THE LATE CENOZOIC FORMATIONS OF S. E. SHANSI* 

BY P. TERLIAIRD DE CHARDEIN AND C. C. YOUNG

(Cenozoic Research Laboratory of the Geological Survey of China.)

CONTENTS

INTRODUCTION ................................................... 207

PART I. Description of Localities ......................... 209
1. The Shouyang Basin ........................................ 209
2. The Shitaitang Basin ...................................... 211
3. The Tsali Basin ........................................... 213
4. The Hengshan anticline .................................... 216
5. The Yihshu Basin ......................................... 218
6. The Chaishan Area ......................................... 223
7. Yitouwen to Fachengchen ................................ 226
8. Fachengchen to Ichou ..................................... 227
9. The Residual Chaluo Faulted Basins .................... 228
10. The Late Cenozoic Sequence of Hohhot ......... 230

PART II. General Observations and Conclusions ............. 231
1. The Late Cenozoic freshwater deposits of S. E. Shanxi. (The "violet sand" facies.) .......................... 231
2. The Late Cenozoic tectonic movements in S. E. Shanxi .................................................. 232
3. The three Red Loams of East China and the Changhsien stage ............................................. 234
4. Relations between the torrential-lacustrine deposits and the red loams in S. E. Shanxi .................. 235
5. The coluration of the red loams ........................ 236

REFERENCES .................................................... 238

LIST OF LOCALITIES ........................................... 240

INTRODUCTION

Up to 1931 nothing was positively known concerning the Cenozoic formations eventually preserved in S. E. Shanxi. The large area bounded by

*Read at the 9th Annual Meeting held on October 6th, 1932.
the Chengtai Railway on the North, the Fenbo on the West, the Taihangshan on the East, and the Fugwhangshan system on the South, had only been skirted by geologists; and, for this whole region, the geological maps reported practically nothing but a single large Triassic syncline.

First, in the winter of 1931, Dr. G. Barbou (v. Barbou, 1931) discovered the Sanmenian Taiku basin on the very eastern border of the Taiyuan plain. This unexpected geological feature created a new interest and called for new observations to be made within this so far rather neglected part of Shanxi.

During the summer of the same year, Mr. Liushikou was sent to the area as a fossil collector for the Geological Survey. He reported that mammal fossils were extensively found and collected for the native drug market considerably to the south of Taiku, in the Chihhsien district. The specimens collected by Mr. Liushikou, however, showed a puzzling mixture of Pontian and Sanmenian forms so that a new and definitive survey of the country was recognized as being necessary.

In the course of July 1932 the authors of the present report were sent into S. E. Shanxi by the Cenozoic Research Laboratory of the Geological Survey of China. In spite of very bad weather conditions then prevailing, they succeeded in covering the area indicated in the adjoining map, an incomplete exploration of course (the eastern margin of the Hooshan has still to be surveyed), but sufficient to enable a fairly good idea of the general characters and extension of the Cenozoic deposits over the big S. E. Shanxi plateau to be obtained.

As explained in this paper, the chief result of our investigations is to establish that traces of a very peculiar terrestrial and lacustrine Pontian formation, associated with Sanmenian (= Nihowan) sediments and bearing exactly the same facies, are extensively spread over the undulated Triassic floor of S. E. Shanxi.

1. The thick and continuous series of consolidated sands, silts and clays forming the central part of S. E. Shanxi being absolutely unfossiliferous, we adopt simply the denomination given by the Geological Map. In these beds (most generally violet and dark red), the only recognizable organic remains observed by us (in addition to the fragment of bone already described, v. Teilhard and Young, 1929a) was a Columites in the lower horizon near Wuhsinghuan.
Both the Ponnian and the Sammalian freshwater series have been tilted (or even folded) in the course of a very recent rejuvenation and faulting of the broad and gentle Palaeozoic or Triassic synclinal area; and they are actually preserved as large or small patches in the depressed parts of the old floor. Passing into (or dissecting) these marls, sands and conglomerates, a complex sheet of red or reddish loams, including at least three terms (respectively Ponnian, Sammalian-Nihowan and "Choukoutien"), actually covers or has obviously formerly covered the entire plateau.

This paper is presented in two parts. In Part I the stratigraphical features observed along our road are successively described; while in Part II some general conclusions are tentatively set forth.

**PART I.**

**DESCRIPTION OF THE LOCALITIES.**

1. The Shouyang Basin.

The town of Shouyang (on the Chengtai Railway) lies in the center of a strongly dissected pre-Loessic basin the remnants of which build around the

![Diagram of a hill in the Shouyang basin. L. Loess, r. red loam ("Choukoutien stage"). V. violet freshwater series (Sammalian-Nihowan). The red loam is darker at the base, and contains layers of large concretions.]

...a series of hills, 60 m high on the average. The section of one of these hills (N. W. of the Railway station) is illustrated in our Figure 1. Two series of unconformable deposits are clearly to be observed and may be described as follows:——
(a) A lower, fluviatile or lacustrine, one (40 m thick in the observable part), consisting of violet or brown sands, dark clays, and thin layers of white limestone (the upper one, however, being 30 cm thick).

(b) An upper, sub-aerial, one formed by typical red or reddish-banded loam, containing some layers of large grey concretions. The first few meters of this upper series are characteristically darker and redder than the remainder.

As in other localities described below, the violet colour of the lower series is evidently due to the reworking of the Triassic sandstones forming the floor of the basin. But, near Shouyang itself, the base of the freshwater Cenozoic deposits is concealed.

In this lower series freshwater shells are abundant: _Lymnaea_, and a characteristic _Planorbarius_, of a rather large size (15 mm broad, 4.5 mm thick). In addition, we collected a few strongly fossilized jaws of Rodents: _Caprolagus_ sp., and _Spheniscus_ cf. _tægii._ Using our present palaeontological knowledge, the presence of true _Spheniscus_ points for the formation, to a post-Pontian and most probably Sanmenian (=Nihewan) age. The Shouyang beds, consequently, would correspond exactly in both facies and age with the Taiku formation.

The unconformable upper red loam did not yield any fossils. But, being together post-Nihewan and pre-Loessic, this series corresponds necessarily in our present knowledge of N. China physiographical stages with the so far obscure "Choutouen stage" (v. Teilhard and Young, 1930a and 1930b).

As observed from the Railway, the Shouyang freshwater deposits are well developed and exposed east from Shouyang as far as the next station of Chencheng (芹城鎮).

