NOTE ON THE GEOMORPHOLOGY OF THE NORTH SHENSI BASINS§

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(With 4 Figs. and 4 Plates of Photo)

CONTENTS

1. INTRODUCTION.

The geology of the north Shensi basin has been studied to some detail by the American geologists Fuller, Clapp and others[1] in an oil exploration party sent out in 1914 under the joint auspices of the Chinese National Oil Administration and the Standard Oil Company of New York. As their interest was chiefly on the economic side, no serious attention was therefore paid to the geomorphological features or Cenozoic stratigraphy which are, however, so unique and well developed in this particular region.

More recently, C. C. Wang,[2] geologist of the National Geological Survey made in 1929 some reconnaissance surveys in Yulin and its adjoining

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1. A number of papers as been published among which the final one on geology: is Fuller, M. L. and F. G. Clapp, Geology of the North Shensi basin, China, Bull. Geol. Soc. Am., Vol. 38, 1927, pp. 287-378.

2. Wang, C. C., On the Stratigraphy of North Shensi, Bull. Geol. Soc. China, Vol. IX, 1925, p. 59.

districts. A number of fossil remains including fish scales, plants etc. were discovered, and on basis of this discovery, it has been possible for him to assign appropriate geological ages to the different formations which have unfortunately been altogether misplaced or neglected by the previous study of the American geologists. Wang has made also interesting observations on the physiographic development of the Yellow River[3] between Shansi and Shensi, a study of immense value to the well understanding of the geomorphologic features of this region.

The systematic research carried on during the recent years by Teilhard and Young of the Cenozoic Research Laboratory has contributed a great deal to our knowledge on the Cenozoic stratigraphy and physiographic history in North China. Their monograph[4] on the pre-Loessic and post-Pontian deposit in Shansi and Shensi is of particular interest as it gives all the fundamental facts which may be used for further research. As their field was limited to the extreme north of Shensi including Yulin and its adjoining districts informations in regard to central and southern part of the North Shensi basin remained, therefore, still unknown.

During a field trip[5] which lasted from Aug. 1 to Sept. 14 in 1932, the writer accompanied by Dr. K. S. Yang & Mr. P. S. Hu had the opportunity to observe in a rather hasty way some of the major geomorphologic features of North Shensi. Because of the limited time at our disposal, we could not make detailed observations as expected. Moreover, it is to be regretted that the determination of elevation of different place—an observation of fundamental importance to geomorphological study—could only be made by barometric reading and which owing to the frequent fluctuation of atmospheric pressure is not always reliable.

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3. Wang, C. C., Physiographic history of the Yellow River between Shansi and Shensi, Bull. Geol. Soc. China, Vol. IV, 1925 p. 87.

4. Teilhard de Chardin and C. C. Young, Preliminary observation on the pre-Loessic and post-Pontian formation in western Shansi and northern Shensi, Geol. Mem. Ser. A. No. 8, Geol. Surv. China, 1930.

5. This trip was made under the joint auspices of the Shensi Industrial Inspection party and the Geological Survey of China.

The writer wishes to express his sincere thanks to Dr. K. S. Yang and Mr. P. S. Hu for many of their criticisms and helps during the entire field work.

2. General topographic fratures.

As has been very well defined by Fuller and Clapp[6] north Shensi is a topographic as well as a geologic basin. In spite of the fact that the general level of the basin is represented by a flat-topped and at many places much dissected plateau, yet it is surrounded on all sides by mountain ranges of higher relief. Thus to the east. it is bounded by the high mountains of western Shansi and to the west, it is limited by the broken north-south mountains of east-central Kansu known under the collective name of the Lungshan mountain range. Toward the north the basin surface gradually merges into the sandy waste of the Ordos and is approximately limited by the great loop of the Yellow River. By Fuller and Clapp, the southern limit of the basin was set at not far north of the fault front of the Tahua and Tsingling mountain ranges, but in a strictly physiographic sense, the Weiho valley is of different origin and should be separated from the basin to form a distinct unit by itself. Therefore, according to the writer's opinion, the southern rim of the basin must lie at south of Ichun (宜君) and north of Tungkuan (同官), where the relief is distinctly higher than the general level of the basin, and moreover, the surface is composed of the solid rock formations without the covering of any younger Cenozoic deposits. According to the geological traverses made by the American oil geologists the same condition was found at northwest of Hancheng which evidently represents the eastern continuation of the southern rim north of Tungkuan and is to be further connected with the eastern rim in western Shansi. From topographic considerations above sketched, north Shensi represents therefore a typical basin which, according to the American geologists is approximately 100,000 square miles in area, but according to our definition with the exclusion of the Weiho valley, the remaining area is about 90,000 square miles.

