

RELATIONSHIP BETWEEN DEVELOPMENTS OF THE HUANGHE AND YONGDING RIVERS AND THE EVOLUTION OF THE FOSSIL LAKES OF THE CENOZOIC ERA IN THE DRAINAGE AREA

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ABSTRACT: The Huanghe and Yongding rivers were formed before the early and middle Pliocene epoch. Then they became interior rivers because of the appearance of interior fault lake basins at the end of the Pliocene epoch. The interior flow period continued until the end of the early Pleistocene or the middle of the Middle Pleistocene, and then they changed into the exterior rivers again till today.

KEY WORDS: the Huanghe River, the Yongding River, developments of a river, exterior flow period, interior flow period

Both of the Huanghe(Yellow) River and the Yongding River have the paleoanthropologic ruins of different periods, showing that they are the cradle of Chinese civilization. In this aspect the study of the relationship between their developments and the evolutions of fossil lakes within the basins during the Cenozoic era can not only reconstruct part of natural environment of the ancient human living in different periods but can also be used as a basic geomorphic background for studying the regularity of soil erosion at present and for working out a comprehensive plan of development and management of the drainage area.

Since Pympey put forward his conclusion in 1868 that the Huanghe River had once flowed from Hetao area eastward into the Bohai Sea via the Yanghe River and the Yongding River, many theories of the development of the river have come into being. In general, the controversy focuses on the channel changes of the upper and middle reaches, the cause of formation and the age of the river. The main ideas are as follows: the ancient Huanghe River was the upper reaches of the Yongding River^[1-4]; the Weihe River was the paleochannel of the ancient Huanghe River^[3,5,6]; with the Jinghe River flowing into the

Weihe River^[3,7,8] the valleys in Shaanxi and Shanxi provinces had half age-old river bed^[9]; the Huanghe River was the result of the connection of basins in the drainage area when they had been silted up^[10]; with the stability of the channel and the consistency of divide and interfluvial^[11], the fossil lake drainage of respective in the basin led to the appearance of the Huanghe River^[12]; the Huanghe River was formed by the interconnection of a few other rivers^[13]; the formation of the channel was due to the tectonic movement^[14]; the channel was formed during the Miocene^[3], the Pliocene, the Early Pleistocene^[13,11], the end of the Early-Middle Pleistocene and the end of the Late Pleistocene.

The authors participated in the paleogeographic study of Nihewan fossil lake basin of the Cenozoic era, a project sponsored by the National Natural Science Foundation of China and directed by Professor Zhou Tingru, and also took part in the study of the stream system changes, a subproject of the project: the comprehensive management study of the Loess Plateau, which was directed by the Commission for Integrated Survey of Natural Resources, Chinese Academy of Sciences. The following is some of the research results on the relationship between developments of the two rivers and the evolution of the fossil lake of the Cenozoic Era in the drainage area.

I. BOTH RIVERS ARE PALEORIVERS

1. The Yongding River

The formation period of the Yongding River can be determined by the analysis of the following profiles in its upper reaches.

1.1 The profile of the Shixia River valley

The existence of mountain erosion surfaces of the Tangxian age can be seen everywhere within the Sanggan River basin. The erosion surfaces are topographically represented by the superimposition of wide mature valleys upon young valleys. For example, a typical wide mature valley overlay the shoulder of a young valley near Shixia (Fig.1). The topographic surface on the right side of the mature valley is distributed continuously with the widespread mountain erosion surface of Haojiatai. This surface is 260 m higher than the present bottom of the valley. The mature valleys like this appear along with the Shixia valley and also extend into the hinterland of the basin, which demonstrates that they are the landform of river valleys shaped by the ancient Sanggan River.

