PRELIMINARY REPORT ON THE CHOU KOU TIEN FOSSIFIFEROUS DEPOSITS*

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INTRODUCTION

The main fossiliferous deposit at Chou Kou Tien has been known in the geological literature since its discovery in 1921** (v. et. 2,3 and 19) but its full scientific significance was not realized until the year 1926 when announcement was made of the finding of two hominid teeth among the material excavated by O. Zdansky in 1922 (v. 4,5 and 6). These two specimens were subsequently fully described by Zdansky (v. 23 and 25) but their generic and specific identification remained obscure for a time.

In view of the discovery of undoubted hominid material in the Chou Kou Tien deposit a systematic study and excavation of the site to extend over a period of two years was undertaken by the Geological Survey of China supported by a grant from the Rockefeller Foundation and in cooperation with the Department of Anatomy of the Peking Union Medical College. At the close of the first season's work on October 16, 1927 a beautifully preserved lower molar hominid tooth was discovered in situ by Dr. Birger Bohlin and upon the morphological characters of this tooth a new hominid genus *Sinanthropus* was established (*S. pekinensis* Black and Zdansky, v. 7, 8 and 9).

The second season's work on the Chou Kou Tien site by Drs. Birger Bohlin, C.C. Young and Mr. W.C. Pei resulted in the recovery of much additional *Sinanthropus* material including parts of two lower jaws and numerous skull fragments (v. 10, 11 and 12). A continuation of this important work by the Geological Survey over a further period of years was then made possible by an additional grant from the Rockefeller Foundation resulting in the organization

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** One of the subsidiary bone deposits at Chou Kou Tien, known as Chi Ku Shan (our locality 6) was visited and described by Dr. J. G. Andersson in 1919 (1) but it was not until two years later in Aug. 1921 that the main deposit was discovered. A full list of papers published up to this date on the subject of the Chou Kou Tien deposit and its fauna will be found in the literature cited at the end of the present communication.

under the honorary direction of Dr. Davidson Black of the Cenozoic Research Laboratory of the Geological Survey of China devoted to an intensive study of Tertiary geology and palaeontology with special reference to human palaeontology.

It was originally planned to publish this year a full and detailed report on the excavation at Chou Kou Tien by Birger Bohlin, C.C. Young and W.C. Pei, but in spite of every effort to carry the work to a conclusion there remains at the close of the third season's work an enormous mass of untouched material within the main deposit and it is difficult to give any estimate of when the excavation there can be completed. On this account, and in view of the importance of the region as the discovery site of *Sinanthropus*, a brief preliminary account of the chief geological and palaeontological features of the Chou Kou Tien formation as at present understood has been prepared and is here presented

I. GENERAL DESCRIPTION OF THE AREA

Chou Kou Tien is the terminus of the Liu Li Ho-Chou Kou Tien branch line of the Kin-Han railway, being approximately 110 li (circa 37

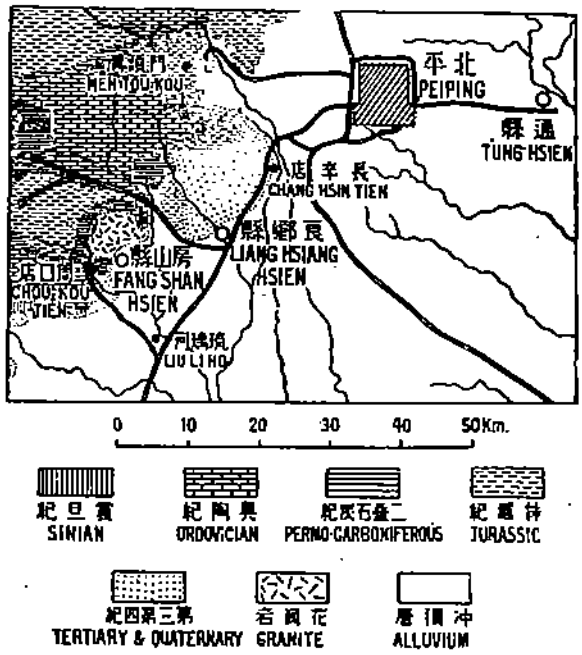

Figure 1. General sketch showing the situation and geology of Chou Kou Tien (After the Peking-Tsinan sheet of the geological map of China.)

miles) southwest of Peiping (Peking). The town lies at the foot of the Western Hills at the edge of the Hopei (Chihli) plain in the close vicinity of large lime stone quarries and coal mines. Its position and the general geology of the area are indicated on the map reproduced here as figure 1. (cf. Yih. L.F., 17.)

As may be seen in figure 1 the hills of the Chou Kou Tien area are for the most part formed of Ordovician limestone and carboniferous shales or sandstones (more or less metamorphosed by granitic intrusions). About 250 meters north of the railway station of Chou Kou Tien a small valley (the Lao Liu Kou) runs approximately along the boundary of the two formations. All the fossiliferous localities (localities 1 to 8*) are found in the Ordovician limestone, large masses of which have been removed from the hill sides during the course of years by quarrying to supply the numerous lime kilns of this region.

The majority of the bone deposits occur on the periphery of a small hill, 60 meters high and strongly brecciated in its eastern part, which lies immediately to the west of the village of Chou Kou Tien (see figure 2). Evidently these sites were originally clefts or caves within the limestone which have subsequently become filled with deposits of red clays and angular pieces of limestone. These deposits have become so hardened by secondary calcareous infiltration that they usually remain in place as solid dykes after the surrounding limestone has been removed by quarrying. (v. localities 2,3,6, etc.)

In addition to the chief fossiliferous localities noted on figure 2 there occur throughout the Chou Kou Tien area many similar residual deposits of reddish material, exposed in fissures or along the hill sides, so that seen from the distance the ground of the Chou Kou Tien area is for the most part distinctly reddish in color. Though most of this red residual material is barren of fossils, it belongs presumably to the same general formation as the bone deposits and its geological significance requires careful study.

It will subsequently be shown that all the Chou Kou Tien red earths, including the bone deposits, are almost wholly restricted to regions lying below the general altitude of 80 meters. Below this level the whole country would seem at one period to have been covered by the "Chou Kou Tien formation."

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* In Zdansky's 1923 paper (21) his "Loc. 1" corresponds to our locality 6; his "Loc. 53" to our locality 1; and his "No. 2" to our locality 2.