The basin has been filled up by a mighty sequence of unconsolidated material ranging from Pliocene to Pleistocene in age with a thickness of more than two hundred meters. The surface of the basin is as a whole remarkably

6. Fuller and Clapp, Loc. cit. pp. 298.

uniform in elevation; it varies from 800-1,000 m or more above the sea level. At places where dissection is not so extensive, the surface of the basin looks almost like a perfect plain of aggradation as can be seen for instance in the vicinity of Chungpu (中部) and Lochuan (洛川) districts. As a rule, wherever a prominent river valley is approached, the elevation of the basin surface becomes gradually lower, and after having acrossed the valley the elevation slowly increases again. This feature can be best observed along the route from Ichun to Chungpu and down to the bottom of the Loho (洛河) valley where a slow but steady decrease in elevation can be noticed on an otherwise almost perfect plain of aggradation. After having passed the village Chiaokouho (交口河) the junction of the rivers Loho and Hulohe, (蘆葫河) and having ascended to the top of the upland, the general elevation of the surface becomes increasing again either toward north to Lochuan district or toward northwest.

Above the general level of the basin there rises at several places rock monadnocks (Fig. 1.) on which the superficial Cenozoic deposits are either absent or extremely thin. Two such prominent monadnocks were found at south of Fushih (膚施) and Yenchang (延長) with elevations ranging from 1100 to 1500 meters. Another monadnocks of perhaps considerable dimension was found at S. W. of Fuhsien and N. E. of Lochuan. This is indicated by its bare rock surface and also from its slight higher relief as compared with the surrounding country. In his recent journey in the districts of Yenchuan (延川) and Yenchang, C. C. Wang[7] noticed the same condition between the two regions just named, so there occurs again a monadnock range futher toward the north and which trends almost in the same direction as the other ones just described.

The basin has been dissected by a great system of valleys dated either before or after the Sanmen stage together with gorges and ravines which have been cut by very recent erosion. The extent and depth of the recent dissection varies naturally from place to place; along the route from Ichun to Chungpu or from Lochuan to Paotzetao (包子頭), the basin seems to have been only slightly dissected, so that plateau remnant of great extent was found and which gave to the traveller the impression of an almost perfect plain. Further toward

7. Oral communication.

north, the dissection seems to be more and more advanced, as, for instance, in the region of Fushih and Yenchang where perfect upland plain of any great

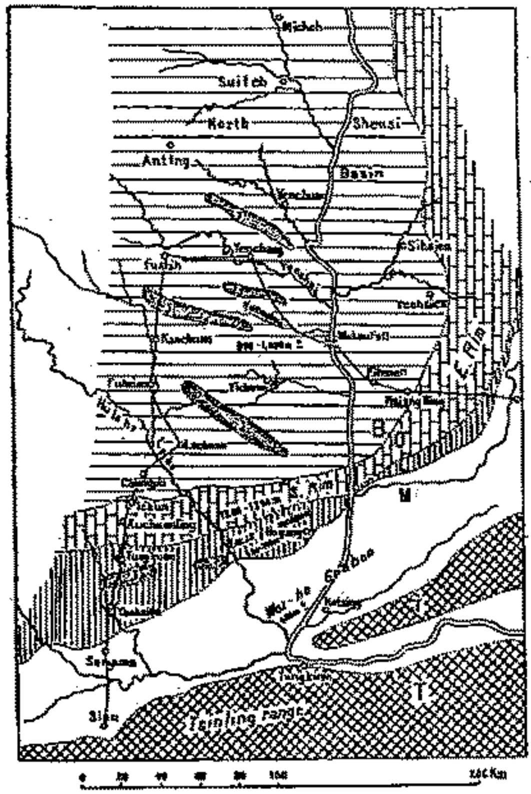


Fig. 1. Geomorphological Map of N. Shensi. T. Tsingling Range composed of metamorphic and crystalline rocks. B. North Shensi Basin. J. Monadnocks, O. Border Range. L. Loess upland or Terrace. M. Alluvial plain.

extent is scarcely to be found. The depth of dissection varies from a few meters in the miniature gullies of recent date up to 200-300 m or more in those prominent valleys of much antiquated date.

The elevation of the southern rim of the basin has been measured only at south of Ichun, which varies 1200-1400 m or more. As can be seen on the pass of Kuchuanling (哭泉嶺), the top of the rim range exhibits generally an uniform elevation which extends for quite a great distance either toward west or to east. This nearly peneplaned surface can be correlated with the Luliang stage of C. C. Wang.[8]

Both the rim ranges and the monadnocks supports usually a luxuriant vegetation. When loess mantle is absent as at south of Ichun, the soil is largely of residual origin. The vegetation is composed mostly of shrubs and grasses but forests are also found at several places, as at northeast of Lochuan, & Kanchuan (甘泉) etc. Since precipitation is generally ampler on higher elevation than on the low land, a more decomposed and consequently more fertile soil to support a more extensive growth of vegetation is therefore, nothing but quite expectable natural results.

3. STRATIGRAPHY & STRUCTURE.

The geological formations of north Shensi basin are rather simple; they may be divided into two categories as follows:

a) *The solid rock formations*:—This is to indicate such well consolidated strata of older geological age. In ascending order, we have encountered along our route the following formations:

i) Ordovician limestone crops out between Tungkuan & Yaohsien (耀縣). According to K. P. Chao[9] the same is found east and west of Puchenghsien (蒲城縣). The outcrops usually represent faulted monadnocks in the loess upland or loess terrace.