Southwest from Shouyang, along our road (v. map), the "violet formation" was observed by us so far as the small village of Yangtouyai (洋頭峪) (35 li from Shouyang), wherever modern dissection had been sufficiently strong to destroy the thick sheet of the Loess and the red loams. Judging by the reworked

1. Fossil bones are reported as fairly abundant in the basin according to the country people.
bones observed in the streams, the sediments are probably rich in fossils in the Yangtouyai area. A few li before the village, the violet sands seem to be separated from the Triassic floor by a distinct layer (some 15 meters thick) of dark red clay (Pennsian?) (v. Figure 2). We could not observe this important feature at sufficiently close range.

Figure 2. A section taken near Yangtouyai. L, Loam, r, red loam ("Chungtia"). V, violet freshwater series of Shangyeng (Isumanian). R, dark red clay (Pennsian). T, Trias.

2. The Shiohsiang Basin.

Southwest from Yangtouyai, the road follows a maze of valleys deeply carved in dark red Triassic rocks, a thick sheet of undetermined red loam being preserved on the top of the plateau. Finally, 10 li after crossing a last and high Triassic ridge, it reaches Shiohsiang (Fia) village. Then, quite a new formation starts abruptly: some 200 meters of powerful conglomerates and violet sands, filling what looks actually like a deep hole in the old rocky floor. The higher levels seem to be horizontal. But the lower alternating soft sandstones and conglomerates are strongly dipping (up to 30 degrees at least locally), conformably with the Trias (v. Fig. 3). A remarkable bed of yellow sands runs at the two-third level of the section. Then, deeply dis-

1. We also collected a skull of Siphonius (cf. "ring").
seeing the violet sands, a sheet of red loam caps the hills. Such is the composition of the small Shiahshiang basin.

Fortunately enough the violet series is fossiliferous. Both at the base and near the top, typical Pontian fossils were collected: Hippopotamus, Chinotherium (limb-bones, molar teeth and tusks), Alcelaphus, etc. Consequently, in spite of an extraordinary lithological likeness, this preserved patch of fan is very different from the Taiku and Shouyang beds: it represents in fact the northernmost extension of the Yushé and Chihshien formations (vide infra). The red loam of the top is of a Seminian (Nihowan) or "Choukoutien" age—most probably both.

**Figure 3.** Section of the Shiahshiang basin, L, Locus, R, red loam (Seminian?) V, torrential-lacustrine violet series (Pontian). Tr, Triss. The crosses mark fossiliferous places. y, yellow sands.

Coming now to the tilting of the lower violet strata, we were first inclined to consider it (even so strong it is) as an original dip of sedimentation. But, using the further knowledge obtained in the Taiku, Yushé and other areas, we believe now that the inclination of the beds is really due, or has been increased, by some late tectonic movements of the floor.

The northern extension of the Shiahshiang basin is unknown. Our route, striking westward too much, left it immediately after crossing the Shiahshiang valley.
From this place to the Taiyuan plain, we travelled constantly across an extensive fan of red loams, not collecting any fossils (with the exception of a Styrinus skull, apparently from Taoping (泌陽) (Loc. 23)). In these loams, a thick middle series, regularly banded of red and reddish zones, is probably Samarian (= Nihowan). Very dark and sticky basal clays, spotted with perfectly white concretions, represent possibly the Puszian (that is a lateral facies of the Shihbiang sands). To the Choukoutien stage can be attributed a series of upper light reddish loams chiefly developed at the very approach of the Taiyuan plain, along which they build a most regular terrace.

3. The Taiku Basin.

The Taiku basin has already been thoroughly described in this Bulletin by Dr. Barbour (v. Barbour, 1933). It will be sufficient therefore to mention here only some supplementary features of the formation which for various reasons have perhaps not been sufficiently emphasized by its discoverer.

(a) The first interesting point is that the Triassic barrier separating the basin from the Fenho plain builds a clear anticline, in which a single deep break (or gorge) is open for the actual drainage of the basin. Along the main river escaping by this opening, the "Taike beds" are generally concealed under a thick torrential Loessic sheet. But good exposures are found along two recent branch rivers (a southern and a northern one) falling from the main valley shortly before the gorge, and running along the faulted eastern wing of the faulted Triassic anticline (v. Fig. 4, A).

(b) Along the northern branch river, the sediments filling the Triassic syncline correspond exactly with Barbour's description, with this noticeable exception that the red upper loam seems to dissect cleanly and deeply the violet lower sands. Under a small tower (f) built not far from the north end of the valley, the red loam forms distinct pockets (lined with a basal gravel) no less

1. This upper loam (a typical "reddish loam") is spotted with numerous small "hollow stars" due to the dissolution of gypsum crystals. The same feature is observable in the reddish loam forming the last pre-Loessic terrace outside of the eastern wall of Taiyuan.
than 40 meters deep in the torrential-lacustrine formation (v Fig. 4, B, and 5).

c. Along the southern branch valley, the section, very impressive, is much more detrital and coarse than indicated in Borbon's description.

\[ \text{Figure 4. (A), diagrammatic sketch of the Tsink basin. (B), generalized section of the basin.} \]

\[ \text{r, red loam ("Choukshan").} \]

\[ \text{V, violet freshwater series (Samaranian).} \]

\[ \text{T, Trias.} \]

\[ \text{P, Plant-bearing bed at the base of V.} \]

\[ \text{F, fault.} \]

\[ \text{T, town. Lines omitted.} \]

Over several meters of dark, plant-bearing shales, some 60-100 meters of violaceous deposits consist entirely of sands or sandstones alternating with thick gravels, the maximum of the gravels being apparently found at the very top of the preserved formation: 1 a powerful torrential fan, evidently. Some 40 meters

---

1. The same feature (growing coarseness of the deposits, terminating in a top-conglomerate) was observed by us in the folded Late Cenozoic fans forming the fore-ranges of the Nanshan, near Sochow (W. Kana).
of well banded red loam cap the conglomerates, probably starting in several places with a special basal conglomerate.

(d) Both along the north and south branch rivers and everywhere that the violet series is observable under the Loess along the main river, the beds dip clearly S.E., conformably with underlying Trias, in their whole thickness: not only the coarse southern gravels, but also the fine grained sands and soft bedded sandstones found along the north branch river. A tectonic tilting of the formation, therefore, is highly probable. The red loams, on the contrary, seem to be undisturbed.

Age of the formations. As already recognized by Dr. Barbour, the violet tilted series is proved, palaeontologically, to be Sammeleni (and corresponding most exactly with the Nihowan beds). We collected ourselves, in the sands, a canon bone of true Horse, and a skull of Siphneus (ingi). But the red loams, at least in the north branch river, being highly disconformable with the torrential deposits, are evidently younger than they were believed to be by Barbour, and have to be referred to the Choukoutian stage. They do not belong to the Taiko formation proper.