On the right bank of the Shixia valley there is a branch valley named "the Tiger valley". There are some knick points in certain level of the valley. The valley above the top knick point is wide while below is narrow. The wider part of the valley is at the same altitude of the surrounding mountain erosion surfaces and is distributed continuously. On the right side a layer of red clay and gravel was found. In comparison with that near Chengqiang and Hongya, we find that they have the same buried landform and the identi-

cal features of lithology so that they were the accumulations in different places at the same time. The Hipparion fossil found in the layer near Chengqiang and Hongya^[15] indicates that the topographic surface and the layer of red clay and gravel were formed in the

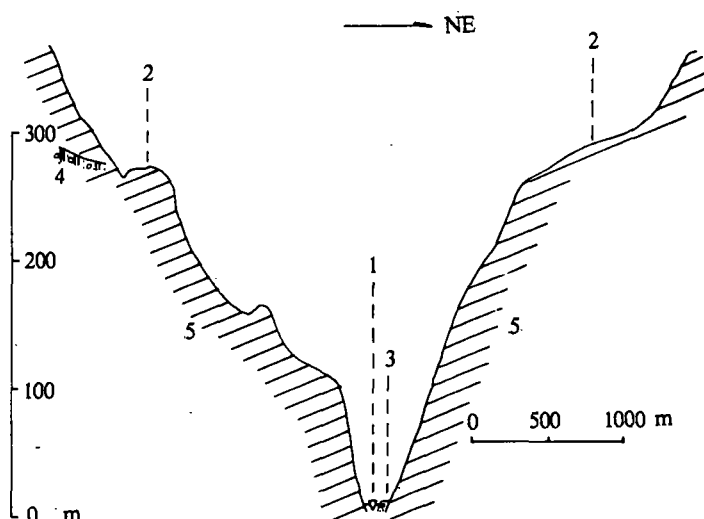


Fig.1 The profile of Shixia valley. Legend: 1.Present valley bottom; 2.Mountain erosion surface; 3.Sandy gravel layer; 4.Red clay and gravel layer; 5.Bedrock

Pliocene epoch. From this viewpoint, we can say that the ancient Sanggan River had not only existed in the period of the Pliocene but had also completed the process of shaping the landform of the wide valleys.

1.2 The profile of the Dapu paleochannel

Dapu is located in the east of Taohuayu, Wei County, Hebei Province. Dapu Town lies in the central lowland of a typical landform of wind gap, about 1,700 m above sea level. It had once been a paleochannel of the ancient Anding River which flowed into the Sanggan River via Chadao. The drilling profile obtained southwest of Dapu Town shows that the loose accumulation layer nearby is over 120 m thick. The top layer is brown loess and below is red clay and sandy clay (Fig.2). From Dapu northward to Chadao, the erosion surface of the Tangxian age extends asymmetrically and discontinuously on both sides of the valley. It constitutes a complete longitudinal profile in combination with Dapu paleochannel. Since there is no relative rise or subsidence from differential neotectonics from Dapu to Chadao, the longitudinal profile can represent a profile of the very river period: the Pliocene epoch. Thus, during the Pliocene epoch not only the main valley of the Sanggan River but also the ancient Anding River, its major tributary, had become wide valleys with full development, indicating that it had been subject to a long erosion. It can be concluded, therefore, that the system of the ancient Sanggan River would not be formed af-

ter the early Pliocene epoch.

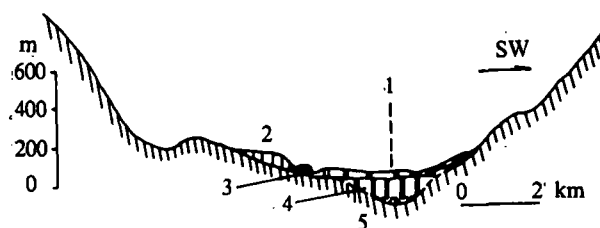


Fig.2 The profile of wind gap landform in Dapu. Legend: 1.Dapu; 2.Loess; 3.Brown loess; 4.Red clay and Sandy clay; 5.Gravel layer