8. Wang, C. C., Explanation to the Taiyuan-Yulin sheet, Geol. Survey. China, p. 38, 1926.

9. Chao, K. P., Geology of the lower parts of the rivers Chin & Lo in Shensi province, Contributions No. 2b, National Res. Inst. of Geology, 1931.

ii) Permo-Carboniferous coal measure:—Outcrops of this formation are numerous among the rim-ranges of the basin. We have examined, however, only two localities, namely south of Tungkuan and west of Hsiangning (鄉寧) in Shansi province. Several coal seams are present which are being mined by native pits.

iii) Permo-Triassic red sandstone & shale formation:—This was called by the American geologist the Puhsien formation. During our excursion, we have crossed it at two places; the one was at north of Tungkuan which is comparatively limited in extent and the other along the Yellow River gorge and east of it as far as to Hsiangning district of Shansi province.

iv) The Shensi formation:—The Shensi formation originally named by Sowerby[10] of the Clark expedition in 1908-1909, was redefined by Fuller & Clapp as follows: It is a "great series of shaly or platy sandstones, with local limestones, shales, coals, and an occasional massive sandstone, which overlies the reddish Puhsien formation and underlies the Anting limestone and Ichun conglomerate, or when these are absent, the thick false-bedded Loho sandstone." As to the geological age of the Shensi formation, the American geologists found no evidence at all and in their unpublished report handed to the Chinese Government, this formation was even assigned to Carboniferous. Plant fossils indicating a Mesozoic age was first discovered by C. C. Wang in his first journey to northern Shensi in 1923.

Within the area traversed by us the Shensi formation is the most widespread; it forms the rock ground of the north Shensi basin on which the immense sequence of the Red Clay, Reddish Clay and the Loess mantle was deposited. Besides a number of plant fossils found near Chungpu and south of Fuhsien, we discovered also a *Cyrena* and fish-scale bearing black shale at S. E. of Yenchang. Since about 2 km east of the black shale lies the Yellow River gorge in which red shale and sandstone of Permo-Triassic age is exposed, so we can conclude that this shale in question must lie very near to the bottom of the Shensi formation. During their recent journey to Shensi C. C. Wang & C. H. Pan discovered again several horizons of plant fossils. All these fossils are under

10. Clark R. S. and A. de C. Sowerby, Through Shenkan, p. 116, 1912.

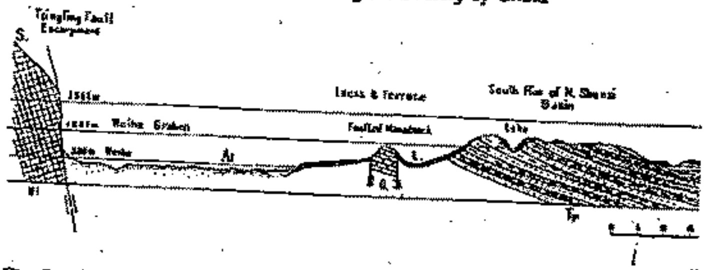


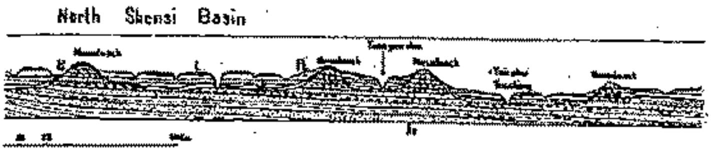
Fig. 2. Generalized section of North Shensi Basin. Wt. Metamorphic rocks of Algonkian Puhsien series. Js. Jurassic Sandstone and Shale, the Shensi series. Pp.

study from which it is hoped that the exact age of the Shensi formation may be determined. A separate paper will be published by Wang and Pan in the Bulletin of the Geological Survey on more detailed stratigraphy and the oil bearing feature of this great formation.

b) *The superficial, mostly unconsolidated Cenozoic Deposits*:—Unconformably overlying the older solid rock formations is a thick sequence of Cenozoic deposits in which the three following formations may be subdivided:

i) Red clay of Pliocene age:—This is composed of red clay, red sand and a layer of basal conglomerate which is unusually compact and well consolidated. The whole formation measures only 30-50 m in thickness. It rests unconformably on the eroded surfaces of the Shensi formation or in the Yellow River gorge it rests on the Permo-Triassic red sandstone and shale. Its contact with the overlying Reddish Clay is also an irregular one and at many places, especially along the recent river course, the contact is often marked by a layer of gravel containing abundant pebbles of rolled lime concretions.

ii) Sanmen Reddish Clay of Pleistocene age:—This is by far the most abundant and important uncohsolidated deposit in the north Shensi basin. It is composed essentially of loam or loamy clay of brown to reddish brown color. Without careful study it is often difficult to distinguish it from the true loess which assumes in most cases, however, a grayish tint. Another characteristic feature is the presence of an unusually abundant amount of lime concretions which occur either in nodular, lenticular form or in irregular shape of difficult description. The concretions are often arranged in layers which are parallel to the



age. O. Ordovician limestone. Tp. Triassic purple sandstone and shale, the Paoteh Red Clay. Ps. Sanmen Reddish Clay. L. Loess. Al. Alluvium.

