

## A PHYSIOGRAPHICAL STUDY OF THE LOWER WEIHO GRABENS

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### INTRODUCTION

On the 31 of August, 1932, the writer of the present paper was appointed one of the five members by the National Geological Survey, Peking to survey the soils of the Weiho plain in Central Shensi. For the most part of the trip the writer had the pleasure to accompany Mr. N. F. Chang of Kinling University and Mr. W. Chen the late soil surveyor to the National Geological Survey, China. Most of the time, of course, was spent in the cultivable and cultivated areas of the valley plain; and only occasionally did the writer have a chance to shift his attention from soil study to the study of the geo-forms. A short trip, of about ten days, was made alone to Puchenghsien and Yaohsien districts (蒲城縣, 耀縣) during the end of the trip, but it was in such a hurry that detailed work was not carried out.

In writing up this report the writer is indebted to many of those who have traveled in this part of the country, especially Prof. C. Y. Hsieh<sup>1</sup> who has generously encouraged and aided the writing by granting him the privilege of personal discussion. It is fitting that acknowledgement be made to Prof. G. B. Barbour whose inspiration and teaching during the last two years led me to devote attention to these problems. Whilst the field work was not then completed and results can only be stated in tentative forms, the writer ventures to let this preliminary statement seen in the paper that it may draw attention of other geologists and travelers to these problems, and he may benefit from their criticism. No pretensions are entertained to completeness and accuracy.

### THE LOCALITY

As one enters the famous Tungkwan (潼關) he presently sees a wide open plain stretching toward the interior of the province. On his left hand side

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§ Received for publication Jan. 1933:

1 See his paper on Geomorphology of North Shensi basin in the same Bulletin.

there are mountain peaks of over 2000 meters in height composing the Tsinling range, the foot of which is flanked by terrace of reddish clay and loess. The historical highway of the Changan from Tungkwan to Hsian has been built for its most part on such terrace against the Tsinling scarp. On his right, northward beyond the Weiho, the graded plain is circled by distant mountains of generally, gentle relief, presenting a picture which is quite different from the south. The valley plain narrows from the east toward the west and ends at Paohih sien (寶雞縣).

Beside the topographical features, climatic evidence also marks the geographical unit. The Tsinling being a lofty and continuous range has been acting as a barrier cutting of rainfall from the valley plain. Thus, precipitation is reported to be over 100" south or in the Tsinling range while north of it or on the valley plain rainfall is so scant that the aridity has been the chief factor of the local famine which has continued for several years. During his field work the writer noticed that hundreds of the natives were leaving their homes for the so-called north and south hills where they can get a better living.

Rivers are numerous on the basin plain. Beside the main one, the Weiho, there are the Chingho and Loho on the north and the Paho and Chanho on the south. Hundreds small streams come down from the precipitous Tsinling range. The Weiho, on account of lack of rainfall, though of considerable

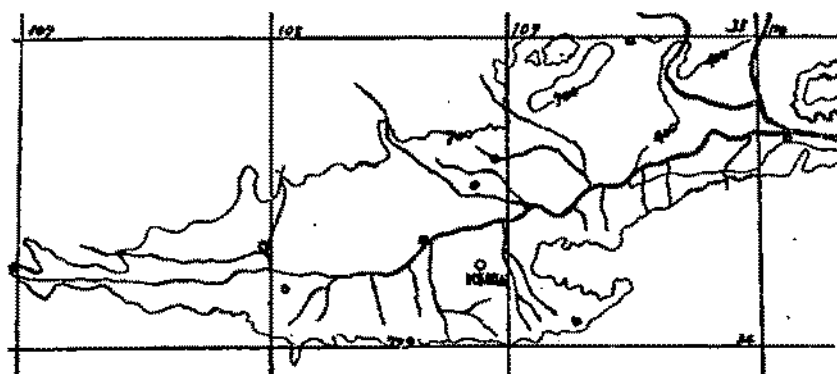


Fig. 1. Position and boundary of the Lower Weiho Graben.

length and size, discharges little amount of water. The tributaries, being intermittent in nature, are often flooded during the rainy season though for the most part of the year can be waded across. Artificial canal system on the fertile plain of Weipei (渭北平原) and others had been started as early as in the Chin (秦) Dynasty.

The lower Weiho basin lies approximately within latitude  $34^{\circ}$ — $35^{\circ}$  N and longitude  $109^{\circ}$ — $111^{\circ}$  E. As to the altitude the local base-level is limited by the 350 meter contour line above the sea; and the border regions are limited by the contours of 700 meter.

#### GENERAL GEOLOGICAL STRUCTURE

##### The Pre-Eocene Mature Surface

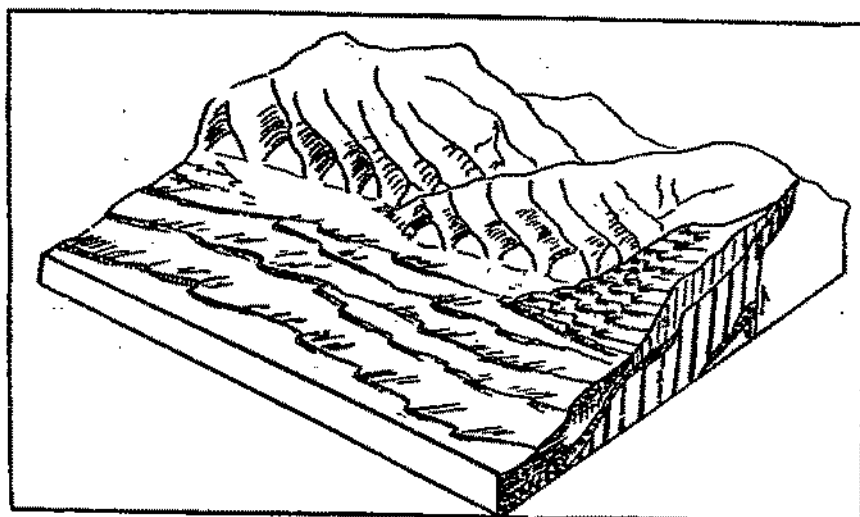


Fig. 2. Simplified Block-diagram of the structural relationships of the deposits of the Weiho Graben after the faulting.