1.3 The profile of Danli paleochannel

The Yongding River came into being as the convergence of the Sanggan River and the Yanghe River. It flowed through the Western Hills of Beijing into the Guanting valley. Danli paleochannel, a typical landform of wind gap with a thick layer of red clay and gravel, is situated at the Guanting valley, not far from the col (Fig.3). According to the statistical data of 50 gravel samples (diameter > 2 cm) from the red clay and gravel layer, the lithologic composition of the samples is: tuffaceous component 30%, andesitic component 37.5%, siliceous limestone and chert 17.5%, basalt 7.5%, granite 5%, sandstone 2.5%. Of them, basalt appears only in the basins of the Sanggan River and the Yanghe River. The gravel with 7.5% of basalt found in Danli paleochannel indicates at least that the Yongding River had been interconnected with the Sanggan River and the Yanghe River as a unified stream system when Danli paleochannel was developing. Moreover, as the Huailai basin was not yet a sedimentary basin, at that time the basaltic gravel could be transported to the Guanting valley and take a proportion in the gravel composition. In this regard, researchers in the Teaching and Research Section of Geomorphology, Beijing University, considered the gravel layer as the accumulation of the Pliocene epoch^[16]. From the above analysis, we can conclude that the Sanggan River and the Yongding River not only coexisted in the period of the Pliocene epoch but also were connected with each other. They were both the exterior rivers formed before the early Pliocene epoch.

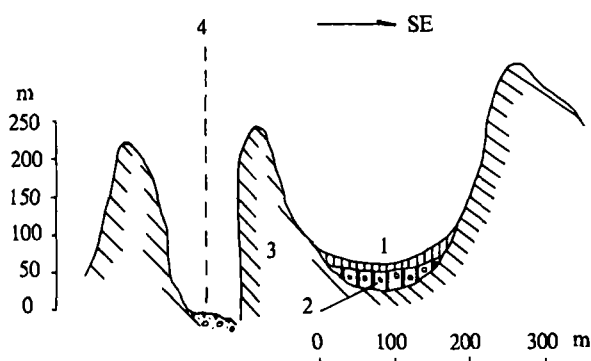


Fig.3 The profile of Danli paleochannel of the Yongding River. Legend:
1.Loess layer; 2.Red clay and gravel layer; 3.Bedrock; 4.Danli

2. The Huanghe River

An outline of the formation period of the Huanghe River in the early stage can be seen from the following profile analysis.

2.1 The Profile of Jiuzhoutai, Lanzhou

This profile can be considered as a representative of the latest period of the river formation in Lanzhou region (Fig.4). On the upper part of the profile is the thick bedded loess of 338 m. Below is a 3.8–4 m layer of silt and sandy clay of flood plain facies, and the calcium cemented sand bed. The lower part of the profile is a 5.5–6 m layer of gravel of river bed facies. The thickness of this gravel layer varies greatly and its composition is complicated, including mainly metamorphic rock, granite, sandstone and conglomerate, and gypsum filled in the pores of the gravel layer. Because of its complex gravel components, its till-folded structure, the gravel ab face facing the upper reaches of the river and the distribution of it being along the river valley, constituting the fifth level of the terraces, this set of gravel layer is inferred to be the accumulation of the ancient Huanghe River.

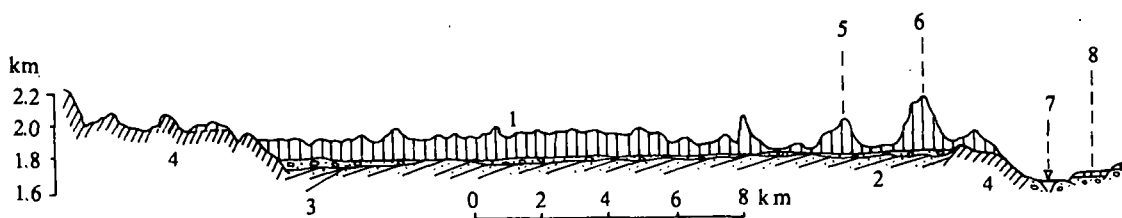


Fig.4 The profile of Jiuzhoutai of the Huanghe River. Legend:1.Loess layer;
2.Silt and gravel layer; 3.Gansu system; 4.Bedrock