Upon the basis of the preceding observations, we feel inclined to imagine the history of the Taiko basin as follows:

1. Deposition of the freshwater Sammeleni beds: possibly contemporaneous with the faulting. Under the gradual waning of the Trias syncline, the sediments, first muddy, become gradually coarser, and finally, decidedly torrential.

2. The deposition of the red loams occurred later than the faulting, but earlier than the definitive opening of the river gorge in the Triassic ridge.

---

1. Along the south branch river, where the loam is thicker and redder, the disconformity was not observed so clearly as in the north, but is held by us as most probable. If, however, such disconformity was not existing, then two types of red loams would be found in Taiko (as for instance at Changchishedan, v. Figure 8): an older one, of Sammeleni age, chiefly preserved in the southern part of the basin; and a younger one, representing the Choukoutian stage.
Hence the thickness of the deposits, the relative scarcity of thick basal conglomerates, and also the preservation of the underlying violet series.

3. The deposition of the Loess occurred after the final opening of the gorge (Chindhu stage). Strong dissection of the basin, exactly as in the case of the Nihowan basin (after the pre-Loessic opening of the Sangkanho gorges).

Figure 5. A section taken in the Taiku basin, passing by the tower T. L, Loess; r, red loam ("Gouwatan"); V, violet series (Summarian); p, Plast-bearing clays.

4. The Hungtshan (K-I-II) anticline.

Some 20 kilometers north of the Taiku basin, in the very place where the Taiku-Yitshê road leaves the Fenhu plain, the highly interesting section illustrated in Figure 6 was observed, on the right bank of the river followed by the road.

As shown in Figure 6, a perfectly distinct Cenozoic anticline was formed there: rusty or violaceous sands and conglomerates, interrupted by 25 meters of dark red, concentric-bearing clay, are regularly arched, and deeply dissected by undisturbed reddish loam. The dip of the beds reaches 35-40 degrees.

Lithologically, and with the exception of the red interbedded clays, the formation is exceedingly similar to the Taiku beds. Unfortunately, the several fragments of bones collected (in the upper violet sands, layer 5, only)
Figure 6. A section across the Hungtuan antiform. 1. Trias, 2-3, lower conglomerates and sands. 4, dark red concretionary clay (top of the Penitum?). 5, middle fossiliferous sands and conglomerates (Seramiens of Taik). 6, conglomerate. 7, upper violet sands. 8, red limestone ("Cheuloulicia"). Loess omitted. Length of the section: approximately a kilometer.
are equivocal. And since, as already said, the "violet sandy facies" is found, exactly the same, for both the Pontian and Nihowan sediments in southeast Shanxi, it is not possible at present to date the deposits exactly. A rather large fragment of *Siphurus*, however, found in layer 5, would point to a Nihowan-Taiku age for this special level.

We should like to suggest that the layers 2-3 correspond to the Shian-hsiang-Yühsé Pontian deposits, the red intermediate clay to the classical Pontian Hipparchion clay, the levels 5-7 to the Taiku-Shouyang formations, and the upper red loam (level 8) to the Hoorkertiens stage. But this is perhaps too precise and too simple to be wholly true.

The lower conglomerates (layers 2-3) seem to consist exclusively of well rounded Triassic boulders. The upper series, on the contrary (layers 5-6) contains a large number of quartz and Wutai quartzite "impressed" pebbles, clearly derived from Carboniferous conglomerates such as are found in northwest Shanxi (Pao-tse-Chingle area). We did not observe this type of conglomerates anywhere in southeast Shanxi.

5. The Yühsé Basin.

East from Humpushan the Taiku-Yühsé road crosses a high Triassic anticline, from which recent erosion has almost removed even the last patches of a loessic cover under which traces of an equally destroyed reddish sheet are recognisable.

But, as soon as the upper valley of the Yühsé river is reached, the Cenozoic deposits become thicker; and near Hoom (433) village, an important and typical basin is encountered, a characteristic section of which is given in the adjoining Figure 7.

As shown by this section, the dissected hills (100-200 meters high) forming the actual topography of the basin consist essentially of a thick torrential-

---

1. Several of these pebbles are found broken and chipped in an atypical way, probably in Neolithic or even protohistoric times. A piece of painted Yangshao pottery was collected in association on the ground.
Figure 7. A section across the hills near Homu, in the Yuhó basin. L, Locas. R, red loam ("Chondrosia"). V, Violet freshwater series. Tr, Tria. 1, basal conglomerate of V. 2, lower sands. 3, dark, Plant-bearing, clays. 4, middle sands ("Turtle sands"). 5, yellow sands and limstone. 6, upper sands. The base of V is surely Potsian, the upper levels possibly Szomolán. The hills are 100-200 meters high, in average.
lacustrine series, dissected and capped by thick red or reddish loam, this latter being in turn dissected and capped by the ordinary Loess sheet.

(a) The torrential-lacustrine series. In the torrential-lacustrine series, the chief following terms are observed:

1. Powerful basal conglomerates of perfectly rounded Triassic boulders. (Layer 1 of the Figure 7).

2. Lower grey or violet sands, scarcely consolidated, containing a few isolated gravels or boulders, and also layers of hard cemented sandy-concretions. Fossil remains of mammals are found here, generally embedded in the concretions. *Alopecotherium*, *Mesohippus*, *Gazella*, *Hipparion*, etc. (Layer 2).

3. Dark violet clays, with carbonised wood and small freshwater shells (*Lymnaea* and *Planorbas*). More than 10 meters thick. (Layer 3).

4. Middle violet sands, very rich in remains of Turtles, Fishes, Birds, etc. (Layer 4).

5. Yellow sands, and thin white limestones (Layer 5).

6. Upper violet sands, fossiliferous: *Ptychoceras*, and (found on the ground but most probably derived from the sands, and not from the red loam) a broken skull of true *Siphonius* (Layer 6).

The entire series probably more than 200 meters thick dips clearly in a NW. direction conformably with the underlying Trias. The dip over 20 degrees along the Triassic ridges approaches still some 10 degrees NW. in the central parts of the basin, and remains the same on both sides of the valley: the formation being consequently entirely independent from the present drainage system.

(b) The red loam: The red or reddish loam, rich in concretions, did not yield any fossil. The formation is regularly striped with darker red bands distinctly dipping (a dip of sedimentation of course) around the preserved patches of the older torrential-lacustrine formation. The distribution of the red loams is in general accordance with the present drainage system.