- Formations:
1. Santmen deposits
  2. Basal gravels of Loess
  3. Malan loess
  4. Fluvialite and Secondary Loess
  5. Recent River Washes

It is by no means easy to tell whether or not the range of the Tsinling had been peneplaned, but it had evidently reached a stage of maturity before it was faulted. The fault scarp with its Weiho Graben on the southern side is quite obvious and is of textbook perfection. Above the fault scarp and before reaching the top there is a well preserved profile, representing a mature surface and which is as prominent and conspicuous as is the fault scarp.

#### The faults

According to Huang<sup>1</sup> there are three normal faults bordering the Weiho Graben on the southern side. They are the Lantien Meih sien fault, the Huayin-Lintung fault and Lintung-Shanghsien fault. The first two faults with their general E.W. direction and striking features cannot be readily explained on any other assumption. The last fault which reverses the direction into NW.SE, is therefore explained by the same author to be a tear fault rather than a normal gravity fault. The normal faults are also called boundary faults since their presence has marked out a magnificent geographical feature. Huang dates them as early Miocene from the fact that they cut the Eocene beds and leave the loess, reddish clay and gravels of the Sanmenian age undisturbed.

On the north border of the region studied, fault scarps are not as conspicuous as on the south. Eocene deposits are cut by normal faults along the foot of the Changchiashan (張家山) north of the Chingyanghsien (涇陽縣). Another fault is observed cutting the monadnocks of the Puchenghsien (蒲城縣) district. Many minor faults were observed by Prof. C. Y. Hsieh during his recent trip to the north Shensi region. It seems probable that all the normal faults bordering the graben are contemporaneous. However, the mode of occurrence may be different.

The history subsequent to the faults is more complex than the diagram suggests. Careful study of the simplified block will give a clearer idea of the fundamental structural setting than can be grasped from a verbal description. In Fig. 2 the surfaces of both the downthrow and uplift blocks are shown buried underneath the superficial deposits, which have built up the Weiho Graben to

1. Huang: The Geology of the Tsinlingshan and Szechuan, Mem. Geol. Survey China, Ser. A, No. 9, p. 187.

its present relative level. It is apparent that during recent evolution of the earth surface of this region the graben and its borders have had a close relationship e.g. with the exclusion of the colian and other transported material from far places, the quantity of material eroded from the graben keep pace with the quantity supplied from the border regions. Thus, the study of the sediments and their relationship will help us to know something about the history of this region.

#### The Northern and Southern Borders of the Graben.

There is a remarkable contrast of structure between the mountains on the south and north of the Weiho Graben. Along the southern border the mountain range attains a general height of over 1500 meters with peaks sometimes reaching over 2000 meters (the Sacred Huashan). This mountain range known under the generic name the Tsinling Shan, is deeply cut and trenched with structures representing its youthful stage along the fault lines. Along the north side of the graben, the mountain range, is generally highly eroded and has a low relief expressing a senile, old stage of its life history. Near Puchenghsien and Yanhsien the mountain range is almost entirely buried up by the superficial deposits, chiefly reddish clay and loess. Physiographically these low, rolling

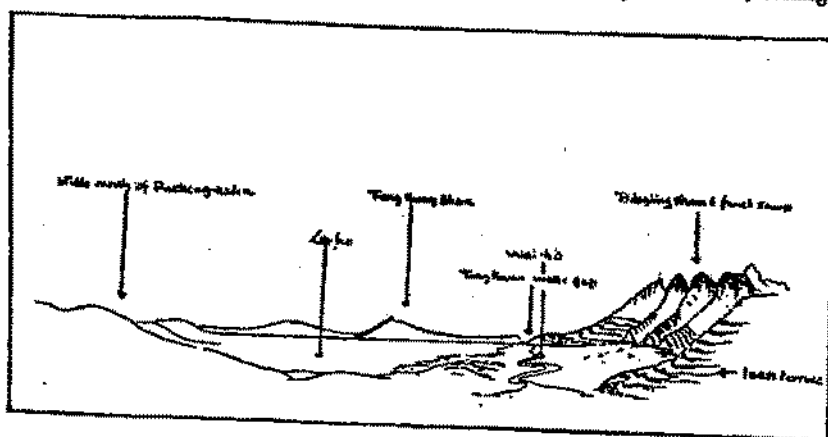


Fig. 3. Panorama of Weiho valley, showing contrast of N and S. borders.

hills, half-buried and isolated by superficial deposits cannot be better named than monadnocks of the Tanghsien stage of maturity.

Evidently it is due to the low topographic relief that the superficial deposits have been protected from being seriously destructed. The features described are well contrasted in the view as sketched from the Puchenghsien looking southeast toward Tungkwan (潼關), where the rivers of the graben plain join the Yellow River.