bedding planes of the deposit. Except *Helix* shells we have found no other fossil remains. Basal gravel composed of rolled limy concretions is generally present especially along the present drainage course, but when this is absent, the contact with the underlying clay becomes generally undistinct. The thickness of the Reddish Clay amounts to 200-250 m.

iii) Loess:—The true Loess forms usually a thin mantle covering on Sanmenian deposits or solid rocks of different ages. In the region studied, no Loess with a thickness of more than 50 meters was observed. This statement seems at first unexpected, since almost everywhere on the top or on the slope of the hills in the basin, loess is usually present. This universal occurrence covering the underlying Sanmenian clay easily makes people think of the whole hills to be made up of loess only. This becomes the more so when the Loess of the upper slope is washed down by erosion and deposited in the lower slope as secondary loess. However, wherever a gulley is found or the superficial covering has been washed away by rainfall, the Reddish Clay will be exposed. Thus we have often seen spots or patches of Reddish Clay lying scattered among an otherwise homogeneous mantle of gray Loess. Aside from its distinct gray color, the Loess is characterized by an often well developed vertical cleavage, and the presence of lime concretions usually of much smaller size and less regular distribution as compared with those found in the Sanmen deposit. At many places a basal gravel of the Loess is found in which rolled limy concretions from the chief constituents.

The geological structure of the basin is rather simple. The whole Cenozoic formations have suffered practically no orogenic movement, so as to remain in most cases in almost perfectly horizontal position except in local cases where these deposits flanking an old land or on the slope of monadnocks, show some initial dip amounting to 30°. Distinct dip is however found in the underlying solid rock platform; this varies from extremely slight inclination in the greater part of the basin proper to pronounced disturbance shown by sharp folding and faulting in the mountainous area which borders the basin.

As can be seen from the geological map published by Fuller & Clapp the strike of the Shensi or other rock formations curves around from E-W at Ichun and Tungkuan to almost N-S. along the Yellow River gorge. In the former region the strata dip gently toward N while in the latter, a uniform west dip of a few degrees persists over an extensive area as far as to the eastern border of Kansu province. This indicates that structurally speaking north Shensi region forms also a basin, but since the upper Jurassic strata seem not to be repeated in Kansu, the western rim of the basin may have been cut off by a fault.

From the fact that Cretaceous strata (The Anting limestone or younger formations) are folded together with the upper Jurassic (the Shensi formation) as well as older ones, the date of folding may be fixed as post Cretaceous or early Tertiary. The movement was an extremely gentle one in this area resembling in some respects an epirogenic uplifting.

4. THE TANGHSIEN EROSION SURFACE.

Below the surface of the dissected Cenozoic covering is the buried beveled surface of solid rocks which in the basin proper consists essentially of Mesozoic sediments while in the border ranges older sediments ranging from Triassic to Carboniferous. The depth of the rock surface from the basin level naturally varies between wide limits and much depends of course on the altitude of the surface. However, if the absolute elevation of the rock surface be considered, it is found that its surface is generally represented by one of mild relief marked by rolling hills and smooth valleys; this is the Tanghsien erosion surface of advanced maturity (Fig. 3).

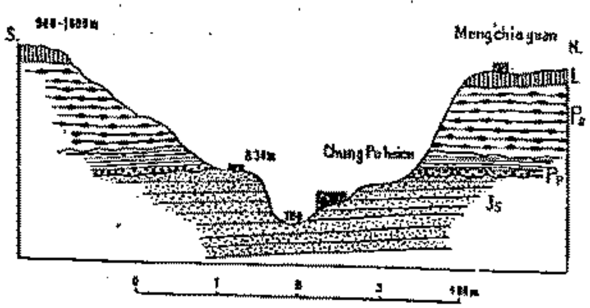


Fig. 3. Profile of a tributary of Loho showing the flat Tanghsien Erosion Surface. Js. Shensi Series. Pp. Paoteh Red Clay. Ps. Sanmen Reddish Clay. L. Loess.

As has been stated above the general contour of this older rock surface, i. e. the Tanghsien erosion surface conforms to a great extent to the present drainage system of the basin. Thus this older surface slopes toward the bottom of every existing valleys such as Loho, Yenshui, (延水) Yuenyenshui (黑岩水) etc. Its relationship with the Yellow River course is especially well marked; thus the Tanghsien surface slopes from 800 or 900 m in the central portion of the basin from Fushih to Chungpu down to 500 m along the Yellow River. According to Fuller & Clapp this same rock surface in west Shansi mountain slopes from 1200 or 1500 m to elevations of 900-700 m at corresponding portions of the river. According to the same authors this rock surface slopes in southeastern direction towards the Yellow River from 1400 m in N. W. Shensi and from 2700 m in Central Kansu to 760 m along the River canyon.

This uniform but gentle slope of the Tanghsien surface toward the Yellow River as well as to any of the present river valleys points conclusively that the major drainage system was already well established in the Tanghsien epoch. This conclusion on the existence of an initial Yellow River during Tanghsien stage closely agrees with what has been expressed by C. C. Wang,[11]

11. Wang, C. C., Physiographic history of the Yellow River between Shansi and Shensi Loc. cit.

who based his study, chiefly on his observations in the Yellow River gorge itself.