1. These are two generations represented in these concretions: a series of smaller and darker ones is invariably found embedded in the larger ones.
(c) The Loess: The ante-Loessic erosion (Chinhsui stage) is responsible for the lost modeling of the actual topography. A system of evenly rounded hills, covered with the habitual loess veneer, is still perfectly distinct under the wild recent erosion, which, in several places, has already destroyed about a third of the total Cenozoic formation.

Age of the sediments.

Judging by the fossils, the base and probably the bulk of the torrential lacustrine deposits filling the Yüshê basin are clearly Pontian. Nevertheless, the probable presence of a true Siphonix in the upper levels near Hemu (vide supra) suggests the presence of Sanmenian (= Taiku) sediments in the top of the formation (= layers 3-6),—just as in Chinhsien (s. below, p. 225). If so, the red loam, exactly as in Shueyang, Taiku, etc. would represent a post-Sanmenian, that is the "Choukoutien" stage,—an age in good accord with its rather recent-looking physiographical characters.

Extension of the basin: The Homu violet and yellow sands are found without any interruption and with the same characters, so far South as Yüshê and Wuhsianghsien. The general dip of the sediments is always the same (NW.), and in some places we believe to have observed distinct flexures and gentle anticlines. Over this area, the fossils are intensively collected (and destroyed) for trade by the local people. For instance, in a small shop south of Yüshê we saw heaps of sandy broken bones, including the following types: Machairodus, Hyena, Hipparion, Sin Antelopes, Cassela, primitive Deer, Sphéodont Mastodon or Stegodon (those forms), etc.

All those forms being typically Pontian, it would seem that south of Yüshê, the fossiliferous violet sands do no more include, as in Homu?, any Sanmenian upper term. This idea is strengthened by the study of an instructive section (v. Figure 8) observed, 20 li north of Wuhsianghsien, near the Chang-chikhu (張家渡) village (to the right bank of the Yüshê river). In this locality a plateau, some 100 meters high above the river, shows from base to top, over a Triassic core, the following series of Cenozoic sediments:

1. Tilted deposits of the Homu type: basal conglomerate, thick violet and yellow sands, thin layers of white limestone etc. (V).
Figure 8. Section of the Changchihkue plateau. L, Loess; r, younger red loam ('Checkouline'). R, older and darker red loam (Saanonian). V, violet freshwater series (Pamien). Yr, Tins. *R is separated from Y by a strongly consolidated basal conglomerate.
2. Old, dark red, loam, levelling horizontally the preceding formation and beginning by a strongly cemented (bearing quartz-and quartzite-pebbles) basal conglomerate (R).

3. Younger, and lighter coloured red loam, dissecting clearly the dark red loam. The red bands of this younger red loam plunge distinctly in the direction of the river.

4. Locals.

It is to be noted that in the dark older loam (R), Mr. Liushu has collected in situ in large piece of antler belonging to a Deer approaching closely Cervus (Elaphurus) hortesilus Teill., and Piv. from the Nihowan beds. It seems therefore that we must fix as follows the respective age of the pre-Locass deposits: the sands are Puritian; the older loam, Sannianian; the younger loam, "Chonkantian."

Here, consequently, the Sannianian deposits are exclusively represented by their loamy facies. And, at the same time, in curious opposition to the conditions met in Taiku, Hungshan and (?) Horn, they seem here to be perfectly horizontal, overlying the Puritian unconformably. We shall discuss the reasons for these features subsequently in the Conclusion (v. p. 232).

Near Wuhuanshi, the basal conglomerate of the Puritian sands becomes thicker. And we suspect that the eastern border of the main torrential-lacustrine formation is reached,—possibly along the same Permian anticline as in Hainan (vide infra, p. 225).

6. The Chilkotan Area.

From Wuhuanshi to Chilkotan, the road probably crosses, from the east to the west, the same Puritian basin as the one described above. Without any major interruption, the violet and yellow sands, interbedded with thin white limestone, constantly dipping NW. (conformably with the underlying Trias), and dissected by red loams, build the core of a series of hills or small plateaux (Figures 9 and 10).

Sometimes (Figure 10), the cap of loam is dark red and restricted to the top of the hills, suggesting, as in the case of the older red loam of Ching-chialeu a Sannianian (= Nihowan) age. More generally (Figure 9), the red
sheet descends rather low in the valleys, the layers of concretions and the coloured bands plunging distinctly all around the Triassic and Positian core of the hills; and then the loam belongs more probably to the Ciaochotien stage (as the younger red loam of Chengchikou), an assumption supported by remains of fossil Siphonites cf. jondartii. (v. Teilhard and Young, 1930a, p. 6 and 1931, p. 20).

Figure 9. A section taken between Wuh-shianghsien and Chhihsien (near the Shihhotze village). L, Loem. r, red loam ("Ciaochotien"). V, violet freshwater series (Positian). The red loam begins with sandy sediments, is banded, and contains layers of concretions.

Figure 10. A section taken between Wuh-shianghsien and Chhihsien. R, dark red loam (Saiosima). V, violet freshwater series (Positian). Tr, Trias. 1, basal conglomerate of V. 2, lower sands. 3, yellow sands and white limestone. 4, dark clays. 5-6, upper sands. Loess omitted. The hill is at least 200 meters high over the Wuh-shianghsien river.
North of Chihhsien, as in Henu, the question of the red loams is made rather complex by the fact that Mr. Liushikou has collected in the tip of the yellow-violet sandy formation, a series of foot bones belonging to a typical Horse (probably Equus samniticus Teilh. and Piv.). The only way to explain this, is to admit that, from place to place, the terrestrial-lacustrine formation of the Yoush-Chihhsien area, fundamentally Purian, is overlain by a younger Samnienia series of the same exact facies (= Taihu and Shouyang beds), (vide infra, Conclusions, p. 232).

Figure 11. A section taken along the motor road, south-east from Chihhsien. L, Loess; r, younger red loam ("Chihhsien"); R, older red loam (Samnienia); V, violet freshwater series (Purian). Tt, Tith. 1, basal conglomerates and coarse sand, fossiliferous (Turtle, Hinnia, Poekilosternum); 2, dark clays with Laminius and Plemarcia; 3, upper violet sands.