This set of the ancient Huanghe River alluvion is widespread distributed in the vertical direction perpendicular to the river valley and it is not less than 19–20 km wide near Jiuzhoutai, and is referred to as material evidence of the razed plane of the Gansu age. The youngest stratum on the base of the alluvion is of the Gansu system which is thought to belong to the Pliocene epoch. It contacts unconformably the over burdened alluvion of the ancient Huanghe River indicating some absence of strata of depositional hiatus between them. The coverage of the alluvion is loess stratum. Paleo terrestrial magnetism dating indicates that the accumulation time of the loess at the bottom is $1.1 \times 10^6 \text{a}^{[17]}$. But the time when loess began accumulating in Xijin village, Lanzhou, is calculated to be $2.09 \times 10^6 \text{a}^{18}$ by paleo terrestrial magnetism dating and sedimentary rate. So, the alluvion in Jiuzhoutai was formed in the early time of the Early Pleistocene epoch. If the time of topographic razing to plane by the Huanghe River in Lanzhou region is considered, the time when the river appeared in the region should be slightly earlier than that of the gravel layer in Jiuzhoutai, that is, the late Pliocene epoch.

2.2 The profile of Jia County

The Huanghe River valley in the Shaanxi and Shanxi provinces is geologically made up of strata of the upper Paleozoic group and Mesozoic group. Their occurrences are gentle with dip angles mostly 4–8 degrees. Besides terraces along the convex bank, the landforms on both sides of the river generally have bedrock platforms, 130–180 m above the water level. The surface of the platform is slightly undulatory and is covered with loess of different thickness (Fig.5). In Yagou, the midway between Wupu and Lishi, a turning point of the back edge on the platform is observed. There is no lithologic line near the turning point, nor fault line. Obviously, the appearances of the turning point was the result of river erosion. Since the strike of the back edge goes nearly perpendicular to the flow direction of the Sanchuan River, it is not the back edge of the erosion terrace formed by Sanchuan River. Therefore, it must be the back edge line of the bedrock platform. The shortest distance from this back edge line to the Huanghe River, 18.5 km, represents the width of the local bedrock platform on the left bank. Since the Yagou turning point is about 900 m above sea level and the platform near the river bank is 830–840 m, the slope of the platform is 3.7‰–3.2‰. Is such a gentle platform a tectonic surface or erosional surface? First, because the river valley in the Shaanxi and Shanxi provinces develops in the flexure zone between the Luliang anteklise and the Ordos syncline in the North China table the strata are gentle. But, anyhow, they have some dip angles and have been influenced by the secondary folding. It is reasonable, therefore, to say that this platform is of erosional surface, considering its stable altitude difference in several hundred kilometers along the valley and the clear turning line of the back edge. Second, the remnant alluvion of the ancient Huanghe River, observed on the platform surface near Jia County, is an evidence supporting the above-mentioned idea.

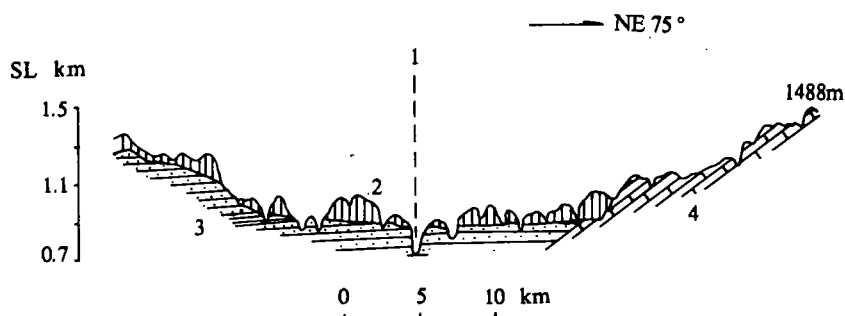


Fig.5 The profile of the Huanghe River valley north of Wupu. Legend: 1.The Huanghe River; 2.Loess layer; 3.T.P. sand and shale; 4.O₁₊₂limestone