#### DISTRIBUTION OF THE SUPERFICIAL DEPOSITS

To many of the foreign and native tourists including geologists, the northwestern China especially Shensi is a loess park. The hills, the terraces of the rivers and the highways are all built of a material collectively known as the loess. Superficially it is all loess. However the basin deposits consists of various kinds of material, namely, reddish clay, sand, loess, secondary loess and river wash. Of all these materials mentioned loess is only a fraction. Horizontally the loess occupies a wide area but vertically it does not have as great a true thickness as it is usually supposed. The present chapter which attempts to locate the deposits may throw some light upon the loess problem and its relation to other materials.

##### The Eocene Deposits

Eocene deposits being covered by younger deposits are not often seen on the valley plain. On Huang's map they are marked along the foot of the hills north of the Chingyanghsien (涇陽縣). There, they form the foot hills, extending from the mouth of the Chingho eastward for quite a distance until reaching the Chingkuho. Generally, the deposits consist of sandstone, conglomerate and red clay with a total thickness of no less than one hundred meters. Here, they are unconformably underlain by Sinian and Cambro-Ordovician systems. Being slightly faulted the whole formation is tilted, with a general and gentle southwest dipping.

##### The Pliocene Deposits

The Pliocene deposits in this basin are far from being complete. Where they are, by any chance, exposed, they consist of basal conglomerate and gravels and a thin layer of red clay loam. A layer of red sand is often seen between

the former layers of deposits. On the Shansi Shensi border ten miles north of the Tungkwan (潼關) the writer observed that the faulted beds of the basal conglomerate, red clay loam and red sandstone lie unconformably upon the Ordovician limestone. The deposits are however, not recognized on any fossil evidence. The total thickness of the presumable Pliocene deposits is only about 10 meters. Along the Paho (陂河) and Yushui (潯水) valleys only the basal conglomerate and sandstone are seen, the red clay loam is not readily recognized. Moreover, the writer is not sure to date them, for they may belong to the Eocene formation. Besides, their thickness varies from several to ten meters. No detailed section was exposed and studied.

#### The Sanmenian deposits

The Sanmen is the thickest superficial formation in the Weiho Graben plain. Owing to Post-Sanmenian erosion, however, this formation has been reduced to its smallest amount. Logically, the latest erosional period if it was vigorous and continued a long time, may have destroyed all the previous erosional records. This is apt to be so in a valley, where deposits are subject to both aggradation and erosion. As shown on Fig. 2 the Sanmen deposits form the great upper terrace covered in turn by a thin layer of loess, below which is a vast aggraded basin plain of a rather mixed up nature.

The Sanmen deposits chiefly consist of reddish clay loam always underlain by layers of gravels and sand. Superficially, they look reddish to brown. Resembling loess, they also form vertical cliffs whenever cut by rivers or rain-wash. Deceptive they are, a common field worker often take them to be true loess. Limy concretions are very abundant, and when they are present as a basal formation, they are of huge sizes and in the form of gravels. When weathered, the latter become red and stain their surrounding material. Concretions, in upper formation are regularly arranged into concretionary layers which are parallel to the bedding plane of the deposits. But, the same phenomenon is also prevailing in the loess formation. The thickness is at present doubtful.

The fossil remains are very limited. *Helix* seem to be the only and most popular one throughout. Big bivalves are also seen in the deposits in Yushui (潯水) valley, near Weinanhsien (渭南縣).



## The loess deposit

With the increasing knowledge of physiography the estimated thickness and amount of the loess has been very much lessened. The loess, however, is still deserving of accurate study and discussion.

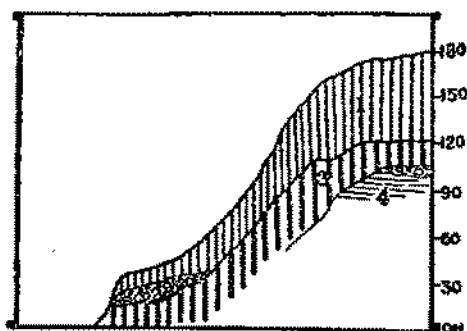


Fig. 4. Cross section of the Yushui valley, Weinanhsien, Shensi.

1. Loess 2. Gravels 3. Reddish clay and lake beds 4. Sandstone

The genuine loess:—The so called genuine loess of eolian origin is scarcely seen, especially in the valley, where erosion has permitted no material remain undisturbed. The less doubtful loess representatives are limited to the great upper terraces. Thickness of the loess varies locally. A thickness of 50 meters of the pure Malan loess, fine in grain, yellowish-white colour, forming vertical and columnar cliff was observed in the Yushui ( 潞水 ) valley, near the city of the Weinanhsien. It is unstratified, without concretionary bandings. In many other parts of the valley the loess unless filling in the local depressions, is seldom over 30 meters in thickness.

The reddish loess:—Every traveler from Tungkwan westward on the old highway of Changan must have noticed loess hills on his left, bordering the northern foot of the Tsieling range. Here, the loess hills seem to be hundreds of meters high, mantling over a comprehensive area and might be supposed to have been once the universal mantle of the whole basin and had afterward, been dissected.



A short visit to Machiakou (馬家溝), a small village located on the east side of Chanshui (滄水) and about 25 li east of the city of Hsian (西安府) revealed the true nature of the so-called loess hills. The natural profile exposed along a loess gully shows that the material composing the hills is neither the pure yellowish-gray loess nor does it look like the Sanmenian reddish clay loam. Along the vertical cliffs on both sides of the gully there are indications of stratification in the form of distinctly tilted reddish colour bandings. They are regularly two or three feet thick. Patches of pebbles are often present along the base of the reddish bandings. Alternating with these bandings are the loess, yellowish gray, forming vertical cliffs and giving a general impression of pure loess.