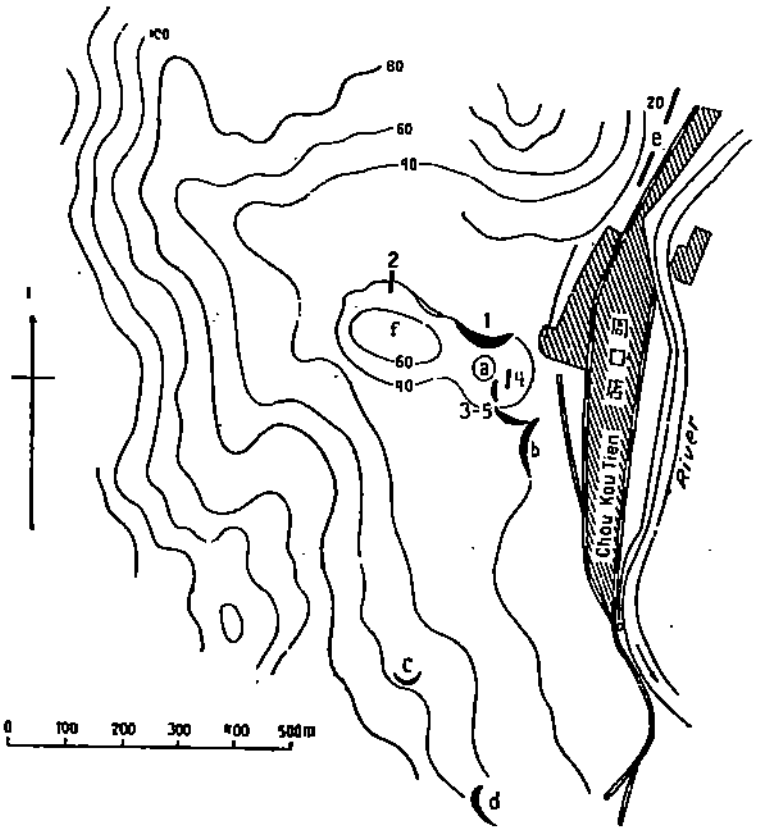

Figure 2. Topographical sketch showing distribution of chief Chou Kou Tien deposits. Abbreviations:—1 to 5, fossiliferous (brecciated) localities; a to d, Upper-gravels deposits; e, Lower-gravels; f, stalagmitic floor (v. p. 189) The red Chou Kou Tien formation (surface and clefts deposits) is practically restricted to levels below the 80 meter line. The 60 meter line can be considered as the upper level of the Upper-gravels. (After Zdansky's 1923 map.)

II. PROGRESS OF THE EXCAVATION

The major part of the Chou Kou Tien field work is represented by the excavation carried on at locality 1 (*Sinanthropus* site). A few days only have been spent excavating at localities 2 and 6, although localities 3 and 4 have been explored to some extent, and numerous fossils have been obtained rom quarry men working on these sites.

A list of the various men in charge of the field work since 1927, together with a synopsis of the amount of gross work done and material recovered for laboratory preparation is presented below in tabular form, the extent of the work being further illustrated by the plan shown in figure 3.

SEASON	FIELD WORKERS	TIME IN FIELD	EXCAVATION	MATERIAL
1927	C. Li B. Bohlin	24 weeks	circa 3000 cu. meters	500 boxes
1928	B. Bohlin C. C. Young W. C. Pei	14 weeks	circa 2800 cu. meters	575 boxes
1929	W. C. Pei C. C. Young	26 weeks	circa 3000 cu. meters	410 boxes

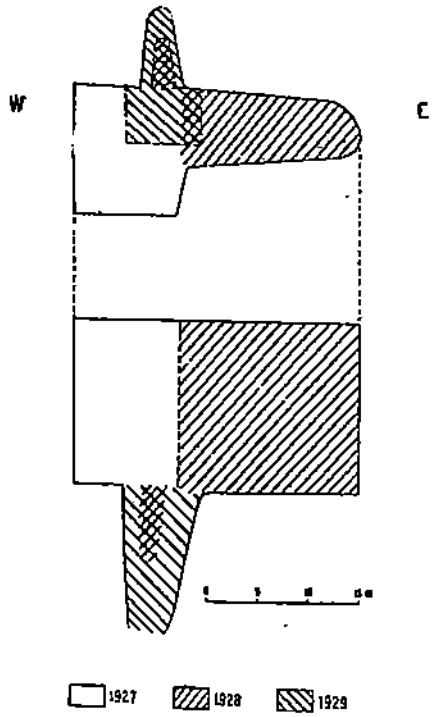

Figure 3. To illustrate the extent of the excavated area in Locality 1. Upper diagram, top view or plan; lower diagram, vertical section (taken along the northern "Outer wall").

Although in places the residual material of the main deposit was loose and easily worked, for the most part it has been of such hardness that drilling and blasting operations have had to be carried on extensively. A detailed description of the special technique evolved in the course of this work will be given in the final report on the Chou Kou Tien excavation.

III. GEOLOGICAL DESCRIPTION OF THE CHOU KOU TIEN FORMATION

A. Fossiliferous and brecciated fissures.

(1) Locality 1.

(a) General features.

Both by its size, and on account of the number and value of the fossils recovered locality 1 is the most important of the Chou Kou Tien deposits. In this locality the bone-bearing layers are contained in broad E-W elongated fissure, the roof of which is wanting. The definite shape of the cave is still a matter of conjecture because it is not yet known how far the sediments extend southwards, westwards and downwards. It can only be said from the area excavated that the cave deposit probably exceeds 35 meters in length (E-W direction), 20 meters in breadth (N-S), and 34 meters in height (above the bed numbered 10 in figure 5).

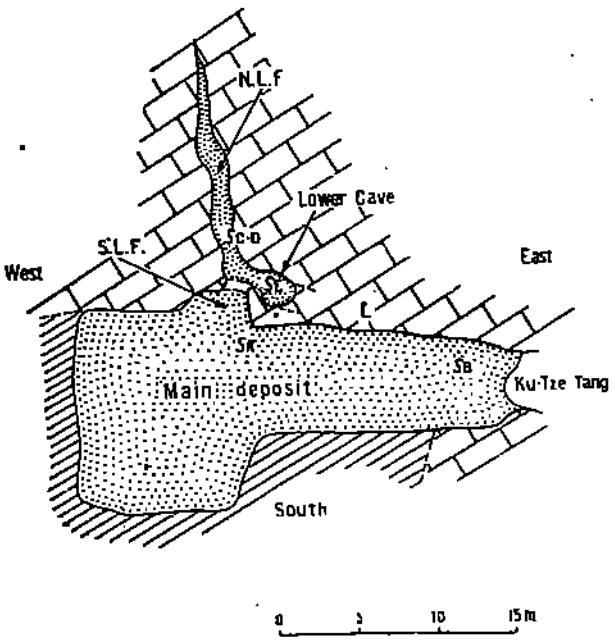

Figure 4. Horizontally projected view of Locality 1. Abbreviations:—L, limestone of "Outer wall"; N. L. F., north "Lower fissure"; S. L. F., south "Lower fissure"; *SA*, *SB*, *SC-D*, *SE*, various loci in which *Sinanthropus* material has been found; Ku-Tze-Tang, open cave. Dotted area, excavated part; oblique lines, non-excavated part of deposit.