The front edge of the bedrock platform is 176 m above the Huanghe River surface near Jia County, which is located on the platform. Due to the later destruction, there is no alluvion on the platform any more. But, 300–400 m northeast from Zaoshutiao, Jia County, a paleo alluvion is found on the platform (Fig.6). The top is a fine sand layer 3.5–4 m thick, with clear cross-stratification and trough-shaped cross-stratification. Underneath is a layer of gravel, the outcrop thickness of which is 1.6 m. The surrounding bedrock is sandstone of the Triassic period. The gravel size is generally 5–10 cm, with 50 cm as the maximum. The roundness is about 3–4 grades. Its composition is quite complex: quartzite, quartz sandstone, siliceous sandstone, gross sandstone, granite, chert, jasper, gneiss and a little gabbro, etc. In contrast with what the geologic map tells, we find that many components of the gravel can not be found in the adjacent area. This means that the paleoalluvion indicates the existence of a big, long-distance flowing river. The top of the paleo alluvion is 875 m above sea level and its base is the surface of the bedrock platform. All these demonstrate that the paleo alluvion is the accumulation of a big river which shaped the platform. Its accumulating period can be known in the comparison with the Pliocene alluvion of Mt. Baodehuo, which is also accumulated on the platform^[18]. To sum up, the Huanghe River valley in the Shaanxi and Shanxi provinces had developed so perfectly during the Pliocene epoch that a mature valley represented by the erosion surface and bedrock platform had formed.

2.3 The profile of Ningjiawo–Zhaihoucun at Sanmenxia

Ningjiawo is situated on the mountain southeast of the Sanmenxia reservoir and Zhaihoucun lies in northeast. The profile between the two villages demonstrates the geomorphic section of the valley-in-valley in Sanmenxia region of the Huanghe River (Fig.7) with a wider valley at the upper part and a gorge at the lower part. A thick layer of calcium-cemented gravel is found at the bottom of the wider valley, which is about 30 m thick in Ningjiawo and 30–50 m in Zhaihoucun. The lithologic components of the gravel

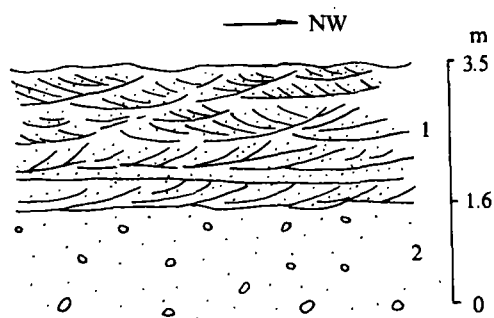


Fig.6 The profile of Zaoshutiao at Jia Country. Legend: 1.Sand layer; 2.Gravel layer

layer near Ningjiawo are simple. They all came from the southern limestone area with a short distance transportation and lower grade of roundness—the sub angular form. In Zhaihoucun, however, gravel with 3–4 grades of roundness are found in the gravel layer and these gravels with higher roundness are not local components. They are granites, intrusive rocks and gneiss, etc. Although the amount of these components is low, it indicates that some materials from a long distance source were mingled in the accumulation while the gravel layer was forming. On the gravel layer is red clay 3–5 m thick, with debris and tooth fossil of *Caprinae*, which was found within the layer phenomenon of the cementation by dispersing CaCO_3 and the sandwich of calcium concretion. Layers above it are Lishi loess and Malan loess. Based on its occurrence characteristics and the lithology in the layers above it the gravel layer is determined to be accumulated in the Early Pleistocene or the Pliocene epochs. The exact time within the epochs can not be determined yet. However, the underlying landform of wider valley is not only widespread in the gorge area but also remains obviously at the southern side of Mt. Zhongtiao in the Sanmen fossil lake area, where it forms the mountain ridges of a similar height (600–700 m) because of the later erosion. So, both the wider valley here and the bedrock platform in the valley region of the Shaanxi and Shanxi provinces are the erosional surface of the ancient Huanghe River, which formed in the same time—the Pliocene epoch, but at different places. In summary, both the Yongding River and the Huanghe River had existed in the period of the Pliocene epoch and had shaped their own landforms of wider valleys respectively. From the fact that the landforms of wider valleys formed by these two rivers extended through Mt. Zhongtiao and Mt. Taihang respectively, one can conclude that both of the rivers were exterior ones at that time.