In the Puchenghsien about a hundred li direct north of Machiakou, the same conditions prevail. A ravine with a depth of 30 meters and a length of twenty five li (25) running N. E.-S. W. from Shangwangchuang (上王莊) to Puchenghsien beautifully exposes the natural profile of the deposits. Reddish bandings with concretions are seen. Definitely below ten meters from the ground level is a reddish banding with a thickness of approximately three meters. From the upper part downward to the bottom was noticed a gradual change of colour ranging from yellowish to reddish. Samples were carefully collected. Fossil shells were collected with special care from the material, where immunity of intermixture of recent shells, which might be, by any chance, washed down from the cliffs, is insured. But the *Helix* collected from the bottom reddish material, thirty meters deep, shows literally no difference from those collected above, and that from the pure loess.

Summarizing the facts together, we draw a concrete picture by a few words. Under the yellowish gray true loess lies another material very much thicker than the former, in part like loess but with cleavage that is vertical rather than perfectly columnar, with reddish layers, with concretions often in well defined layers dipping, locally, parallel to the bedding plane of the deposits. Nothing like real Pontian clay is seen, the nearest being a reddish loess usually apt to be in the base of the sections. The writer tentatively calls it reddish loess in order to distinguish it from the real Sanmenian reddish clay and the pure loess.

The fluvatile and secondary loess:—Another type of loess, which is often referred to as fluvatile loess is seen in the valley plain, distributed generally in the depressed region. The writer holds that the fluvatile and the true loess are mainly contemporaneous deposits. It is natural to suppose that a formation which owes its origin essentially to a change of climate would pass laterally into deposits of different character in places where moist condition still persisted. Undoubtedly, after the loess had begun collecting on the greater upper terraces, streams, though sluggish, would, however, keep on flowing. It was in this steppe condition, that loess deposited in the depression were intermixed, locally, with gravel deposits and sand patches, while on the higher terraces the loess was not intermixed with other materials, thus, pure loess.

During this loess epoch, the broad Weiho was becoming smaller and smaller as the climate was changing from moist to less moist. The decreasing of the volume of the streams together with the increasing of deposition of the loess would be a check to the flow of the streams. The writer does not believe that the loess deposition had, at any one time, filled up and occupied the whole valley and blocked up the streams. But it is natural to suppose that with the aggradation of loess, some or some part of the streams would be occasionally and locally blocked up. Where a section of stream was thus blocked, the river passing for a while, would overflow at some point, scouring out a passage through some lower places and might either take a new course over the valley plain or divided into tributaries, to unite again further down the plain. By its repeatedly dividing and subdividing, flowing in the braided or anastomosing courses the river, thus, offered a chance of the formation of fluvatile loess over the entire valley plain.

It is important, to emphasize the origin and formation of the fluvatile loess. For the most part of the valley plain, the material seen may be classified under his name. It is important to notice that eolian erosion and deposition unlike that of ordinary processes is not limited by basal level either temporary or final. On the upper terrace the loess after deposition was constantly under eolian erosion while in the basin the same material deposited was too readily intermixed with any other material transported. Thus, part of the thick formation forming the terrace of the Yellow River from Hankukwan (函谷關) to Tungkwan and

for the most part of the material above the lower terraces of the Weiho valley may come under the name fluvatile loess. Even Huang's<sup>2</sup> "true loess terrace" of Ch'anshui where the city of Hsian is situated is of the same origin.

The secondary loess, as it generally occurs in the depressed regions, roughly between the 400-500 meter levels, differs from other facies of loess by its location. Its colour, being dark gray resembles neither the typical loess nor the Sanmen deposits. The tendency to form cliffs moreover leads every passenger to call it loess. But patches of pebbles are often seen, and locally there are different facies as being more or less sandy, silty and clayey though the loess character dominates. Being far less heterogeneous in nature, it is hardly suited for the term alluvium which might, otherwise, be applied.

Deposition and erosion of the alluvium and some resulting special features

As is shown on the map, the recent alluvial deposits are all concentrated along the courses of the Weiho and its lateral streams. Owing to the different topography and distance between the lateral streams and the main one, the resulting features are different on the border regions of the valley.

Natural levees:—Huang<sup>3</sup> says in his *Memoris* "On both sides of the Pashui there are slight elevation of the alluvial plain which bound the course of the river. The foundations of the big bridge Pachiao, are laid on these elevations. As can be observed in the field, these elevations are not artificial bank but are the natural levees of fully mature river." It is true that the accumulation of the fine sand and silt deposits is enormous close to the lower courses of streams, where deposition takes places as soon as the streams lose their velocity by spreading over the vast flood-plain of the Weiho valley. Concerning the Pashui, the writer does not believe it is a fully mature river owing to its present gradient. But formation of natural levees is, by no means, impossible in such a less moist region where the stream are subject to seasonal floodings.

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2. Huang op. cit. p. 12.

3. Huang op. cit. p. 11.

4. Term proposed by Prof. C. B. Barbour through personal communication.

Composite levee<sup>4</sup>:—However, the streams, like the Chihshui, Fushui (赤水敷水) and others coming down from the Tsinling range with uneven gradient in the Weinan and Huahsien districts (渭南縣華縣) do not in the real sense, possess any natural levees. There are banks closely resembling the natural levees but their origin is complex and unnatural. The so-called natural levee have been formed after the courses of the streams were artificially protected with dikes. Levees unnaturally formed like these, with their composite origin are therefore termed "composite levees".