South-east from Chihhsien, following the motor road, the conditions remain essentially the same (v. Fig. 11), up to the small village of Hisien (新店) (some 30 kilometers from Chihhsien). Then along a stronger NE-SW Triassic antilcline, in the center of which the classical yellow "Purian" beds of the Shawi are apparent, traces of an exceptionally thick Purian fan are crossed: alternating soft sandstones and powerful conglomerates, dipping of 30

1. We ourselves did not visit this area.
degrees in a NW. direction; and this is the end of the formation. Further south east (i.e. around the alluvial plain of Tunlin (吨林), cf. the Geological Map), the Cenozoic series consists entirely of red loams (30-10 m. thick) in which, in the absence of fossils, distinction between the zones is practically impossible. The Sammnenian and “Choukoutien” loams are surely both present; existence of red Pontian clays is much more questionable.

7. Yuanwen to Fuchengchen.

Between Yuanwen (岳溫) to Fuchengchen (腐城鎮), our road crossed, in its high parts, the Triassic Plateau of south east Shansi: a very monotonous area, in which more or less extensive remains of a continuous sheet of Loess and younger red loam (Choukoutien stage) are easily recognisable. Older Late Cenozoic formations have evidently been washed away before the deposition of the younger red loam.

In a small closed basin however, lying on the very eastern foot of the high Triassic anticline corresponding to the “cote 1850” of the Geological Map (Puchuan (埔蕉)), an interesting patch of loam was observed (v. Fig. 12): some 40 meters of well rounded conglomerates, violet concretionary sand, and soft sandstones, exposed for a few hundred meters only, but possibly spread rather extensively under the sheet of the red loams. This is exactly the Taiku-Yushé facies. In the absence of any palaeontological data, we cannot decide whether this residual formation has to be referred to the Sammnenian or to the Pontian. The latter hypothesis seems to be the more probable. No distinct tilting noted.

Along the Chihsa (岐河), at Fuchengchen, no traces of old terraces are observable. The Loess and the upper red loam, capping directly the Trias, reach

1. In addition to Triassic rounded boulders, this conglomerate contains numerous quartz and quartzite “impressed” pebbles, derived from a Carboniferous formation (vide supra, p. 218).

2. Along the upper (western) part of the Yuanwen river, the loessic terraces exhibit a curious “Shih-o-sung facies” (shiny and sandy beds, containing freshwater shells), a feature possibly due to the abundant sandy material derived from the Trias.
the bottom of the valley, which seems to belong to a very recent (post-Saanien?) drainage system.

Figure 12. Section of the residual terraced beds near Puchuan. R, red loam. V, violet torrential formation (Poxian?) On the right side of the section, the red loam is embedding a turbid down praescutum of Trias. Lenses omitted.

6. Fuchengshan to Icheng (鳳城)

A few kilometers west from Fuchengshan, the road reaches the Fenhe basin; and then begins the classical Cenozoic regime already described by us (Teilhard and Liang, 1927.—Teilhard and Young, 1930a): huge fans of reddish loams descend from the Triassic and Paleozoic plateau, towards the central parts of the basin. The reddish loam, 50 meters thick in average, is regularly banded by dark red zones and is highly concretionary, the coloured bands and the beds of concretions descending conformably with the slope of the rocky floor. Marvelous exposures are met with everywhere, the best ones being probably found a few miles north of Icheng, along the ridge of intrusive syenite.
and metamorphosed rocks forming the conical Shoushangshan (雙山) in its eastern part, and ending by the Shushan (或 Tower Mountain) between Chiu (芝) and Linfen (臨汾). In this area, we collected several jaws of skulls establishing that the bulk of the banded clays (just as in the Hochin (和興) area, v. Teilhard and Licent, 1927, p. 134) represent the "Siphneus ling" Zone, that is the true Sammamish (=Nihowan). The passage to an upper red loam ("Choukoutian") is possibly indicated by a characteristic dark-red zone constantly observed near the last upper third of the formation; but this hypothesis is not yet supported by any palaeontological find.

In the Icheng plain on the contrary, the perfectly flat 30 meters terrace of light reddish red-banded, pre-Loessic sandy loam bordering the Icheng river is clearly referred to a post-Sammamish (=Choukoutian) age. Remains of the Sammamish terrace are still clearly observable, emerging of 50 meters over the plain, between Icheng and Chianghsien, near the Ch’i-yü (吉峪) village.

On the whole, the conditions are essentially the same as all along the lower Fenho, south of Hsiung (許河) (v. Teilhard and Young, 1930, p. 22).

9. The residual Chiu shu faulted basin.

Some 20 kilometers WNW. from Chianghsien, (蜂縣) at the place where the main road going to Homa (侯馬) crosses the curious faulted anticline of Chiu (the Wangfushan 韋夫山), it was a great surprise for us to light on a distinct remnant of what we believed to have definitely left behind us when reaching the lower Fenho basin: the violet torrential-lacustrine facies of Ta-tu-Yü-hsü-Chihhain, etc. (v. Fig. 13).

The formation, probably a hundred meters thick on the average, consists of well rounded conglomerates and more or less consolidated violet sands or sandy clays, dipping conformably with the underlying limestone. The consolidation and the dip are sometimes so strong that, for the first minute, we believed we had to do with some Triassic outcrop. In the absence of any fossil:

1. Fossil Heli are especially abundant in the concretions.
2. A well fossiliferous broken jaw of a Deer, of a bivalve type, was only collected in the basal gravel of the overlying red loam. Between the violet series and the Palaeozoic limestone, a hard banded conglomerate is found.
Figure 13. Section of the residual basin of Chaiwu. R, red limestone. V, violet torrential formation (probably Pontian). 1. Archaean. 2. Jurassic quartzite. 3. Cambrian (?) limestone. 4. sill of microsyenite. F, fault. Loss omitted.
we cannot positively decide whether the series is Pontian (as, for instance in Shihsiang) or Saumian (as, for instance in Taiku). But the former idea seems to be by far the more probable, since all over the lower Fenho basin the Saumian is extensively represented by a different facies, viz. the Sphinctes lingi red banded loam.

In any event the sedimentary and tectonic analogies found between the Ch'awu and the Taiku basin are obvious, and extremely curious.

10. The Late Cenozoic sequence of Hohsiien.

Twice already (v. Teilhard and Licent, 1927, p. 139, and Teilhard and Young, 1930a, p. 22) we have dealt with the fine and complex system of terraces, or erosional fans, descending from the Heshan (霫山) to the Hohsiien (霍山) area.

In the course of our last journey, crossing the same places, but with more experienced eyes, and by a different way (that is, following the motor road, and not the ancient highway), we believe we have reached a more distinct and more definitive understanding of the locality.