At its eastern end, the fossiliferous fissure is continuous with an empty cave, called Ku-Tze-Tang*, the level of which corresponds roughly with that of the *Sinanthropus* layer 5 shown in figure 5. Another open cave, some meters to the east and lower than the Ku-Tze-Tang, may represent an extension of the original cave and correspond to the original floor level of locality 1.

The northern boundary of the excavated area is formed by a wall of limestone (the front of an ancient quarry, designated the "Outer wall"), cut transversally by a vertical fossiliferous cleft rapidly tapering off northward, the "Lower fissure". In its upper part, the Lower fissure is continuous with the main deposit, but below the level 7 (vide infra) an irregular transverse septum of undisturbed limestone or of fallen blocks subdivides it in two parts: a southern part (the "southern Lower fissure"), shorter, broader, intimately united with the main deposit; and a northern part (the "northern Lower fissure"), longer, narrower, connected by its lowest levels with a newly discovered fossiliferous accessory fissure, the "Lower cave".

The Lower cave had just been reached at the end of the 1929 work, so that, concerning its shape and extension, we can say practically nothing. The excavated part shows a length of 4 or 5 meters, a roughly cylindrical roof (3 meters broad, 2 meters high), dipping gently in a south-easterly direction. The Lower cave branches perhaps with the main deposit somewhere under the Ku-Tze-Tang; but there are many other possibilities.

(b) Stratigraphy.

As shown in figure 5 the following layers can be distinguished, from the top to the base, in the part of the locality 1 already excavated.**

1.—Light yellow hard clay, with limestone fragments of small size and bone remains fragmentary and rare. This layer is partly covered by the waste of an ancient quarry, and perhaps by some other less recent deposits. Thickness: 1.20 meters.***

2.—Grayish sandy clay, moderately hard, containing some small bones, blue or black in colour. Thickness: 1.75 meters.

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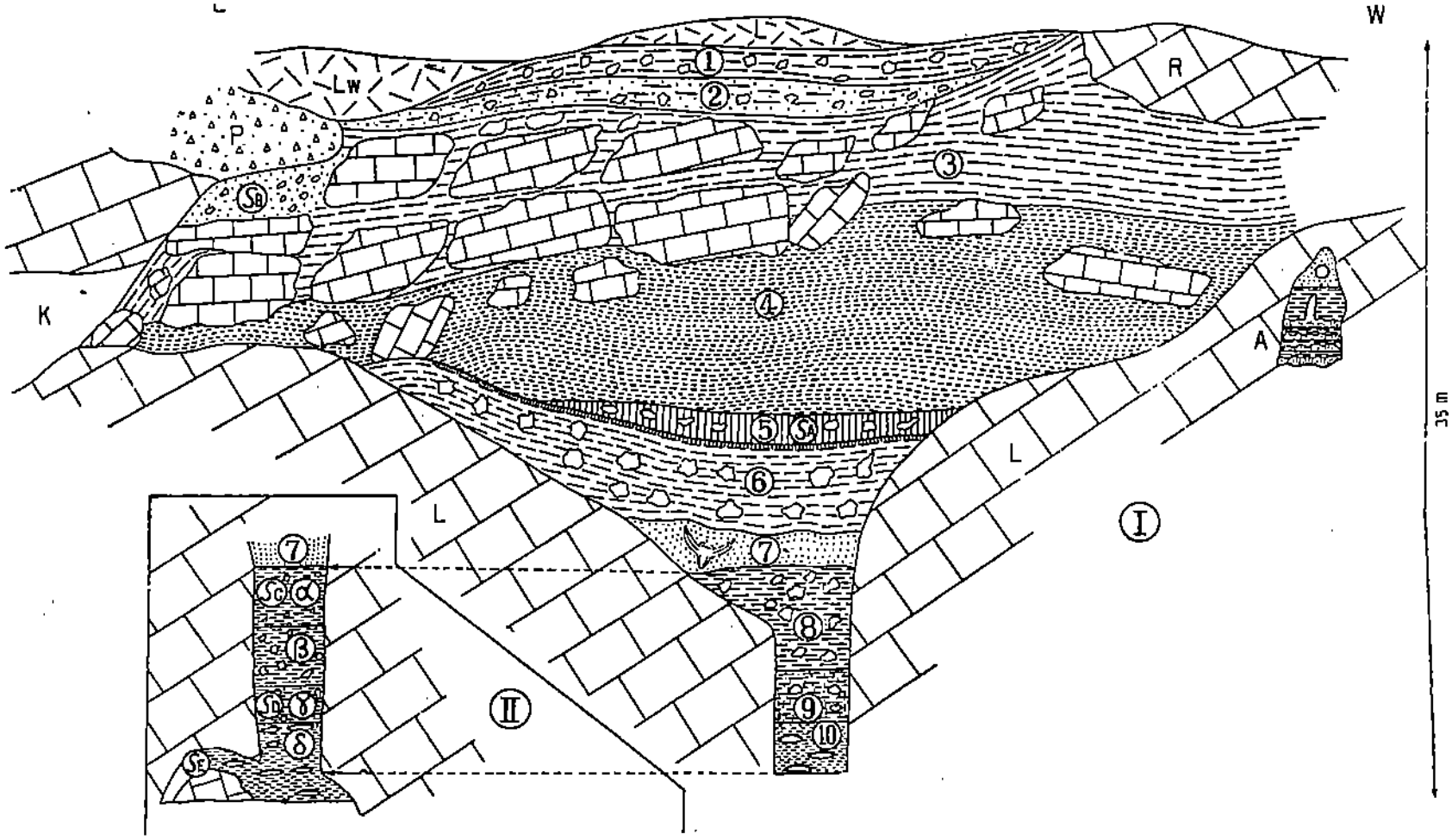
* This cave almost surely forms a part of the locality 1 which has been artificially emptied in recent times.