Composite topography: While formation of levees either natural or composite are characteristic of the constructive work on the southern border of the valley, composite topography developed by the stream action on the north is another characteristic feature. Examples of composite topography are common but the causes of the river rejuvenation which is responsible for the topographical feature cannot be discussed here. Among many areas characterized by such topography the Puchenghsien and Talihsien (大荔縣) deserve to be first mentioned. Thirty li east of the Puchenghsien, benches or terraces which are now from 500 m to 600 m above the level of the Loho (洛河) are remnants of a broad floor of a former mature valley. Within this older valley which is about a mile broad flows the Loho (洛河) in an entrenched narrow channel. The benches or the 'great upper terraces' as we have often referred to in former chapters consist chiefly of reddish clayey material covered by a thin veneer of loess while the present channel is walled by secondary loess and alluvial deposits (Figure 5).

In the Talihsien (大荔縣) very young "valley in valley" forms are seen, indicating that two cycles have passed since the initiation of the erosional stage of the Panchiao or Huangho. Here, the Loho (洛河) flows in a narrow trench about 20 feet below the surface of the alluvial plain which is two miles wide. A similar feature is observed in Sanyuanhsien (三原縣) where the Chingkuho (青谷河) flows in a narrow channel trenched below the Sanyuan plain (三原平原).

Dissected delta (?): Along the south bank of the Loho in the Chaoihsien (朝邑縣) and Talihsien districts there are sand hills occupying an area

of approximately 600 square li. As shown on the map, this sandy region has roughly given a triangular shape which resembles the form of a delta. The writer regrets very much that he did not study it carefully enough to find if it had the detailed structures, such as the top-set and fore-set, the presence of which would prove the real essence of the delta and indicate the direction of the ancient flows. Generally, the sandy region stands 20 meters above the river bed of the Loho, which is flowing at the 350 meters level. The northern and southern borders of the delta being dissected and drained by the rivers, Loho and Weiho respectively, have been partly fixed by the growth of orchards and the intensive cultivation by the natives.

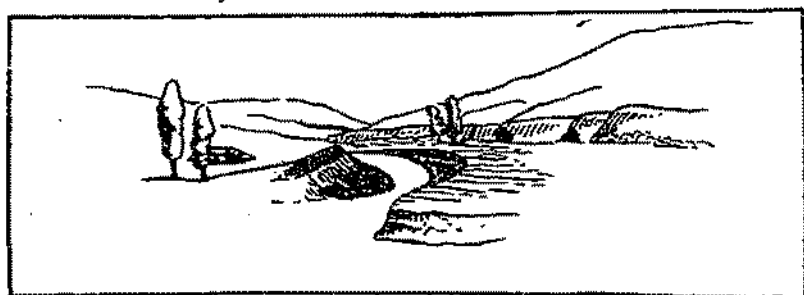


Fig. 5. Composite topography of the Loho, at 15 li south west of the Talihsien, Shensi. (sketch)

At present the origin of the sandy deposit is uncertain. Considering its location, shape and nature it cannot be better explained than by a dissected delta. Supposing that during moist condition when the carrying and eroding power of the rivers was much greater than it is today, the Loho and the Weiho would, naturally, carry more wastes and deposited them after they reached the junction where the former meet the Huangho and where was, then, probably a lake, serving as temporary local base-level before the wastes reaching their ultimate resting place. Owing to the lowering of the local base-level as either the outlet had been cut down or the moisture decreased, the delta which was partly submerged, has been emerged and was exposed as a delta plain. Again, either the lowering of base-level or the increasing of moisture would help streams to dissect the exposed delta. In addition, the eolian force,

especially in this semi-arid region, have been an important factor in modifying the topography. And in many places the sandy region, being subject to eolian action was quickly transformed into sand dunes.

However, the possible origin of the sandy area, described above is not limited by the ideal delta formation. During the time when eolian construction was dominant, formation of sand dunes in the low lying places is by no means impossible. Possibly, the present sandy area might be originally a wandering sand dune or dunes. The supply of sand was chiefly from the intermittent rivers and hillside. Being accumulated in the semi-arid region, they were liable left unfixed by vegetation and moving or drifting forward leewardly.

The return of moist climate had checked to some extent the eolian force and hence the formation of dunes. The latter were more or less fixed. Clearly, the growth of the rivers Lohu and Weiho (as a result of the return of the moist climate) has checked the dunes from wandering and highly modified their shape into the present forms.

Either of the above hypothesis is applicable but detailed and careful study is needed to prove or disprove.

#### DEVELOPMENT OF THE DRAINAGE SYSTEM

##### Summary:

The initial Weiho valley was originated by the late Jurassic time after the formation of the Tsinling range<sup>5</sup>. By origin, it is a subsequent valley. Latter crustal movements had accelerated erosional activity and before the present graben was formed, the valley had reached its stage of maturity which we often refer to the Tanghsien stage. The latter crustal movements were followed by dissection of the mature surface and the establishment of the new drainage system. A new cycle of erosion thus began.

The new drainage system once established, remains. Erosion followed by deposition and the local fluvial and lacustrine deposits were collected in the valley. Movement of warping and locally faulting initiated another erosion. No sooner than this erosional period had expressed its full activity it was stopped

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5. Huang op. cit. p. 206.



by the loess deposition. Loess, from that time, has been the veneering material, the destruction of which by the latest erosional period has carved out the present landscape.