For instance, a most illuminating section illustrated in Fig. 14 A was clearly observed along the road some 4 kilometers from the town of Hohsiien:

1. Loess.
2. Pale reddish loam and sands, with a 5 meters thick basal gravel (=Choukoutien stage).
3. Pink red loam, with a thick and well consolidated basal conglomerate (=Saumian-Nihowan).
4. Green marls overlying a hard (several meters thick) lacustrine limestone (=Pontian). cf. Teilhard and Young, 1930a, p. 28.

A few kilometers further south (Fig. 14 B), the zone 3 becomes strongly torrential. Its basal conglomerate forms along the Fenho, a hard massive, 15-20 meters thick, platform; and the Pontian lacustrine beds pass into hard cemented red clays.
Figure 14. Sections in the 50 meters terrace near Hobaiton (accurately diagrammatic): (A), transverse section; (B), longitudinal. 1. Loco. 2. “Choutocul” loams and gravels. 3. Sammernian loams and gravels. 4. Pisanian green marls and lacustrine limestone. 5r, Pliocene. On the right of the section (B) the Pliocene sediments are passing into dark, cemented, red clays.

PART II.

GENERAL OBSERVATIONS AND CONCLUSIONS.

1. The Late Cenozoic freshwater deposits of S.E. Shantii.

(The "violet sands" facies).

The fundamental and most obvious result of the preceding observations is the fact that, over the large Permian-Triassic synclinal of south east Shantii, clear traces are found of an extensive torrential and lacustrine Late Cenozoic formation, covering the whole of the Pliocene times (from the Pontian to the Sammernian inclusively).
So far as the Sauvania is concerned (viz. a formation originally discovered under its fluvi-lacustrine facies), this condition is not especially new. But, up to now and with the exception of some Mongolian localities (Dalai Nor, Erdenet), the Lower Pliocene, or Pontian, was practically only known as "Red Clays." Consequently by the very different condition now recognized in SE. Shanxi, we are introduced to somewhat renewed conceptions, concerning the climatic and topographic conditions prevailing in Eastern China at the end of the Tertiary times.

Taken as a whole, the Pliocene was not a dry period; but, from the North of Kalgan, down to the Taiyuan range, there extended an almost continuous series of rivers, or lakes or pools; this system reaching apparently a maximum in the Pontian, but still largely persisting in Sauvania times.

Over this partly emerged area, the sedimentation seems to have been locally continuous. In any way, the terrestrial lacustrine facies is so perfectly the same all along the Pliocene times that, just as it is the case for the red loams, the geological age of the "violet and yellow sand" of SE. Shanxi can not be fixed but by a careful analysis of their palaeontological content.

2. *The Late Cenozoic tectonic movements in the SE. Shanxi.*

From the Norin’s, Berkeley’s and our own observations it is now recognized that the Late Cenozoicfans (up to the Sauvania inclusively) are strongly tilted.

1. This continuous deposition all across the Pliocene is suggested by the fact that, in the Yubre and Chihlihia basins (vide supra) Sauvania fossils (Horse and Siphonax) occur in the top of the violet sand, those sands containing a rich Pontian fauna at their base. Some internal disconformities in the formation, however are suggested, for instance in the Hungchou by the red loam (r. Figure 6, layer 4), and in Hsima by the middle swampy beds (Figure 7, layer 3). Let us observe here as a parenthesis, that in the Nihowan basin, the association of Eohippus and Hippionius is not explainable by a similar comprehensive succession of Pontian and younger beds. In Nihowan, the Horse and the Hippionius (a very special form, probably) occur in the same pocket. On the other hand, a typical Pontian fauna (Eohippus, Mammalia, Chirotherian, Glaucops, etc.) has never been observed anywhere in the Nihowan area.
or folded along the Northern front of the Nanshan, the Southern front of the Tianshan, and even along the Mongolian Altai (v. Beckey and Morris, 1927, p. 312). But, so far (and with the exception of the faulted and tilted Ptolemaic beds of the Dalai Nor, v. Teilhard, 1926, p. 34), those conditions were believed to be special to Western China. In Eastern China, the Pliocene and Placidocene movements were supposed, even (it seems) by C. C. Wang (v. Wang, 1926 p. 33), to be of a more epigenetic nature. Possible traces of tilting were reported by ourselves along the Ferbo gorges (v. Teilhard and Young, 1930, p. 30, note 2): but in a very dubious way.

Now, in full accord with the recent views expressed by Dr. G. B. Bour, in the case of the Tsikui basin, it seems that tilting and even typical folding (v. Figure 6) are a normal condition for the freshwaters Late Cenozoic beds of SE. Shansi. As already explained above, the inclination of the Ptolemaic and Sanmenian strata could be, in some cases, explained by an original deposition along a slope. But the generality and the high grade of the dip, its extension to thick, silty and muddy sediments, and finally the observation of true anticlines, make unavoidable the recognition of very late tectonic movements east of the Ferbo river.

Our feeling, therefore, is that, throughout the Pliocene period, the SE. Shansi plateau has been moving: a slow but continuous process of elevation and compression rejuvenating the ancient folds, and occasionally faulting the floor. The formation of the fans and of the lakes would have been a direct and simultaneous consequence of this process.

These movements, of course, have not to be understood as perfectly universal and homogeneous. Some places were moving earlier or quicker or stronger than the others. For instance the Sheyuan Sanmenian sediments are apparently horizontal, while, on the contrary, the Tsikui beds are tilted. The borders or the basal deposits of the basins seem to have been more affected than

---

1. In spite of their extension and of the thickness of the deposits, the SE. Shansi Late Cenozoic lakes were possibly very shallow. So could be explained the fact that we could not find, in this area, any trace of the Uromienses (Lampetidae) which were surely living somewhere in E. China during the Ptolemaic, lacking the Miocene "Pre-lampetidae" of Tong Ge (v. Teilhard and Young, 1930, p. 123) with the Sanmenian Lampetidae of the Sinianhe and Fushanhe basins.
the central or the upper zones. But such is the case in any folded area of the world.

A remarkable fact is that the tilting does not seem to reach the cap of the older red loams, but is apparently confined in the torrential-lacustrine facies only (v. Figure 8). If this fact is not a mere appearance (due to the difficulty of noticing a tectonic disturbance in massive non-bedded sediments), it would support the above presented suggestion that the formation of the fans and lakes were under the actual control of the tectonic movements, the loamy facies invading promptly each stabilised area. But this is of course, an hypothesis.

In any case, the time of the lacustrine conditions and of the tectonic changes seems to have been closed before the Upper red loams ("Choukoutien") deposition.