**After three years of work, a precise correlation with the Zdansky's 1923 profile (21) is rather difficult to establish. The section given by him corresponds probably to some part of our layers 5 and 6. Li's classisication (19) in the prcsent state of the excavation need no longer be considered. It will be fully discussed in the final report.

***All these measurements of thickness are variable from place to place in the deposit.



Firgue 5.—Front view (east-west section) of Locality 1. Abbreviations in section I: — 1 to 10, various levels of deposits; *SA*, *SB*, *SC*, *SD*, *SE*, various loci in which *Sinanthropus* material has been found; L, Limestone "Outer wall"; R, limestone (residual part of roof ?); P, rubbish; LW, lime waste; A, accessory fissure; K, Ku Tze Tang. For abbreviations used in section II, see text.

3.—Irregular level, chiefly composed of large limestone blocks, dipping approximately in the same direction as the limestone of the hill, probably representing a fallen roof or suspended floor; matrix formed by yellow or brown clay. Thickness: 7.25 meters.

In the eastern part of this layer, an isolated pocket of yellow fine grained hard material has yielded (1928) crushed skull and skeletal parts of both young and mature *Sinanthropus* specimens. This pocket has been designated "Locus B" in the preliminary descriptive notes on the 1928 *Sinanthropus* material. (v. 10, 11 and 12.)

4.—Very conspicuous fine grained, sedimentary zone, formed by red loam and sandy clay of various colours (yellow, reddish, brown, gray, etc.) thinly bedded and interbedded*. At several levels, some black layers occur which are full of Rodent remains and other micro-fauna. Elsewhere in this zone fossils are very rare, with the exception of some well preserved bones (e.g. an *Elephas* tusk) found in its lowest part. Thickness: 6.70 meters.

5.—"*Sinanthropus layer*" (Locus A). Highly fossiliferous layer, half brecciated, half consisting of soft black clay; limestone fragments strongly weathered. Thickness: 0.40 meters.

6. Hard limestone breccia, with red clay and sandy loam. Fairly abundant fossils. The upper surface of this breccia is strongly hardened over a thickness of some 20 centimeters, and forms a conspicuous floor. Thickness: 6.00 meters.

7.—Apparently a lenticular layer of gray, dark, loose sands, with isolated limestone blocks and some pebbles; fossils exceptionally abundant and well preserved (e.g. skulls of Buffalo, Deer, Pig, etc.). Thickness: 1.50 meters.

8.—Another very hard breccia of limestone blocks and smaller pieces, embedded in a red sandy loam; few fossils. Thickness: 5.00 meters.

9.—Like the level 8, but more sandy; few fossils. Thickness: 2.00 meters.

10.—Sandy red clay, containing a number of concretions, but no limestone blocks. Practically no fossils. Thickness: 2.00 meters.

* In this sandy-clayish material, Dr. Bohlin was able to distinguish more than 100 individual laminae.

The layer number 10 is probably not very far from the bottom of the cave; but the excavations did not go further. The level reached is still about 8 meters above the present bed of the Chou Kou Tien river.

As here described, and as shown in the figure 5, I, the levels 7-10 form the filling of the "southern Lower fissure"; and they extend probably rather far into the main deposit southward. But, with the exception of the level 7 (which has been recognized over the whole Lower fissure) they are replaced, in the "northern Lower fissure" by special layers α—δ, which are as follows (vide figure 5, II):

α.—"Carnivores layer"—Greenish sandy clay, containing small limestone fragments, and abundant fossils: *Hyaena* (entire skulls, and coproliths), *Ursus*, "*Euryceros*" (whole antlers), six isolated teeth of *Sinanthropus* (Locus C). Thickness: 2.50 meters.

β. —"Rodents layer". More brecciated layer, cemented with red clay. Many fossils: Rodents (*Arctomys*, *Lepus*); *Moschus* (abundant). Thickness: 3.00 meters.

γ. —Less brecciated layer of locally hardened red clay. Very fossiliferous; 5 isolated teeth of *Sinanthropus* (Locus D). Thickness: 1.50 meters.

δ. —Identical with the layer number 10 of the "southern Lower fissure". Red sandy clay, occurring in irregular concretions. Practically no fossils. Thickness: 2.00 meters.

At this level the excavations are actually stopped; and the Lower fissure branches with the "Lower cave".

Lower cave. In its excavated part (about 4 x 3 x 2 meters), the Lower cave was found filled by the same fine-grained, homogeneous, partly cemented, red material as the layers 10 and δ. But, as a difference from those two layers, the fossils were abundant and well preserved; skulls of *Hyaena*, skull of *Rhinoceros*, skull of *Sinanthropus* (Locus E). The place is still almost untouched by the excavation.*

On the whole, the excavated part of the locality 1 (main deposit and "southern Lower fissure") may be considered as consisting in three chief

*Embedded in the fine grained material of the Lower cave, Mr. Pei picked up an angular piece of quartz—a type of stone which is not found within one mile at least of the locality 1. Similar quartz fragments have been found from time to time in the course of the excavations, the first ones being noticed by Dr. J. G. Andersson, but none of them has ever shown any recognizable trace of artificial breaking.

zones, as follows:—the upper part (layers 1-3), forming the *Upper breccia zone*, which is more developed in the eastern corner of the section; the middle part (layer 4) representing a thick *Sandy phase;* and the lower part (layers 5-9) constituting the *Lower breccia zone*. This lower brecciated zone contains more sandy pockets and more fossils than the upper one. The contact between the hardened top layer of the Lower breccia and the middle sandy zone (layer 4) is exceptionally sharp, and corresponds precisely with the *Sinanthropus* Locus A; so that the question might be raised whether *Sinanthropus* did not live there during some break, and before some important change, in the sedimentation.

Compared with the main deposit, the Lower fissure (northern part) and the Lower cave form a rather isolated department, in which, in the absence of any big fallen blocks, the deposits are more regular, and the fossils much better preserved.

(c) Stalagmitic formations.

The stalagmitic formations have to be considered as one of the very interesting features of the locality 1. Of course no true stalagmitic floors (but brecciated levels only) have been met within the main mass of the deposit, but along the walls of the cave, and specially of the "Lower fissure". thick layers, and even small raised pillars, of crystalline calcite are rather common. These are surely contemporaneous with the filling of the cave, since they are distinctly embedded in the clay, or occasionally, they may occur as broken pieces within the breccia itself.