*Tanghsien maturity:*

Considering the location of the Weiho valley region, which is about 840 kilometers distant from the sea, and at an elevation of 1000 meters (The Tanghsien surface) above the sea-level, a reduction of the rock mass to a plane is by no means impossible, but an elapse of time for stability of the crust, however, had not been granted. The study of the topography in this region, has shown that a pre-penultimate stage of erosion had been reached before latter faultings took place. Much of the elevated regions had been reduced to remnants forming the isolated uplands between broad valleys. These remnants which are referred to as monadnocks are well preserved north of the Weiho valley. Even the Fenghuangshan (鳳凰山) on the Shansi-Shensi border is claimed to be one of the same features.

*Post-Tanghsien development. (Development of new erosional features)*

A. *Ante-consequent streams:*—Any erosional cycle initiated by crustal movements like this, the inequality of the initial surface will give rise to the common features characteristic of the youth, for example, consequent lakes, consequent falls, etc. The consequent and subsequent rivers to the earlier stages, however, might not be diverted but remained in their courses as usual; and rivers thus modified are termed ante-consequent and ante-subsequent respectively. Example of these two types of rivers may be illustrated by the Chingho, Loho, and the Weiho. The former crossing mountain ranges and the highland north of the basin, with their hard rock gorges, locally, several hundred feet deep, are entrenched consequents. Whether or not the Weiho may be called ante-subsequent is less sure. It might have been shifting its course, now and then, from north to south and vice versa during the geological time but has always maintained its course along the strike and has never been stopped flowing.

Beside the Chingho and Loho, consequent streams on the Tanghsien surface would also be numerous on the slope of the Tsinling range. The main valley along which the path to the sacred Huashan is built, surely has a com-



plex origin. This valley as well as other minor ones on this granite mass possesses precipitous cliffs hundred meters high. Contrary to the sign of youth, the main valley which leads to the sacred mont has a meandering course instead of a straight one. In interpreting these phenomena the writer agrees with Prof. C. Y. Hsieh who holds that the zigzag valley course which is a characteristic of the graded and sluggish stream was adopted from the Tanghsien mature surface and that the high cliffs are primarily caused by the vertical joint of the granite mass which is apt to collapse after being weathered or undermined by river corrosion. "In that case, therefore, the rivers that have maintained their courses on the uplifted areas cannot be strictly called antecedent. But, being consequent on the earlier and antecedent to the latter stages of a single series of deforming movements, are termed ante-consequents".<sup>6</sup>

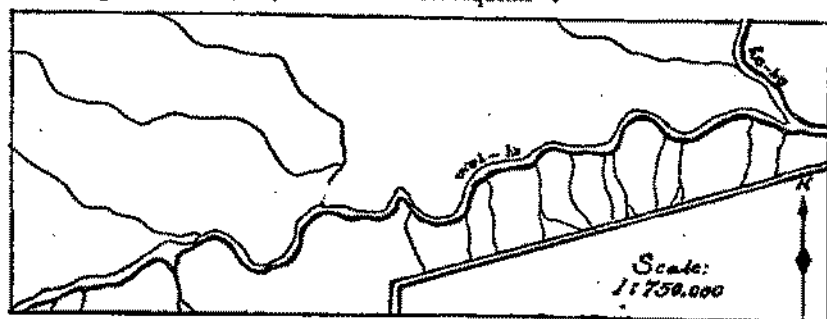


Fig. 6. Rectangular pattern of Weiho drainage

B. Insequent streams:—On the uplifted regions insequent streams were initiated. They were waterfalls accidentally started on any regions above the fault scarps. With increasing water quantity, chiefly from rain fall, these waterfalls eroded headward into the inter fluves and formed deep ravines and gullies. Examples are not uncommon in the granite mass of the sacred Hua-shan. Any traveler who views the famous waterfall, Shuilientung (水簾洞) may appreciate the real work the waterfall has done beside the beauty she offers. Streams, started first as waterfalls along fault scarps where topographical adjustment is complete from the beginning, may be termed insequent.

6. Cotton C. A. Geomorphology of New Zealand, p. 24.

The drainage pattern:—The drainage pattern is very much emphasized and controlled by the fault system. The main and the lateral streams being rectangular to each other, the main pattern may be thus termed rectangular drainage pattern (see figure 6) or trellised.

#### The valley plain

The absence of the thick Pontian red clay and others may be logically explained as having been eroded after the tectonic movements. Erosion co-exists with deposition. While streams were entrenching and eroding on the up-lifted regions aggradation in the down faulted places was undoubtedly rapid. It is probable that underlying the present valley plain thick beds of reworked Eocene material may be found, provided later erosion had not completely swept all them away. Thus the history of this Graben valley is very old.

#### The Weiho

The Weiho is by origin mainly a subsequent river, taking the advantage of the weakness between the highly folded granite gneiss and schists and the resistant formation of the Sinian and Cambro-ordovician systems. The Weiho valley running parallel to the strike is, therefore, a longitudinal or strike valley.

#### Times of aggradation

Following or contemporaneous with the erosion was the deposition or aggradation. At last, during the beginning of the Pleistocene time aggradation took place of erosion and resulted in the formation of thick gravels, sands, and reddish clay loam. In general, this deposition had built up the frame work of the plains in the north China and it has been specially prominent in this region.