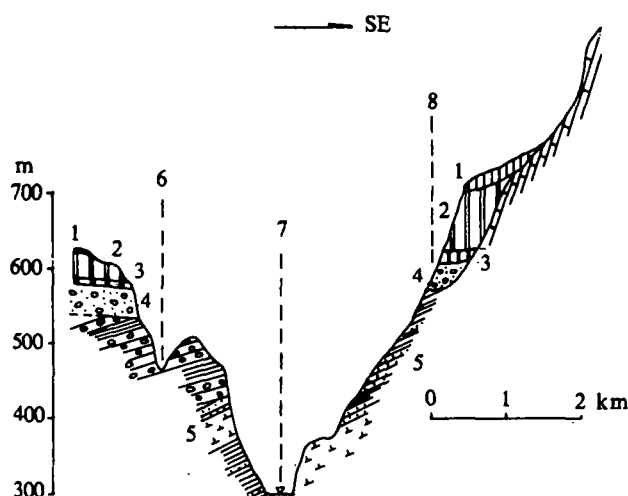


Fig.7 The profile of Ningjiawo-Zhaihoucun. Legend: 1. Malan loess; 2. Lishi loess; 3. Red clay with debris; 4. Gravel layer; 5. Bed rock

II. THE INTERIOR LAKE PERIOD

1. The Fossil Interior Lakes Within The Yongding River Basin

In the reaches of the Yongding River there was the Huailai fossil lake. In the Sanggan River from Datong to Nihewan and Wei County there were a series of fossil lakes. All these lakes are fault lakes—lakes formed from the faulted basin. The occurrence of the fault was roughly after the wider valley landform of the Pliocene epoch was formed, corresponding to the late Pliocene epoch—the Jingle age. In other words, before the occurrence of accumulation of the Jingle age, faults took place simultaneously in different regions of fossil lakes and the original fossil lakes came into being. And materials of lacustrine and river facies of the Jingle age deposited on the bottom of the lake basins^[19]. Upon it was a thick layer of accumulation of the early and middle Quaternary, among which the main was of lacustrine facies, and partly of river facies as sandwiches. Its thickness is approximately 1,000 m in the Huailai fossil lake and over 500 m in the Datong-Nihewan-Wei County fossil lake systems.

In order to analyze the relationship between a fossil lake and a river, whether the fossil lake is interior or not is the most critical question. To answer this question, some sedimentologic characters of the lacustrine sediment profile are studied in detail. Take Futujiang profile of the Nihewan fossil lake as an example. In the upper part of the profile, a phenomenon of saline accumulation or partly-cemented marl can be directly observed, and the interbedding of gypsum and marl is found in the lower part. A similar

sedimentation sequence is found in the outcrops of each fossil lake. The colouring identification indicates that the main carbonate mineral of marl is magnesian calcite and some aragonite (18.4 m deep in the Hutouliang profile). The chemical illuviation of salts in the lake implies that there must be a process of saline accumulation, seasonal or periodic saturation and illuviation. Such kind of lakes can only be the confined interior lakes. Otherwise, the amount of salts flowing with water into or out of the lakes maintained the dynamic balance and the salt content of the basin was in the state of running off. The chemical analyses of the dissolvable salt absorbed in sediments in the Nihewan fossil lake are carried out, which, give more than 150 groups of data. The statistical result indicates that the Futujiang profile is the most typical one (Table 1). The composition of dissolvable salt in the upper part of the profile consists mainly of chloride, and the mineralization degree of the fossil lake water was 16.9 g / L at that time. The lower part was primarily of sulphate and paleodegree of mineralization was 8.2g / L. This result indicates that there existed a process not only of saline concentration and deposition but also of its transformation from the sulphate to the chloride. This means that the Nihewan fossil lake was interior lake and so was the Huailai fossil lake since it had the identical deposition with the Nihewan fossil lake. Since the middle and upper reaches of the Yongding River were occupied by interior lakes, its exterior flow in the Pliocene epoch was replaced by interior flow from the beginning of the Jingle age.