Another characteristic feature of the Tanghsien erosion surface of north Shensi basin is the existence of numerous rock monadnocks, some of them are of considerable sizes. The high elevation of such monadnocks is being reflected even on the present land surface and by such they can be easily recognized in the field. In elevation these monadnocks vary from 1000 to 1300 meters above the mean sea level.

5. The post Tanghsien erosion cycles.

The post Tanghsien erosion cycles in the N. Shensi region are represented by the following stages:

(1) Paoteh stage:—On the Tanghsien erosion surface, the deposition of Pliocene sediments with a layer of basal conglomerate took place. This is now known as the Paoteh stage. The Paoteh sediments was of much greater thickness than it is now but because of the later erosion, especially during the next epoch of the Fenho stage, a greater part of them has been swept away so that now there remains only a thickness of about 50-80 m.

(2) Fenho stage:—The Fenho stage is characterized by vertical cutting of immense scale initiated either by the lowering of the base level or due to the uplifting of the region. It is especially felt along the Yellow River; to this vertical cutting is due the present magnificent gorge of the River.

An ideal profile of the Yellow River gorge at Wukou Waterfall[12] is shown in the accompanied sketch (Fig. 4). From this sketch, we can see that the depth of the gorge measured from the base of the Paoteh gravel to the bottom of the river valley amounts to about 160 m. Fuller & Clapp gave similar amount of 152 m. The width of the gorge has not been accurately measured; by estimate it amounts to about 1 km.

12. A detailed topographic map of the Wukou waterfall has been recently made by J. T. Fang, member of the Geological Survey of China, whose report containing numerous topographic and hydrographic data is now in preparation.

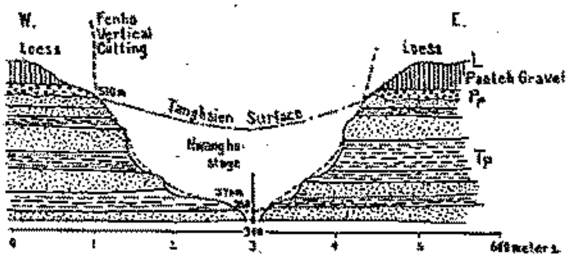


Fig. 4. Idealized Profile of Wukou Fell on Yellow River. Tp. Puhsien Sandstone and Shale. Pp. Paoteh Gravel. L. Loess.

Gorges with rock cliffs of 50 m or more in elevation were also observed along the valley of Loho, Yenshui and their tributaries. These gorges correspond also to the Fenho cutting.

The existence of a period of post Paoteh erosion is further indicated by the occurrence of a basal gravel in the overlying Sanmen Reddish Clay as well as by the reduction in thickness of the Paoteh Red Clay itself.

(3) Tsingshui stage:—The second period of erosion which took place since the deposition of the Sanmen red clay and corresponding to the so-called Tsingshui stage is also of great importance in the north Shensi basin. Perhaps all the prominent drainage system as Loho, Yenshui etc. were first brought to their present form ever since the superficial filling of the Sanmen Reddish Clay was removed. This period of removal of the Sanmen Reddish Clay corresponds to the Tsingshui stage. Whether or not the Yellow River gorge had also been entirely filled by Sanmen red clay and became first exposed by the Tsingshui stripping is yet unknown. Loess mantling or capping took place chiefly after the Tsingshui stage, i. e. it deposits or fills on a land surface practically identical with the present one.

(4) Hwangho stage:—The third period of erosion consisting principally of a vertical cutting is also well developed in the region studied. It is most marked, however, along the Yellow River gorge. By its activity, the

bottom of the valley was further entrenched down to about 10 m or more. This small gully was called by C. C. Wang [13], the Hwangho stage. It is chiefly due to this deep trenching that the famous waterfall at Wukou (壺口) was formed. Nearly all tributaries of the Yellow River was marked by similar deep trenches, the depth of which varies from two to five meters or more. A new base level of erosion was thus initiated and since erosion is now just in the beginning, the *Thalweg* presents a very irregular and uneven profile so favorable to the development of waterfalls. Thus in the lower part of Yenshui and Yuenyangshui, waterfalls are of frequent occurrence which together with the magnificent rocky floors, the overhanging cliffs etc. makes the region abundant in beautiful scenery. Similar trenches of varying depths were also observed along the rivers Loho, Yichuanshui, etc. and their tributaries.

(i) *Cause of Hwangho trenching*:—The cause of the deep trenching during the Hwangho stage may be explained by either of the following three ways:

By the first explanation, a warping or uplifting amounting to several tens of meters may be assumed for the whole or a part of the north Shensi basin. By this uplifting erosion was then revived, and new trenches formed which cut deeply and vigorously into the floor of the older valleys. This was the explanation offered by C. C. Wang in his study of the Yellow River gorge between Shansi and Shensi. Field observation gives however no positive evidence of any warping or uplifting.