A very striking example of the way in which these stalagmites have been *repeatedly formed* has been noted in a small accessory fissure which is situated in the western part of the excavation (v. figure 5,A). As indicated in the figure, this miniature cave (2.50 meters high and entirely filled by hard cemented material) shows four successive stalagmitic floors separated by four red clayish levels. The second floor is locally transformed into phosphate of lime and above the fourth floor a fine stalagmitic cone (40 centimeters high and 13 centimeters broad) was standing, entirely embedded in the overlying hardened clay. Many small fossilized bones were found in this upper stalagmitic layer, and some *Helix* specimens occurred in the underlying clay. The top of the cavity is filled by cemented coarse sand, and contains a large, broken, rounded pebble of Jurassic sandstone. This upper filling is possibly contemporaneous with the middle sandy zone (layer 4) of the main deposit.

(d) Origin of the deposits of locality 1.

It would seem to emerge from the foregoing facts that the fossiliferous material filling locality 1 has been accumulated by a slow process of weathering, under humid conditions (water infiltrations and occasionally brief flooding), but without any real torrential action. Rolled pebbles of foreign origin are found, it is true, at almost every level of the deposit, but always as isolated occurrences so that they can safely be regarded as derived, together with angular limestone pieces, from the "*Upper gravels*" (v. infra p. 188) still preserved at the top of the hill. Even the sandy bands of the middle zone (level 4) are interrupted, as we have noted above, by Rodent layers. A river must have flowed very close to the cave, as proved by the Lower gravels found near Chou Kou Tien (v. infra p. 189), and also by the presence amongst the fossils of the remains of Beaver, Buffalo, and even of a broken *Unio* (found in level 4). However no true river deposits have so far been encountered in the fissure itself. By the chiefly brecciated facies of its sediments, as well as by the characters of the bones it contains (vide infra), locality 1 has to be understood, not as an underground, water-drained, fissure, but as an ancient, gradually filled, open-air cave.

(e) Palæontological characters and origin of the fossil bones.

At the end of the present paper a full list is given of the fossils already identified from the deposits of locality 1. Of the forms noted in this extensive list the most interesting zoological types, apart from *Sinanthropus*, are the big Beaver (*Trogontherium*), the primitive water Buffalo (*Bubalus*), and the strange Deer (*Euryceros sp.*), the extremely thickened jaws and facial bones and the short flattened antlers of the latter being perhaps the most characteristic among the fossils of Chou Kou Tien. *Machairodus* is exceedingly rare, no specimens being so far known other than the upper canine described by Zdansky (21), and three other canines (an upper and two lower ones) found in the course of 1928 and 1929 excavations.

Bones belonging to these various forms are generally found mixed together, and crowded in the most amazing way. However, as already pointed out above, some peculiar faunistic zones may be recognized, as for instance: the Rodent levels (layer 4), the *Sinanthropus* layer (layer 5 = Locus A), the Ruminant layer (layer 7), and the Carnivores level (layer α).

In spite of such interesting but quite accessory differences, the fauna as represented by its most characteristic types (*Sinanthropus*, *Euryceros*, *Rhinoceros*, *Hyaena*, etc.) is the same throughout the deposit from top to base of the present excavation.

As to the probable origin of the bones, it would seem that while some of the fossil bones found in locality 1 have been introduced into the deposit by brief flood action (e.g. the *Bubalus* skulls of the layer 7), a larger amount has been left or brought in by animals living in the cave. For if the filling of the fissure took place as indicated above under semi-arid conditions, when as we shall subsequently show (v. infra p. 191) the limestone hill was already isolated by the cutting of the valley, neither the amount of water reaching the cave, nor the size of the area drained by this water would seem to be sufficient to explain so large an accumulation of bones in such a relatively small place. More directly, abundance of Carnivore remains and number of coproliths occurring in the lower levels, bear a clear indication of an habitated cave.

There is some probability therefore for supposing that not only the Rodents, the Hyaenas, Bears and other Carnivora, but also *Sinanthropus* itself may once have sheltered within the Chou Kou Tien cave.

(2) Localities 2,3,4,5,7 and 8.

The localities thus grouped are either of small extent or they have been but slightly excavated, so that their description may be given very briefly.

The original limestone walls of locality 2 have been removed leaving the deposit as a dyke-like structure 2 meters thick and 15 meters high extending in a north-south direction. It is composed for the most part of cemented clay of red color and full of calcareous concretions. Its original cave-like condition is evidenced by the numerous stalactites still embedded in the hardened residual clay. Fossils are rather abundant in this deposit and of considerable interest since they seem to represent for the most part a specialized fauna of smaller cleft-dwelling animals (v. infra p. 194 et seq.).

Localities 3 and 4 are represented by two other dyke-like residual masses of coarse breccia extending in an east-west direction. Plenty of *Helix* shells have been collected in both these localities and many well preserved mammal bones (Deer especially) have been found in locality 4.

Localities 5,6 and 8 require only to be mentioned with the further note that some interesting mammal bones have recently been picked up in locality 5.

(3) Locality 6.

Locality 6 (known locally as Chi Ku Shan) is located at some distance from locality 1 (5 li S.S.W. from Chou Kou Tien) and consequently could not

be shown on the large scale map reproduced in figure 2. The geological characters of this locality are essentially similar to those obtaining in the other bone deposits just described. The fossiliferous material of Chi Ku Shan formerly occurred as an isolated pillar of hard red residual material about 5.50 meters in height, and 1 meter in diameter near the base. This pillar has been almost entirely excavated and at its base some layers of shaly limestone fragments were encountered. Many fossils were recovered from this site, for the most part consisting of small Carnivores and Rodents. *Lepus cf. voiostolus* Hodgson was especially abundant (v. infra p. 195).

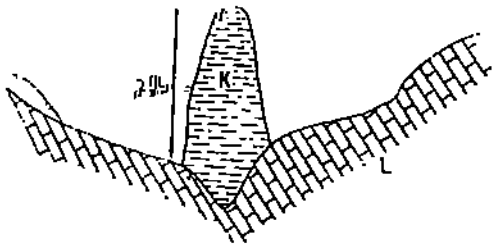


Figure 6. Section of Chi Ku Shan (Locality 6) showing the relationship of the fossiliferous deposits to the Ordovician limestone.

(4) Other brecciated fissures.

Besides the localities 1 to 8, many other fissures filled with breccia or red cemented clay are to be seen everywhere in the limestone of the Chou Kou Tien area. Most of them are barren of animal remains. However isolated bones or teeth, when occasionally found, have proved in each case to belong to the same general fauna as the fossils obtained from the chief fossiliferous deposits already noted.