**Table 1 Statistics of Chemical analysis the Chemical statistics of Jingerwa profile
in Futujiang(ppm)**

Site	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	K ⁺ +Na ⁺	Ca ²⁺	Mg ²⁺
Upper part	98	151	8270	2063	5975	301	80
Lower part	70	175	1019	4614	782	957	588

2. The Sanmen—Yuncheng Fossil Lake Within the Huanghe River Basin

From Lanzhou City down stream of the Huanghe River there were three large fossil lakes: Yinchuan fossil lake, Inner Mongolia Hetao fossil lake and Sanmen—Yuncheng fossil lake. Whether the river had an interior flow epoch depends upon whether the Sanmen—Yuncheng fossil lake was an interior lake. From the Sanmen Gorge, Sanmen fossil lake stretched westward and connected with Yuncheng fossil lake at the Fengling ferry as a whole system. This fossil lake system, going in the northeast—southwest direction, occupied vast regions with an area of nearly 10,000 km².

In the Sanmen Gorge region, the deposition profile of the fossil lakes outcrops sporadically. Layers of lacustrine clay, cemented breccia of lake—shore facies and sand-wiched fine sand of river facies are found in Donggou. In Yaotougou there are mainly

lacustrine breccia layers found with few layers of lacustrine clay. The profile of lacustrine layers in the profile of north Pinglu County is relatively thick. Although there is no gypsum sandwich, marl layers have been found in some profiles, indicating that there is a phenomenon of salt deposition. In order to demonstrate the existence of the salt deposition chemical analyses of the dissolvable salt in the Shengrenjian profile, Pinglu County, were made, and the results (Table 2) indicate that there was certainly a process of saline concentration at that time. The average mineralization degree of fossil lakes is 1.2g / L, and the maximum is 2.9g / L, both of which are much lower than that of the modern nitre pond (4.5g / L), but higher than that of slight salt water (1g / L). From the above facts, we can conclude that the Sanmen-Yuncheng fossil lake was an interior lake, and the salt and nitre ponds in Yuncheng are the relics of the vast fossil lake disappeared. From this viewpoint, we can say that the Huanghe River had once its own interior epoch. Since the fossils of *Lamprotula* found in great quantity in the cemented breccia of lakeshore facies in the Yaotougou is comparable with *Lamprotula* layer in Nihewan, and since the fossils formed in the early Pleistocene epoch, were unearthed in the fine sand layer in Dongpogou, including teeth of *Nyctereutes* sp (Photo 1,2), horns of *Gazella* sp (Photo 3,4), teeth of *Bovide indet* (Photo 5,6,7), and teeth of *Camelus* sp (Photo 8,9,10), we can conclude that the Sanmen-Yuncheng fossil lake in the Huanghe River basin and the Nihewan fossil lake in the Yongding River basin were both formed at the same period and the starting time corresponding to the interior flow might be the same.

Table 2 Statistics of Chemical analysis of Shengrenjian profile(ppm)

Number	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	K ⁺ +Na ⁺	Ca ²⁺	Mg ²⁺
1	240.31	11.85	54.00	256.94	26.42	22.80
2	297.53	1.05	—	248.72	31.38	18.48
3	160.21	0	—	114.07	25.07	21.07
4	349.03	2.1	—	299.29	34.33	17.51
5	297.53	2.2	—	256.65	26.37	16.71
6	297.53	12.9	—	252.35	35.20	22.88
7	984.15	1.5	—	956.10	18.40	11.15
8	612.23	2.90	—	569.67	32.64	12.82
9	411.97	15.20	191.80	551.93	28.10	38.94
10	600.79	12.30	—	547.34	39.14	26.61
11	337.59	64.65	1071.30	1367.02	42.92	63.60
12	623.68	54.90	453.30	1111.48	12.34	8.06
13	835.38	16.95	48.30	876.31	15.12	9.20
14	492.08	3.15	—	454.35	14.91	25.97
15	555.02	3.40	—	533.00	12.85	12.57
16	635.10	5.05	—	590.93	31.71	17.51
17	349.03	31.65	164.20	481.49	28.43	34.96
18	434.86	30.55	36.40	441.39	30.32	31.10
mean	473.00	15.13	112.18	550.50	26.98	22.83
Nitre pond	291.81	180.92	1771.73	1522.63	389.45	332.38

III. THE RELATIONSHIP BETWEEN THE DEVELOPMENTS OF THE TWO RIVERS AND THE EVOLUTION OF FOSSIL LAKES

Now that large areas in the two river basins became interior lakes in the Jingle age, and both of them changed from exterior rivers into interior ones at the same time, the middle reaches of the Huanghe River, from then on, flowed mainly in the Inner Mongolia fossil lake and the Sanmen—Yuncheng fossil lake; the Sanggan River and the Yongding River flowed respectively into the Datong—Nihewan—Wei County fossil lake and the Huailai fossil lake. Only a short part of the very rivers continued to flow east into the sea.