The second explanation may be sought in the change of climate. Detailed study of the Cenozoic deposits in northern China has made many authors to believe that such a change may have really occurred during recent geological time. Thus it is believed that from Sanmen to Malan epoch, the climate become more and more dry resulting in the widespread deposition of Loess and from Malan to Panchiao epoch (closely corresponds to Hwangho stage), the climate changed again to a more humid one which thus made possible the vertical cutting and trenching into an already existing valley floor of older stage.

As a third possibility, revival of erosion may also be accomplished by the increase of water quantity resulting from capture of the northern

13. Wang C. C. Loc. cit.

part of the Yellow River by the Southern one. The peculiar loop-like course of the Yellow River and the sharp bending at the south end of the canyon course between Shansi and Shensi has always been a puzzling problem to geologists. An old, but quite a plausible hypothesis was that the great north-south course of the Yellow River came to its existence only since very recent time. Formerly the north part of the river flowed to north, while the southern part went to south and between these two segments a water shed existed. There was therefore constant struggle in head-ward erosion, and eventually a stage was reached by which the northern segment was captured by the southern one. Since the capturing and mingling of these two originally separated parts of the Yellow River, water quantity in the lower valley became suddenly increased, and probably to this sudden increase of the stream flow is due the revival of erosion with its consequent lowering of base level and vigorous cutting of new trench. Should the above explanation be accepted, then we could consider the capturing and consequently the formation of the N. S. course of the Yellow River accomplished shortly before the Hwangho stage.

As to the eastward continuation of the old Yellow River and the exact cause of the capturing, there remains much to be discussed. It is suggested however, that the great basaltic eruption in the Tatung-Fengchen area may have acted as obstacle to deviate the old course of the Yellow River which then flowed eastward from the Paotou-Suiyuan area and thence connected further east with the present course of the Yungtingho. This hypothesis was long ago proposed by Pumpelly, but its probability is by no means affected by some of Pumpelly's arguments which are disapproved by more recent researches. It is evident that what has been discussed is merely a hypothesis and much more field work is needed before the present problem can be adequately solved.

(ii) *Correlation of the Hwangho Stage*: In the Tachingshan region which is located about 200 km north of the Shensi basin and lying still in the drainage area of the Yellow River, C. C. Wang[14] observed similar phenomenon of deep trenching to which the name Hwangho stage was again applied.

From a purely geomorphological sense, the Hwangho stage can no doubt be correlated with the Panchiao stage which is so widely distributed and well

14. Wang C. C. Geology of the Tachingshan coal field. Bull. Geol. Surv. China, No. 10, 1928, p. 15.

recognized in Northern China. But the present writer still favour the use of the name Hwangho stage to indicate such deep trenching developed in the upper course of the Yellow River and its tributaries for the following reasons:

While the cause of the Panchiao cutting can probably be attributed to a recent warping or a change of climate or both, it is more difficult to explain the deep trenching in the upper Yellow River area and its tributaries by the same Panchiao uplift, so that the third explanation as discussed in the previous paragraph may still be accepted as a plausible hypothesis. Should this be true, then the formation of the Hwangho vertical cutting owed really to a different origin from the Panchiao trenching, a fact well justifying the use of a separate name in order to designate the last erosion epoch due to the regional morphogenic development in this part of the Yellow River valley.

6. DEVELOPMENT OF THE DRAINAGE SYSTEM.

From the above discussion of the geomorphology of the north Shensi basin, we may arrive at the following tentative conclusions on the successive stages in the development of the drainage system:

1) The present river system of North Shensi including the Yellow River follows more or less closely the initial valleys or river courses existing during the Tanghsien stage.

Evidences: Occurrence of basal conglomerate along most of the rivers and the sloping down of the older rock surface (i. e. the Tanghsien surface) toward the bottom of the valleys.

2) The entire North Shensi basin including Yellow River was filled up by the Red Clay. Monadnocks of the Tanghsien surface almost disappeared at this stage.

3) The Fenho erosion & cutting uncovered most of the monadnocks and made deep gorges at the Yellow River and its tributaries.

4) Deposition of Sanmen Red Clay has again filled up the entire configuration of the North Shensi region. Whether or not the Yellow River gorge was also filled up by the same is yet open to question.

5) The Tsingshui trenching after Sanmen deposition was responsible for the bringing up to their present shape of most of the drainage system in North Shensi Basin.

6) The deposition of Loess was only to cover a part of the top or slope of the already dissected plateau. It has never succeeded to fill up the entire landscape.

7) The Hwangho trenching was probably brought about by the general lowering of the base level after capturing and the formation of the present Yellow River.

8) Any trace of warping of the entire North Shensi basin was not observed. It is therefore difficult to explain the development of River System by such movement.

Explanation of Plate I.

Plate I.

Fig. (1) A critical place in topography which shows the end of the Weiho graben and the beginning of the loess terrace. About 40 li N. of Sanyuanhsien. Looking N.

Fig. (2) A typical view of the Shensi formation which is composed essentially of alternating hard and soft sandstone or shales, which makes the development of waterfall a special favor. Notice that the fall has already cut away the upper massive layer and is now flowing in a comparatively softer bed. A little S. of the village Kingssukwan, Tungkuanhsien. Looking North.

