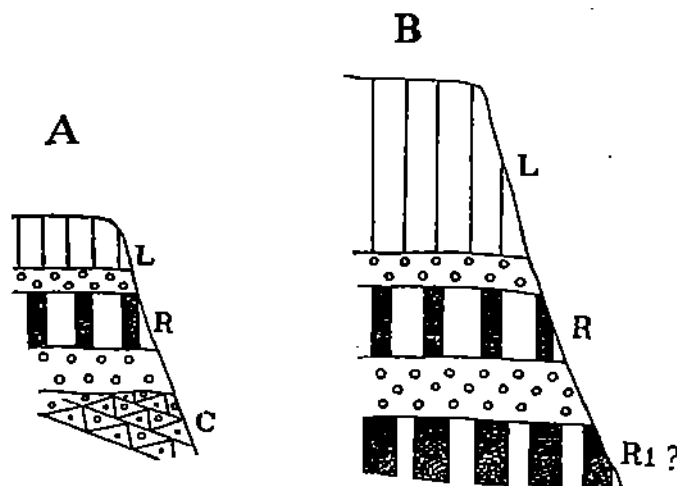


Fig. 8. A. section of Chiehchiaho, B. Section near Wangchiachuan, C. Cretaceous, R₁? Dark red clay, R. Reddish loam with basal conglomerates, L. Loess with basal gravel.

Chiehchiaho valley itself, where the Shanwang series is developed, they are again less extensive, and represented only by a few remnants observable under the loess. Wherever the loessic cap is absent, the destruction is still going on. In several places, the basal gravel of the reddish loam contains an abundance of basaltic pebble.

Remarks on the distribution of the reddish loam. All along the mountainous ranges or the border of depressions in Shantung, the reddish loam is more or less developed, its presence depending chiefly on the local conditions of erosion. The formation is especially well developed south of Tsinan and in S. Lingtzehsien. From the former places some teeth of Bovids, and other bones are reported. In Peimashan along the Tientsin-Pukou line, many fissures with red breccia are found in the limestone quarries, but so far no determinable fossil has been found. For the south of the Taishan range, we have already published some observations made in the Wenho-Ssushui district¹. Since that time, a few fossils (mostly limb bones of deer) have been collected by our technicians from Koulitsun, Laiwuhsien, this fact proving that S. of the range also the beds are not entirely barren of fossils. An important difference to be noted between North and Central Shantung is the absence in the former of the Early Tertiary deposits (Kuanchuan series) occurring in the latter. Neither did we observe in N. Shantung the superficial zone of alteration with manganese-iron pisolites, coating the Tertiary beds in Central Shantung.

5. THE LOESS

As in most parts of N. China, the loess usually coats the previous old formations. The basal gravels are in most cases present. Near Changlo, there is a layer of loess like-deposits with plenty of concretions, lying on the reddish loams. This particular layer seems to indicate a rewashing of the reddish loam with accumulations of concretion, and would thus represent the basal part of the loess.

1 Young, C. C. and Bien, M. N. Cenozoic Geology of the Wenho-Ssushui districts of Central Shantung. 1935. Bull. Geol. Soc. China, Vol. XIV, No. 2.

A secondary loess and various types of late alluvial deposits are developed everywhere along the river valleys and other depressions.

SUMMARY AND CONCLUSIONS

As a summary of these observations, the Late Mesozoic and Cenozoic sequence in N. Shantung can be briefly expressed as follows:

	N. Shantung	S. Shantung
Holocene	Recent deposits	Recent deposits
Middle Pleistocene	Deposition of Loess (Chingshui Stage)	Loess
Lower Pleistocene and Upper Pliocene	Deposition of the reddish loam (Z. Erosion)	Reddish loam
Pontian	Basalt flow (no lateritization) (Tanghsien stage)	Basalt Period of lateritization
Middle or Upper Miocene	Deposition of Shanwang Series with volcanic activity	Bajada breccia
Lower Tertiary	Big unconformity	Kuanchuang series
Cretaceous	Deposition of the Upper Cretaceous Series	

The most remarkable differential character between the two areas is the total absence of typical Kuanchuang series in N. Shantung. Of

course, it is not absolutely excluded that the upper Cretaceous beds of this region (the Laiyang series) may include some Lower Tertiary horizons not yet identified. In any case, due to the absence of marked block faulting in N. Shantung, the "Bajada breccia" is not represented in the area. We suppose that this particular facies is replaced by the Shanwang series.

Another important difference between N. and Central Shantung is the absence in the former of the protracted soil-forming process (lateritization and formation of iron-manganese pisolithes) so characteristically observed S. of the Taishan range over the Tertiary beds. The northward extension of the conditions favourable to this process seems to be entirely stopped by the Taishan range, a true arid climate having apparently prevailed at that time in N. Shantung. The residual gravels observed in so many places in the Wenhö-Ssushui area (Central Shantung) are also scarcely found North of the Taishan. The karstic surface in the limestone regions is however well formed, for instance in S.E. of Changchü.

In spite of the above mentioned differences the whole history of the Shantung is mainly the same. In contrast to Shansi, Shensi and Kansu provinces, conditions seem to have been relatively quiet then (after the great Miocene block-faultings) throughout the whole Late Cenozoic time.