At that time the water surface of each interior fossil lake became the erosion basis of each river, which at least offset part of the erosion basis change caused by the tectonic movement so that the rivers got a chance to shape the wide strait valleys during the middle period of the Early Pleistocene. Such valleys, whose formation time is roughly corresponding to the living period of Lantian Ape—Man, about 1.10×10^6 — 1.11×10^6 yr. are slightly lower than the wider valley represented by the mountain erosion surface formed in the Pliocene epoch^[20]. During the period when the fossil lakes were existent, the Wuding River, the Sanchuan River and rivers near Yichuan County had some down-cutting and lateral erosion, and formed the present terraces along both banks with 30 m altitude difference. The formation and existence of the interior fossil lakes made the topographic relief within the middle reaches of the Huanghe River more gentle than at present. Such a natural landscape with slight erosion provided favorable conditions for the accumulation and conservation of the early loess.

On the basis of the thermoluminescence dating of the baked layer in the upper part of the Yujiashai profile, from Professor Li Huhou the period when the Yongding River became exterior again is 300,000 years. It is found that in Weijiaxiaopu a lacustrine layer covers on the basalt corresponding to the top of Yujiashai formation. This means that the interior fossil lake disappeared quite late, perhaps about 300,000 years ago. The Huanghe River became exterior one again at the time when the Sanmen Gorge was cut through and the fossil lake in the Sanmen—Yuncheng region disappeared. Since the fossils of *Gazella* sp, *Nyctereutes* sp and *Camelus* sp, which lived only in the Pliocene epoch and the early Pleistocene epoch, were found in the Dongpogou and had fossils of *Lamprotula* both at the Sanmen lake and Nihewan Lake, it is clear that the life processes of fossil lakes in the two places had similarity in time. Therefore, the earliest time when the Sanmen Gorge was cut through might not be earlier than the early Pleistocene epoch and the latest time might be slightly later than 300,000 yr.B.P.

In the first exterior flow period of the Huanghe and the Yongding rivers, loess didn't accumulate in quantity. The topographic relief was relatively gentle, and the silt content and total silt discharge were much less than at present. As they became interior rivers. They didn't give much contribution to the formation of the North China Plain. Such a situation

didn't change until 300,000 yr.B.P.

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EXPLANATION FOR THE PLATE

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| 1. <i>Nyctereutes sinensis</i> , right mandible with P_3-M_1 . | 4-3 outer lateral view.($\times 0.73$) |
| 1-1 inner lateral view.($\times 0.7$) | 5. <i>Cervidae indet</i> left $P_{4(3)}$. |
| 1-2 outer lateral view.($\times 0.8$) | 5-1 occlusal.($\times 1$) |
| 2. <i>Gazella</i> sp., a left horn. | 5-2 outer lateral view.($\times 1.2$) |
| 2-1 inner lateral view.($\times 0.75$) | 6. <i>Cervidae indet</i> left M? |
| 2-2 outer lateral view.($\times 0.76$) | 6-1 occlusal.($\times 0.74$) |
| 3. <i>Bovidae indet</i> left M^3 . | 6-2 inner lateral view.($\times 0.74$) |
| 3 ¹ -1 inner lateral view.($\times 0.74$) | 7. <i>Caprinae indet</i> right mandible with P_4-M_2 . |
| 3-2 outer lateral view.($\times 0.75$) | 7-1 outer lateral view.($\times 0.75$) |
| 3-3 occlusal.($\times 0.7$) | 7-2 occlusal.($\times 0.63$) |
| 4. <i>Paracamelus</i> sp. left M? 4-1 occlusal.($\times 0.76$) | |
| 4-2 inner lateral view.($\times 0.71$) | |