Fig. (3) A close view of the Rocky wall along Yenshui with its narrow trail in the solid rock. Looking East.

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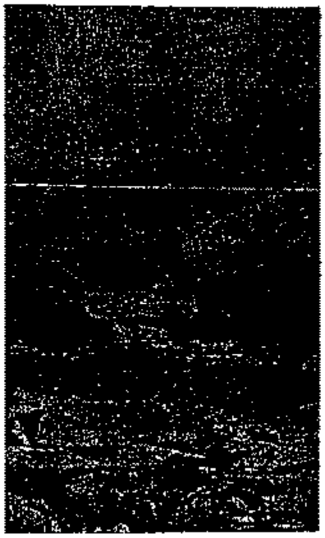

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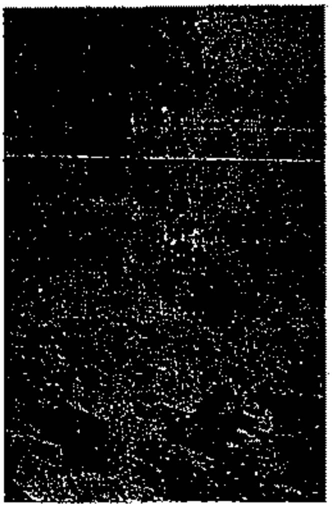

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Explanation of Plate II.

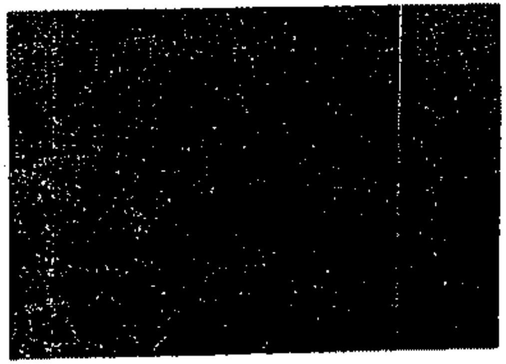
Plate II.

Fig. (1) Dissected loess in the front and Hipparion clay forming the higher elevation in the back. The photograph is taken at some 15 li north of Ichunhsien, a point very near to the edge of the great north Shensi basin. Looking S. E.

Fig. (2) A perfectly preserved plain of aggradation having elevation of about 1000 m. above the sea level. S. of Chungpuhsien. Looking North.

Fig. (3) A narrow gorge cut in Sanmen reddish clay which is overlaid at many places by loess cappings. At the bottom of the gorge outcrop of Hipparion red clay is exposed. Notice the even-sky line in the back representing the top of the basin. 10 li north of Piechiao, Chungpuhsien, looking west.

Fig. (4) A general view of one of the monadnocks in the basin. Notice the dense vegetation growing on residual soil formed from Shensi formation. Loess or reddish clay is conspicuously rare or absent. This place represents a pass between Kanchuanhsien and Fushihhsien and forms a water shed between the rivers Loho and Yenshui. Looking South.



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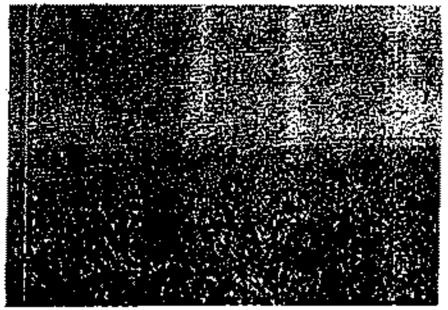

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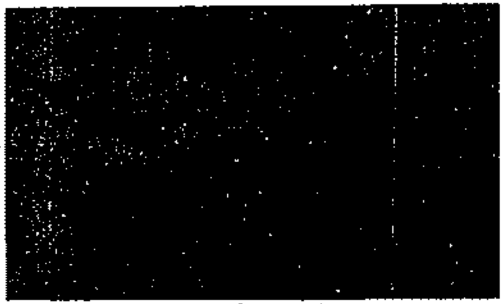

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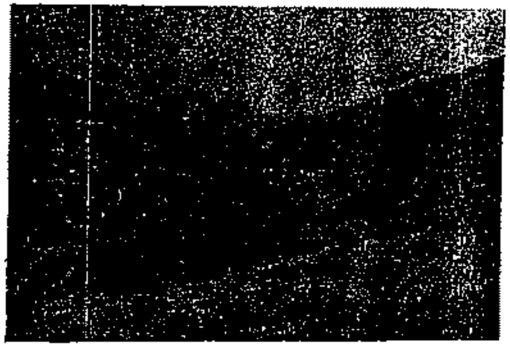

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Explanation of Plate III.

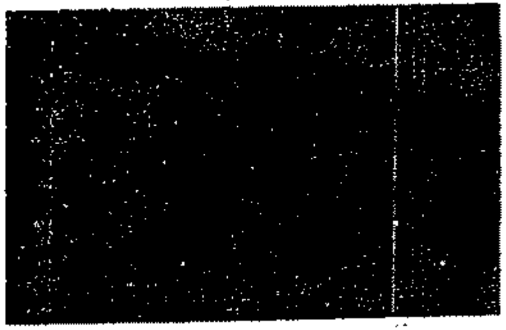
Plate III.