3. The three Red Loams of East China and the Choukoutien stage.

Distinguishing the red and the reddish clays from one another we ourselves found to be a difficult task, when we were working in the west and south Shanxi areas in which the Pliocene and Lower Pleistocene formations are represented almost exclusively by their loamy facies (v. Teilhard and Young, 1930a).

In south east Shanxi, where a torrential-lacustrine facies is the ordinary condition for the Pliocene, and a common feature for the Ssannienian, the distinction of the various Pliocene and Lower Pleistocene zones is much more easy and decisive. For instance the existence of a red Ssannienian loam, distinct from the Pliocene, is absolutely evident in the Changchihkou section (Figure 8).

Furthermore, the recognition of a "Choukoutien" physiographical and stratigraphical stage, suggested by us with much hesitation (v. Teilhard and Young, 1930a, p. 8, "Reddish clays, Zone C,"—and 1930b, p. 125), has become much clearer since such sections have been found where, as in Shouyang (Figure 1), Taiku (Figure 5), Changchihkou (Figure 8), etc., a special series of red loam is observed, dissecting the Nihowan (Ssannienian) definite sediments. By elimination, and even in the absence of characteristic Rodents or Deer, such pre-Lessevie and post-Nihowan red or reddish loams have to be referred to the Choukoutien phase.

As observed above, these presumably "Choukoutien" loams exhibit, physiographically, a decisive approach to the Lessevie conditions. Not only does
their sheet follow closely the modern topography and drainage system, but also they are found preserved, together with the Loess, in several higher districts from which the older Sarmatian loam has been washed away. It would seem therefore, that in some opposition with the fact that the Choukoutien fauna is closer to the Nihowan than to the Loessic fauna (v. Teilhard and Young, 1929b, p. 197), the deposits referable to the Choukoutien stage follow more exactly the Loessic than the Sarmatian physiographical conditions.

4. Relations between the torrential-lacustrine deposits and the red loams in SE. Shansi.

Now that the presence of three well defined, disconformable or even unconformable, Late Cenozoic, pre-Loessic series (namely Pontian, Sarmatian—Nihowan, "Choukoutien") is recognised in SE. Shansi, the three of them being represented by red loams, and the two first ones, in addition, by torrential-lacustrine beds, then the question arises: how to understand the connection and the succession of these various deposits? Are the loams contemporary with, or younger than the freshwater sediments belonging to the same geological period? According to the answers, rather different solutions have to be given to the problem of the Pliocene and Pleistocene Climates.

In the Taiku basin, Dr. Barbour believed that the violet sands were passing conformably into the upper red loams. But, as told above, a deep dissection seems to exist between them. Consequently the Taiku red loam is not a Sarmatian, but a "Choukoutien" formation. By the fact, and with the possible exception of the Hungchuan sections (figure 6), where a red Pontian loam is overlaying sands and conglomerates of the same geological age, we have not observed any clear conformable passage of the "violet sands" to the "red loams," for the same period, along the vertical. It seems, on the contrary that, in the Chihshien area at least, the lakes never did dry up, but were only reduced in size in the course of the Pliocene (from the Pontian to the Sarmatian). These facts are not especially favourable to an alternation of the sands and the loams, that is to the idea of sharp periodical climatic changes.

1. Nothing was clearly observed by us this time, helping to fill the gap between the Pontian and the Sarmatian deposits. A close palaeontological analysis would probably discover, however, in the torrential-lacustrine series, an equivalent of our "reddish clay, Zone A" of 1929 (v. Teilhard and Young, 1930b, p. 6).
We suspect therefore that a large part of the Pontian and Samarian red loams are contemporary with, and pass laterally into their corresponding freshwater deposits: the former (as it is the case for the Loess) being found along the slopes and over the plateaux; the latter filling the depressed Tianshan synclines.

We have no objection, however, to admit that (here again as it is the case for the Loess) the torrential-lacustrine facies is dominantly older than the loams: each period would begin with a minimum, and end under a maximum, of the loamy conditions. This idea, diagrammatically expressed by the adjoining Figure 15, does not contradict, but mitigates, the conception of climatic periodicity.

![Figure 15. A diagram of the Late Cenozoic sediments in SE. Shansi.](image)

5. The colouration of the red loams.

An important problem bearing on the history of the sedimentation and of the climatic variations during Late Cenozoic times, is the origin of the red colour of the loams (red and reddish clays).

The dominant characters of this colouration in Shansi are the two following ones:
a. Taking the formations as a whole, and notwithstanding numerous local exceptions, the red staining of the loams is gradually diminishing from the Pontian to the Sammenian, and from the Sammenian to the "Choukoutien" loams.

b. In the two last formations (Sammenian and Choukoutien), the red-colouration is chiefly marked along a series of parallel bands, horizontal or plunging (according that the loam has been deposited over a plateau, or along a slope). In the Stephanian stage, especially (Sammenian-Nihowan), those redder zones, 1-2 meters thick on the average, occur periodically and regularly, separated by 2-3 meters of lighter coloured sediments. Sometimes as observed by Barbour, the light-coloured bands correspond with the concretion layers; but not always.

This being understood, three different ways can be tried to explain the facts.

1. The red staining of the loam is due to a slow chemical process; affecting the loams according to their sedimentary structure, long after their deposition. Then, the older a loam is, the redder it is, in its entire mass. The Loess will possibly become red, when more "fossilised."

2. The red staining is original in the Pontian clays only; and the gradually lighter colouration observed in the Sammenian and later loams is due to a remoulding and dilution of this original material. The red bands correspond to the periods of stronger dissection (and lesser dilution) of the Pontian (or other derived) red clays.

3. The staining is original for each series of loams, and will never extend, for instance, to the Pleistocene grey loess. But it is under the direct dependence of special climatic conditions which have been regularly decreasing from the Pontian to the Choukoutien times.

Now, the first explanation has to be excluded, because it seems clear that the original staining of a loam is more or less contemporary with its deposition.

The same is true for the formations of the concretions: rolled Pontian concretions occur in the Sammenian basal gravels, and Sammenian concretions in turn, with their characteristic fossils are found in the Loess. (cf. Teilhard and Young, 1930a, p. 5, note 2).
Anywhere, for instance a clod of Postian clay is observed embedded in some overlying Cenomanian sand, it is found to be just as red as the formation itself.

The second explanation although possible in some cases (viz. in the places where limited masses of a younger loam dissect actually an older, strongly coloured loam (v. Fig. 8, 1), cannot be a general one. Enormous and thick areas of Cenomanian red loams are found (for instance in the Icheng area) for which no sufficient supply of red pre-existent matter could be imagined, chiefly for the upper levels. Further as in the same areas the red bands are so regular, so continuous and so extensive, that no torrential spreading of a rowashed clay could be a satisfactory reason for their formation.