This fauna, in spite of some local differences, being therefore a homogeneous one, the whole system of the brecciated Chou Kou Tien fissures may be considered, on the basis of palæontological as well as stratigraphical evidence, as representing *a single geological formation*.

B. Gravel bearing fissures.

In addition to the brecciated or strongly concretioned fissures described above, fissures of another kind are met with in the Chou Kou Tien limestone the filling of which (by poorly consolidated sands and gravels) seems to have taken place under decidedly torrential or fluviatile conditions.

As good examples of such gravel pockets, we will refer particularly to to three places marked as localities *a*, *b* and *c* on the map in figure 2.

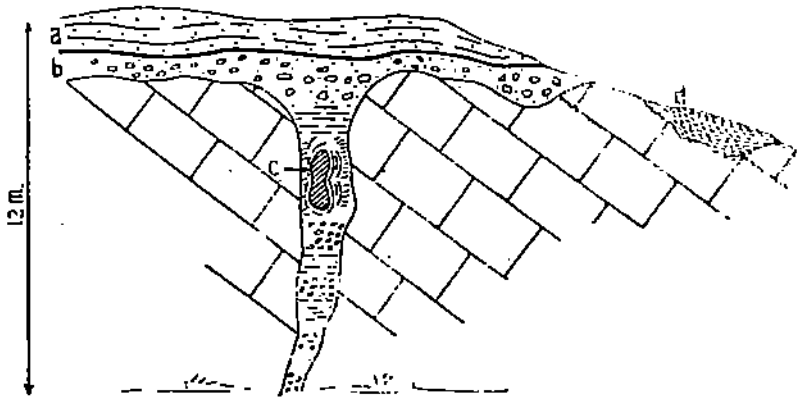


Figure 7. Section of the gravel pocket described in the text as *Locality a*. Abbreviations:—a, thick layer or cap of breccia; b, sand, clay and gravels; c, stalagmitic post-gravel filled fissure; d, hardened yellow sand. The height of the uppermost gravel layer above the present Chou Kou Tien river is 60 meters.

In the locality *a* shown in detail in figure 7 the cleft is 12 meters high, but narrow and entirely filled by alternating layers of well rounded pebbles* and sands. A layer of similar, but coarser gravels extends over the top of the cliff, under a thick cap of hard breccia. About midway up the cleft a secondary fissure was evidently opened some time subsequent to the gravel deposition and became filled with concretions and red clay. The top of the gravels lies at an elevation of 60 meters above Chou Kou Tien.

At the locality *b* shown in detail in figure 8 a whole series of gravel-pockets are distributed along the large vertical wall of a limestone quarry. The pebbles are much larger, more crowded, and more horizontally distributed than in locality *a*. In one place, the gravel series is distinctly cut by a secondary brecciated fissure. In another place, on the contrary, a small pocket shows distinctly, under the coarse sandy deposit, an older filling of red clay. clay of dissolution). The main base of the gravels lies at a height of about 35 meters above the Chou Kou Tien river.

At the locality *c* (60 meters above Chou Kou Tien) the gravels are smaller; but a fine series of fissures is exposed in the quarries and entirely filled with a very coarse quartzitic sand, sometimes cemented, sometimes quite loose.

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* All these pebbles (Jurassic green sandstone, metamorphosed carboniferous shale, granitic rocks) are of foreign origin derived from the mountains north and west of Chou Kou Tien still actually cut by the Chou Kou Tien river.

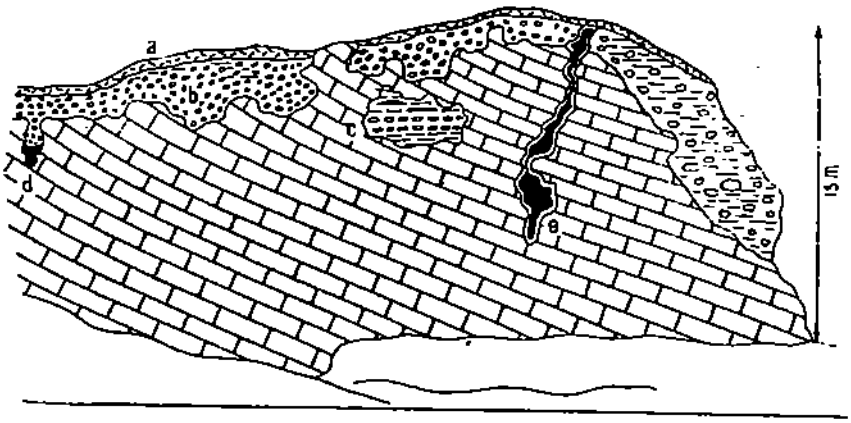

Figure 8. Section of *Locality b* gravel deposit. Abbreviations:—a, humus and rubbish; b, sand and gravels; c, large pocket filled by gravels and hardened sand; d, small pocket where the gravel is lying over an older filling of red clay; e, fissure filled with red concretioned clay. The average height of these gravels above the present Chou Kou Tien river is 40 meters.

No fossils surely belonging to those gravel-bearing fissures have so far been found.* Their stratigraphic interest is however very great since we are led, by their topographical distribution, to recognize an *Upper gravels* level over the hills of Chou Kou Tien.

C. *The surface deposits.*

Extended over the network of the brecciated and gravel-bearing fissures, an extensive mantle of red surface deposits still covers (or was obviously once covering) the whole district of Chou Kou Tien.

A typical section of these deposits is found, along the immediate outskirts of the village of Chou Kou Tien behind the police station (locality *e*). At this place the superficial red clays are well exposed, lying over a thick basal gravel.

The dark red clays, evidently rewashed from their original situs, contain neither calcareous concretions nor any fossils. They are about 10 meters thick, and are interrupted by several layers or angular pieces of rock, dipping conformably with the slope of the adjacent hill.

The gravels, 2.50 meters thick, contain many huge rounded blocks of metamorphosed Jurassic conglomerate and seem to have been laid down by a very swift river, flowing only 8 meters above the level of the present Chou

*A Beaver jaw found in *Locality a* seems according to the matrix to belong to a secondary "brecciated" cleft.