Detailed stratigraphy of the younger rocks along Western Shansi and northern Shensi has been described by Tielhard and Young<sup>7</sup>. They established a formation which they call "reddish clay" a name suggesting a formation between the loess and red clay. Similar occurrences have been reported by different authors in other parts of north China. The writer during his trips to Tatung (大同府) and Jehol (熱河) with Prof. G. B. Barbour had the chance to visualize the magnificence and significance of this formation.

7. Mem. Geol. Surv. China, Series A. No. 8, p. 2.

In general, this period of aggradation was universal throughout greater part of north China.

An erosional period was introduced after the deposition. It was a vigorous erosional period as it has been recorded on the rock terrace cut along the Huang-ho canyon to be 50-80 meters deep. The same record is seen along the Chingho canyon north of the Chingyanghsien where gravels of Sanmen stage are hanging approximately 20 meters above the entrenched terrace. Vigorous as the erosion was, it did no more than removing the valley gravels and cutting rock terrace to moderate depth and was then stopped by the loess deposition.

The loess deposition:—This deposition has filled up the entrenched Sanmen gullies and smoothed up all the irregularity of the surface. Here and there, during the loess epoch, except on the high peaks of the mountain ranges and the streams that were sluggishly flowing, loess was probably the dominating deposit. Descriptions of the loess will not be repeated here, but one thing we shall emphasize is that the loess is just a veneering deposit.

#### Post-loess erosion

This Post Loess erosion or Panchiao stage is responsible for the scenery in the Loess park of the north western China. Many of the fillings were then reexcavated and rock terraces were cut from 10-15 along the Huangho course near Hoshan as recorded by Teilhard and Young<sup>6</sup>. The same terraces are also seen in the Chingho and Loho valleys in this region of the central eastern Shensi.

#### SUMMARY AND CORRELATION OF THE PHYSIOGRAPHICAL STAGES

In order to avoid repetition, the physiographical stage observed in the lower Weiho basin will be given in a very summarized form. A series of diagrams (figs. 7-12) is added to illustrate the relationship between the superficial deposits and the landscapes. It is important to keep in mind that the observed facts may not always coincide with theories; and local difference may be present though the sequence of the major events so far studied appears the same in each case.

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6. *op. cit.* p. 29.

This following chronological table<sup>9</sup>, showing the stages of erosion and deposition applies only to the present region studied.

1. Peitai Peneplane—not identifiable
2. Tanghsien mature surface—remarkably well developed between the 700-1000 meters level on the slopes of the mountain range.
- 3.....Paote red clay deposits—not much preserved; faulted.
4. Fenho dissection—Vigorous and universal; responsible for the local drainage system.
- 5.....Sanmen deposition—thickest formation; upper portion possibly colian.
6. Chinghsui entrenching—continued for a short elapse of time.
- 7.....Malan loess deposition—extensive
8. Panchiao regrading—responsible for the present river courses; gravel deposition.
9. Recent stage—Intermittent trenching and deposition

(1) Tanghsien mature surface: The Peitai peneplane gives no evidences of its presence without a careful tracing of the whole area studied. The Tanghsien mature surface is well preserved. The highly trenched surface above the Tsinling fault scarps and the monadnocks half covered by superficial deposits north of the Weiho mentioned in former chapters fully indicate this mature surface.

(2) The Paote stage: The recognition of the Pontian deposits is unfortunately not based on any fossil evidence. This formation is seldom over fifteen meters. In many places, where it might be expected, it may not be seen at all. The absence and scantiness of this formation may be explained as being highly eroded.

(3) The Fenho stage: This erosional stage is plainly shown by the river valleys, especially that of the Chingho and the Loho. These rivers had all initiated and developed their valleys during the Tanghsien stage of maturity.

9. Table adopted from G. B. Barbour's 'The Geology of the Kalgan Area'.

The Post-Pliocene uplifting renewed their erosional power and bedrocks were, then, dissected in places to a depth of several hundred feet below their old mature surface. The present drainage system was then established.

(4) The Sanmen stage: Paleontologically, this stage may be divided into the lower or Nihowan substage and the upper or Choukuotien substage, but as time did not permit careful study in this region, the writer is unable to give any detailed description. It is important to notice the difference of thickness of the deposits here preserved and elsewhere in the North China Plains. The upper part of this formation, is seldom seen on the coastal plains in north China. The unusual thickness of this formation cannot be explained without some appeal to either a long duration of crustal stability for the complex process of deposition or an escaping from being eroded.

(5) The Chingshui stage: Considering the preservation of the thick deposits of the Sanmen stage, the Chingshui stage if it did exist should have been very much briefer than the Fenho. Removal of the Sanmen deposit by the Chingshui erosion is not very remarkable except in river valleys.

(6) Malan stage: The loess, as its name implies, is believed to have been deposited mainly by the wind. Hence it is not limited to either depressions or high relief. However, it did not, once, at any time, fill up the whole valley. Facies and mode of formation of the loess have been discussed in earlier chapter, and need not, be repeated here.

(7) The Panchiao stage: This stage is responsible for the destruction of the loess mantle. Causes of the erosion are probably climatic. The return of moist condition with an increased amount of precipitation renewed the erosional power of the sluggish streams. Soft as these deposits are, rivers soon entrenched their new channels, and gorges and gullies were then carved. Though, there could not be anything as to the change of the base-level but much of the deposit was, then, eroded; and hand in hand with the destruction of the loess mantle there took place the construction of the alluvial plain.