Consequently, we are restricted to the third explanation, viz. that in the course of the Late Cenozoic times, some climatic conditions have been first prevailing, and then gradually decreasing, up to the Loess exclusively, responsible for the chemical alteration of the loams. These conditions have to be determined by a chemical analysis of the looms, and by the observation of similar transformations actually in progress somewhere in the tropical regions of the world.

REFERENCES.


1. The same observation is very easy to make for the Trias, in the Shanxi; whenever a layer of clay is overlain by a bed of sandstone, the patches of clay embedded in the sandstone (as a result of a disintegration contemporary with the deposition of the sandstone) are just as dark and red as the main clayish deposit.


### Bulletin of the Geological Society of China

**LIST OF LOCALITIES**

<table>
<thead>
<tr>
<th>Loc. 20</th>
<th>Shaoyang (邵陽) N. E. of town</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chief fossils:</td>
</tr>
<tr>
<td></td>
<td>Siphonops tingi</td>
</tr>
<tr>
<td></td>
<td>Capreolus sp.</td>
</tr>
<tr>
<td></td>
<td>Sichuanicetus fangi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loc. 21</th>
<th>Yangtze (揚州) On the way from Shaoyang to Yangtze near the pass.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hippopotam sp.</td>
</tr>
<tr>
<td></td>
<td>Cerchiopterus indet.</td>
</tr>
<tr>
<td></td>
<td>Choetotherium sp.</td>
</tr>
<tr>
<td></td>
<td>Small deer.</td>
</tr>
<tr>
<td></td>
<td>Ochotona (skull)</td>
</tr>
<tr>
<td></td>
<td>Spheniscus cf. fontini</td>
</tr>
<tr>
<td></td>
<td>Conviva indet.</td>
</tr>
<tr>
<td></td>
<td>Siphonops tingi</td>
</tr>
<tr>
<td></td>
<td>Rhinoceros sp.</td>
</tr>
<tr>
<td></td>
<td>Equus cf. sannentenuis</td>
</tr>
<tr>
<td></td>
<td>Cervus cf. bovid</td>
</tr>
<tr>
<td></td>
<td>Gazella sp.</td>
</tr>
<tr>
<td></td>
<td>Bisons cf. poliromos</td>
</tr>
<tr>
<td></td>
<td>Elephas sp.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loc. 22</th>
<th>Shizhang (下張)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loc. 23</th>
<th>Yueze (攸州) Taoping (邵坪)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spheniscus cf. fontini</td>
</tr>
<tr>
<td></td>
<td>Conviva indet.</td>
</tr>
<tr>
<td></td>
<td>Siphonops tingi</td>
</tr>
<tr>
<td></td>
<td>Rhinoceros sp.</td>
</tr>
<tr>
<td></td>
<td>Equus cf. sannentenuis</td>
</tr>
<tr>
<td></td>
<td>Cervus cf. bovid</td>
</tr>
<tr>
<td></td>
<td>Gazella sp.</td>
</tr>
<tr>
<td></td>
<td>Bisons cf. poliromos</td>
</tr>
<tr>
<td></td>
<td>Elephas sp.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loc. 24</th>
<th>Taiku (太谷) Jingtian (仁 знач)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spheniscus cf. fontini</td>
</tr>
<tr>
<td></td>
<td>Conviva indet.</td>
</tr>
<tr>
<td></td>
<td>Siphonops tingi</td>
</tr>
<tr>
<td></td>
<td>Rhinoceros sp.</td>
</tr>
<tr>
<td></td>
<td>Equus cf. sannentenuis</td>
</tr>
<tr>
<td></td>
<td>Cervus cf. bovid</td>
</tr>
<tr>
<td></td>
<td>Gazella sp.</td>
</tr>
<tr>
<td></td>
<td>Bisons cf. poliromos</td>
</tr>
<tr>
<td></td>
<td>Elephas sp.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loc. 25</th>
<th>Taiku (太谷) Hunghatao (紅土口) at the right side of Wumao (五馬河)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rhinoceros sp.</td>
</tr>
<tr>
<td></td>
<td>Siphonops sp.</td>
</tr>
<tr>
<td></td>
<td>Gazella sp.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loc. 26</th>
<th>Yukue (榆椉) Houm (侯目)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Choetotherium sp.</td>
</tr>
<tr>
<td></td>
<td>Hippopotam sp.</td>
</tr>
</tbody>
</table>

---

*The localities are indicated in the map by numbers 20 to 21. For localities 1 to 19 cf. Tellian and Young: Preliminary observations on the pre-Loessic and Post-Loessic formations in Western Shanxi and Northern Shansi. Mem. Geol. Surv. China, Series A, No. 8, 1930, p. 37.*
Teilhard & Young:—Cenozoic Formations of S.E. Shanxi

Sudae indet.
Machea sp. indet.
and Ceratoceras sp.
Giroffidae indet. (Alcioceras)
Goniola sp. und several
Antelopes (Tragocerus?)
Mustelidae and Stegodon sp.
(at least 3 species) etc.

Loc. 27 Wushan (武山) Subotze (四合子)
Loc. 28 Chishan (赤山) Huijiao (惠憲)

Loc. 29 Fanbao (扇包) Peiyangze (必王村)
Loc. 30 Fanbao Puchen (北鎮)
Loc. 31 Fanbao Fanjiao (飛村)

Siphonites fortulaeni
Eolithus sp.
Hippoprot sp.
Siphonites forislei
Cama sp.
Siphonites sp.
Siphonites forislei
Siphonites sp.
Ceratops sp.
Explanation of
Plate I
Plate I

1. A section in the lacustrine Sammonian beds near Shouyang. R, red loam ("Choukoufen"). V, violet sands (Sammonian) (Cf. Text Figure 1.)

2. The late Cenozoic anticline of Hongtushan. (Cf. Text Figure 6).

3. The torrential Pontian beds of Shinzhang. (Cf. Text Figure 3).
Explanations of Plate II.
PLATE II

1. The torrential Pontian beds of Shihang.

2. A section in the Pontian "violet formation" between Wuhang and Chihsiien. Red beam on the top of the hill in the background.
Explanation of Plate III.
PLATE III

1. The Pontian conglomerates south of Chinhacu. Observe a possible dislocation on the right corner of the picture.
2. The tilted Pontian (?) torrential beds of the Chuewu basin.
3. The same from another view.