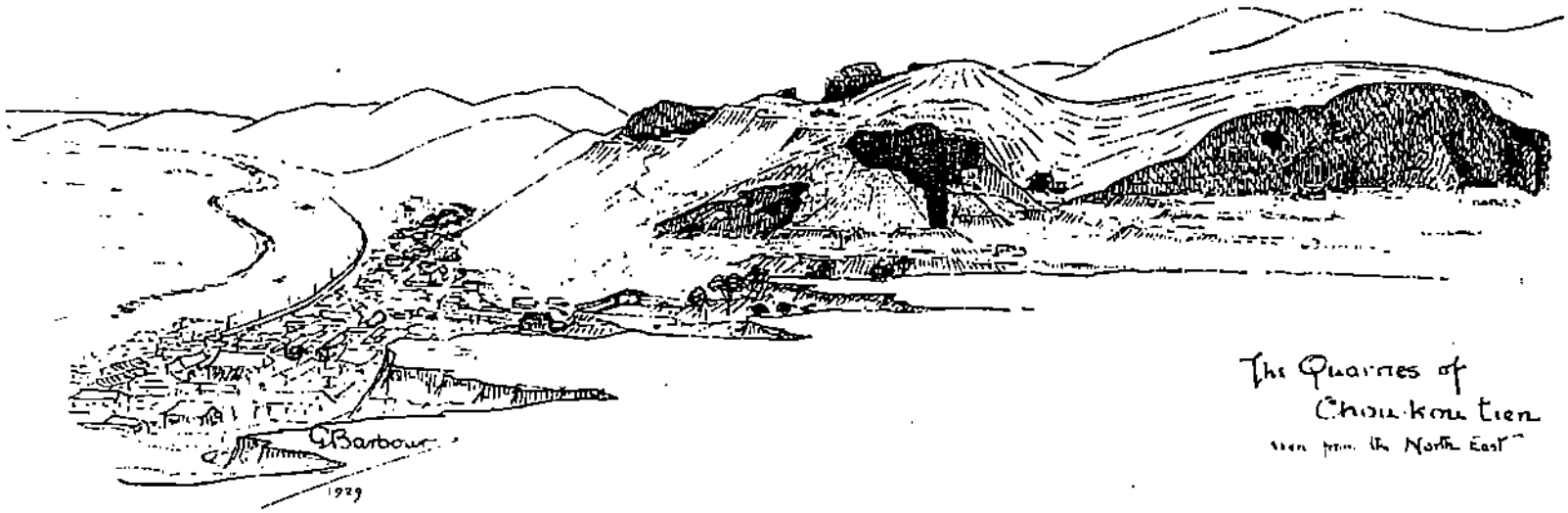

Figure 9. Sketch of Chou Kou Tien sites as seen from the north-east (cf. figure 9 and Plate 1, figure 1).

Kou Tien river-that is to say, more or less on the presumed level of the bottom of the cave locality 1. We shall name these gravels *"the Lower gravels"* of Chou Kou Tien. They can be traced along the valley, at the same height, up to one mile northwards of the village.

Figure 10. Diagram to illustrate the features shown on a larger scale in figure 9. Localities indicated: 1-3; a-b; e-f.

Everywhere along the hills surrounding Chou Kou Tien other patches of superficial dark red clay are exposed on the top of the quarries. Sometimes basal gravels are found, as for instance in the place designed in figure 2 as locality *d*, but they occur *only about on the 60 meter level*. These *Upper gravels* are evidently connected with the system of gravel fissures above described.

As already noted above, the chief red superficial deposits seem to come to an end everywhere along the altitude line of 80 meters, though their mantle is widely spread over the plain. For instance, near the village of Nei Hun Ssu (3 li east of Chou Kou Tien) along a road deeply cut in the ground, a regular layer of red deposits 1 to 2 meters thick and lying upon a markedly developed gravel, may be observed. Over the red formation, the basal gravels of the loess, and the loess itself extend in a perfectly clear manner.

Observations on some superficial stalagmitic layers.

As shown in figure 7, a massive floor of concretioned calcite (more than two meters thick) overlies the gravel pocket "locality *a*," on the top of the hill, behind the locality 1. A similar hard deposit, still better crystallized, has been found by Mr. Pei, capping also one of the summits of the hill, behind the locality 2, just on the same level as "locality *a*". (v. fig. 10, f.)*

* This calcitic crust extends over a probably large pocket filled with a clayish product of dissolution of the limestone.

These horizontal concretionary layers represent most probably the stalagmitic floors of some entirely destroyed caves. But, on the other hand, they are much thicker than any stalagmite met in the filled parts of the Chou Kou Tien brecciated fissures.

For explaining these features, we will admit provisionally, that such levels correspond to the *uppermost level of filling* of the fossiliferous clefts.

Because the detrital sedimentation ended at this level in the caves, we may suppose, the stalagmitic floor was permitted to grow much thicker than before. And because the caves above were left empty, this unconsolidated part was easily destroyed by the subsequent erosional work which probably just before the deposition of the Loess (vide infra) imparted to the Chou Kou Tien hills their present shape. But this is, of course, an hypothesis.

IV. TENTATIVE HISTORICAL SKETCH OF THE CHOU KOU TIEN FORMATIONS

If we try now to reconstruct the historical series of events which gave to the Chou Kou Tien deposits their present distribution and features, it seems that we can admit the following scheme.

1. *The Upper gravels phase* (Chou Kou Tien phase A).

During this first phase the main river, running more or less along the present valley, was flowing at the 35-40 meters level at which the chief gravels of the locality *b* are actually exposed. Then, probably the surrounding mountains were still partially covered by red earth due to the weathering of the rocks during some preceding "X" stage (vide infra). At this time the fissures of the limestone on the level (or in the vicinity of the level) of the river, were filled by sands and gravels (e.g. localities *a*, *b*, *c*, and *d*), the latter occasionally covering remnants of the red clay deposited during the "X" stage, as for instance, in locality *b*. (vide supra fig. 8, d.).

2) *The intermediate period of dissection.*

Then came a time of new (or further) dissection of the land during which the river cut its bed down to the level of the Lower gravels (8 meter level). The cutting was made in the open. But at the same time and by the same process, a new system of internal fissures was formed (or rejuvenated) within the hills, descending as low as the new level of the river. Such was the origin of the various clefts or caves in which now are found the brecciated clayish or sandy fossiliferous deposits, which comprise what we term the typical Chou Kou Tien formation. In this way also may be

explained the fact that these brecciated clefts (Localities 1, 2, 3, 4, etc.) are so sharply distinct from, generally deeper than, and sometimes cut through the gravel-bearing fissures.

3) *The Lower gravels phase* (Chou Kou Tien phase B)

We may suppose that the deposition of the brecciated and fossiliferous material itself took place during the same long period of aggradation in which the red material still remaining upon the mountains became washed down, to form along the lower slopes (above the level of the Lower gravels) and on the adjacent plain, the conspicuous mantle of red clay and loose breccias above described.