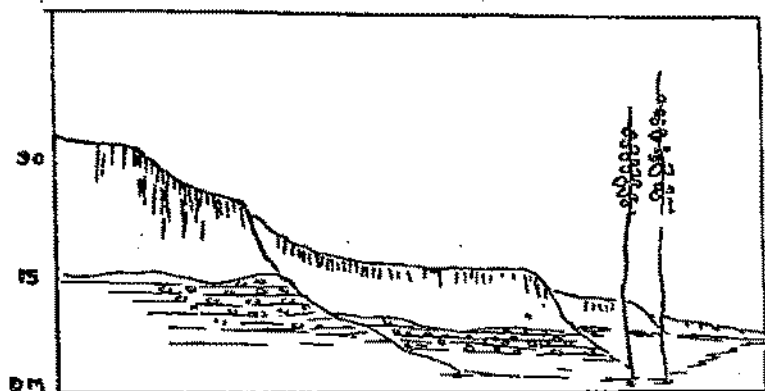


Figure 7. Loess and its basal gravels. Yaohsien, Shensi (sketch)

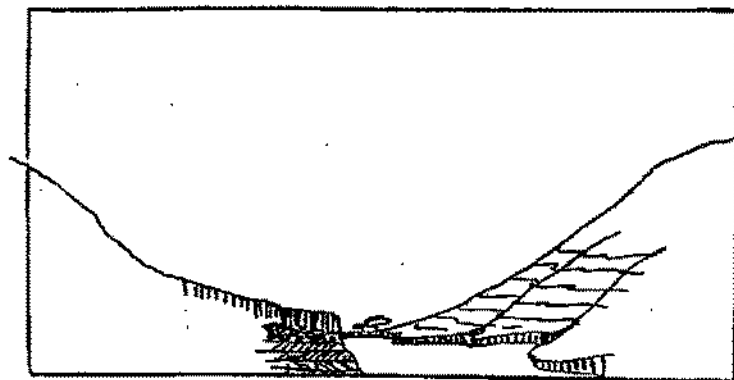


Figure 8. Loess and its basal gravels underlain by Sanmenian lake beds. Weinan-hsien, Shensi (sketch)

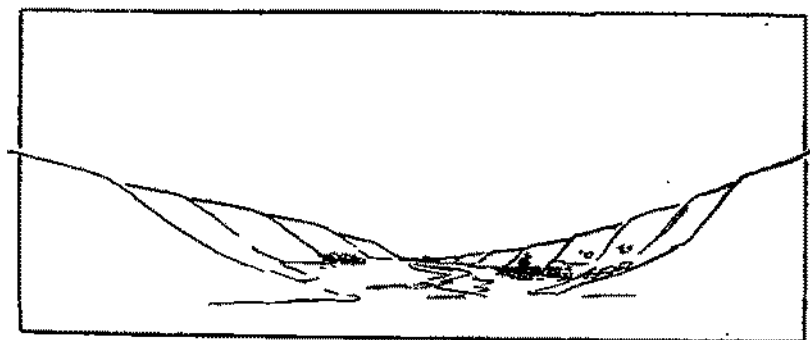


Figure 9. Natural profile of the Pashui valley, looking southeast from the Shihli-liutsun, Shensi (sketch)

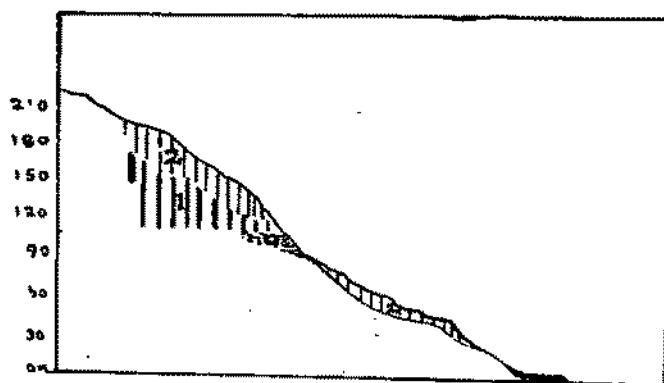


Figure 10. Cross section of the Pashui valley at Hsingchiehchen, Shensi.

- Formations:
1. Sanmen deposits—reddish clay loam, concretions and lake beds.
  2. Loess.
  3. Pashui river deposit.



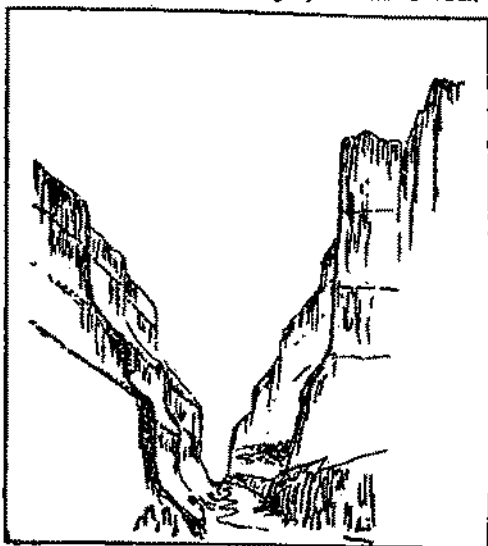


Figure 11. Loess gorge in Machiako 25 li east of Hsian. Dotted lines showing reddish bandings parallel to the bedding plane of the deposits. (The bandings are approximately 6-7 meters apart) (sketch)



Figure 12. Vertical wall and reddish bandings of loess in Machiako with dwellings excavated in between the latter. (sketch)