Fig. (1) A picturesque view of the River Yenshui with its rocky walls formed by the horizontally bedded Shensi formation. The alternation of hard and soft beds in the formation is clearly shown in the picture. Looking East.

Fig. (2) General view of the landscape in the southern rim-range. The even-topped range representing Luliang stage is shown faintly at a great distance. Photograph taken from top of Kuchuanliang, the highest point on the route from Tungkuan to Chungpu.

Fig. (3) A general view of the finely dissected basin top formed essentially by Sanmen reddish clay and covered at many places by loess cappings. Notice the winding trail followed by the Shensi Industrial Inspection Party. Looking East.

Fig. (4) Distant view of the Yellow River water fall at Wukow. The main fall in the center is obscured by the spray. Notice the pot-holes cut in solid rock on the left river bank as well as the side falls a little higher up. Looking N.



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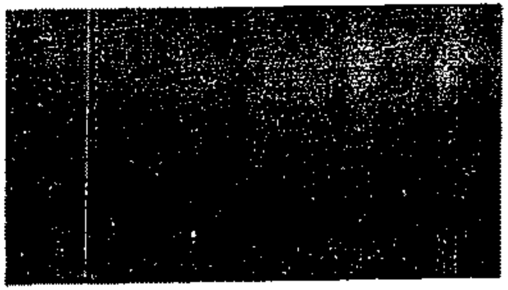

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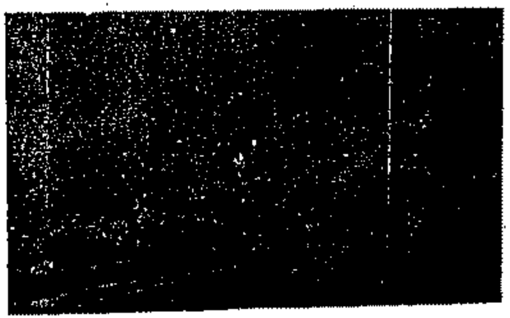

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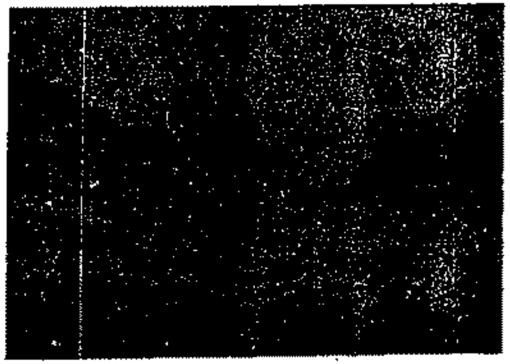

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Explanation of

Plate IV.

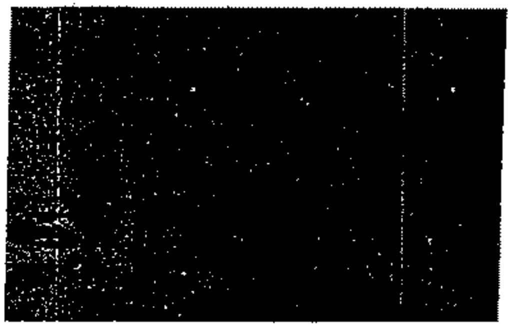
Plate IV.

Fig. (1) A close view of the side falls on the left bank of the Yellow River. Looking N.

Fig. (2) A big side-fall on the right bank of the river about 300 m below the main fall. Looking S. E.

Fig. (3) The Yellow River above the Wukow water fall. Here the river has a width about 300 m. Looking North.

Fig. (4) The Yellow River below the Wukow fall. Here the river has a width of only about 30 m. It is bounded on both sides by steep walls made up by horizontally bedded red sandstone and shale of Triassic age. The river opens out again after flowing about 20 li from the fall. Looking North.



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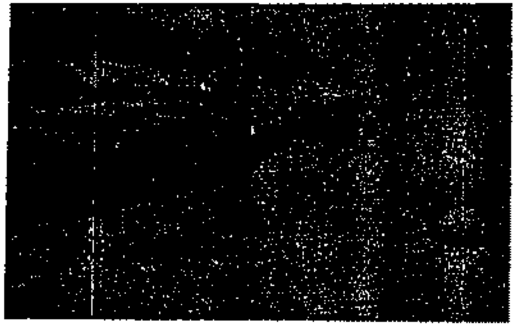

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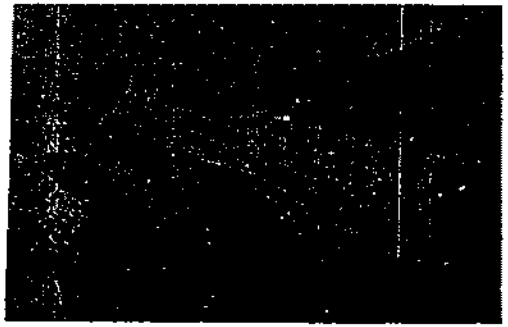

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