Under such conditions the new and open clefts would constitute real caves or shelters, possibly inhabited by animals (Carnivora, Rodents, etc.), and become lined, periodically, with stalagmitic floors. Occasionally, local streams or brief floods may have brought within them coarser and larger material (e.g. large mammalian bones); but as proved by the Rodent levels in layer 4 of locality 1, the fissures must have been more or less dry between such floods.*

Thus, gradually, by a combined outer and inner process, the whole area of the limestone, at least up to the 80 meters level, became buried under, and partially penetrated by a mass of red material, the greater part of which being redeposited,** but some part at least being newly formed in the fissures. As supposed above, the thick stalagmitic floors actually met, on the 60 meters level, behind localities 1 and 2, may indicate the highest point reached by the filling of the caves in this particular area.

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*It has been noted above that the true floor of the deposit in locality 1 has not yet been reached by our excavations. When this level has been reached, if a pebble layer corresponding to the "Lower-gravels" level is encountered, its presence would lend strong support to the foregoing hypothesis of a slow filling of the deposit under semi-arid conditions.

On the contrary, should gravels be found in the course of further excavations either capping the whole of the deposit or at least flooring the "Middle sandy zone" (layer 4), then of course the filling (at least of the layers 4 to 10 of locality 1) would prove to be anterior to the deposition of the "Upper-gravels", the estimated age of the deposits would have to be greatly increased and the deposition of the mammal bones by intermittent flood action become more probable. However, as we have noted, no trace of such gravels has so far been recorded.

**This redeposition would explain the fact that no calcareous concretions are found in the surface red clays belonging to the Chou Kou Tien formation. Such concretions are characteristic of all primary red or reddish clays everywhere in North China.

So ended the Chou Kou Tien period proper.

4) *The Loessic period.*

Next come the Loessic period, first of erosion, and then of deposition.

During the first, erosional, phase, a large amount of the superficial red material, accumulated during the Chou Kou Tien period, was surely washed away;—and even the rocky hills were strongly worn and reduced, those parts of the fissured limestone being destroyed which were not internally consolidated by breccia.

Of the subsequent phase of sedimentation, very few traces are actually preserved at Chou Kou Tien itself. Of course, as we have already noted, the Loessic deposits (gravels and loess) distinctly overlie the red Chou Kou Tien deposits on the border of the plain, near the village of Nie Hun Ssu. But, upon the hills no traces of loessic formation are found, with the exception of a thin mantle of redeposited loess. The loessic deposits have most probably been removed from the steep slopes by the post-loessic erosion. In any case, up to now no cleft in the Chou Kou Tien formation seems to have yielded any Middle Pleistocene (Loessic) fossil.

5) *The problems of correlation.*

The three following problems have now to be solved:

a) to which of the physiographic stages presently recognized in China has the Chou Kou Tien *phase B* to be ascribed?

b) has the Chou Kou Tien *phase A* to be considered as a special stage?

c) what is the "X" stage during which the red material, rewashed during the Chou Kou Tien period, was formed over the mountainous land?

To the first question a palæontological study of the fossils collected in the Chou Kou Tien caves and listed below, demonstrates that the Chou Kou Tien beds are distinctly connected with the Sanmenian period and belong surely to the Lower Pleistocene, though on the other hand, they are distinctly younger than the Nihowan Sanmenian beds along the Sangkanho (v. 13). Therefore we shall possibly be obliged some day to establish for the Chou Kou Tien deposits a new and distinct stage (or sub-stage) between the Loessic and the Sanmenian cycles. However, such a new division, before being introduced, would require a further study of the Hopei plains border, along which the Chou Kou Tien formation seems to be widely extended. So far, unfortunately, no traces of the formation either palæontological or stratigraphical have been clearly recorded from the western plateau (Shansi or Shensi). (v. Appendix p. 199)

In absence of any fossils found in the Upper gravels or sands of Chou Kou Tien the second question can not be answered before a study of the basins or valleys surrounding the Chou Kou Tien valley has been made. If the Chou Kou Tien Upper gravels prove to be a constant and general level along the plain, then we should have perhaps to refer them to a distinct pre-Chou Kou Tien stage. But for the present* we prefer to consider them as marking only a transitional phase in the history of the Chou Kou Tien deposits. They represent we think, a mere trace of the dissection preparatory to the Chou Kou Tien deposits formation, these traces being accidentally preserved in the fissures or asperities of the limestone.

Now, if it was necessary to designate at what period the long weathering of the rocks by which was produced the chief bulk of the red material found rewashed in the Chou Kou Tien deposits, we could perhaps choose the Pontian. But here also, further stratigraphic observations are necessary, since so far no connection has been traced between the Chou Kou Tien deposits and any older Cenozoic formation.

In any case—and this is the chief conclusion warranted by the palæontological study of the Chou Kou Tien finds—it seems well established geologically that the bone deposits of Chou Kou Tien are the cave facies of a very important pre-loessic Lower Pleistocene formation.

V. THE FOSSIL FAUNA OF CHOU KOU TIEN.

Since the publication of Dr. Zdansky's monograph on the Mammals of Chou Kou Tien (25) the collected fossil material has been considerably increased. Some new forms have been discovered and many others known before (*Euryceros, Rhinoceros, Equus, Bubalus*, etc.) are now represented by much better specimens than in 1923. An important supplementary description of the mammalian fauna of Chou Kou Tien is therefore in preparation but will not be ready for publication for some time yet. In the present paper, it is only possible to present a provisional list of the mammals now identified together with some brief remarks concerning the characters and the presumable geological age of the fauna.

(1) *Provisional List of Mammalian Fauna from the Chou Kou Tien Deposits***.

*So much the more since no special sedimentary series seems to overlie these Upper-gravels.

**The systematic classification adopted in this list is after Zittel's Grundzüge der Palläontologie. 1923. (+) indicates the more abundant, (++) most abundant forms. Beside the mammals, other vertebrata are found in Chou Kou Tien, but these have not yet been studied. Remains of Frogs, Snakes, Turtles were collected in Loc. 1, 3 and perhaps 3 and 4. Small bird bones are abundant everywhere, mixed with the microfauna.

ORDER: INSECTIVORA

Family Talpidae

Scaptochirus primitivus Zdansky	Loc. 1 (? 3)
? Talpide sp.	Loc. 1

Family Soricidae

Neomys sinensis Zdansky	Loc. 1
Neomys sp. Zdansky	Loc. 1
Crocidura sp. Zdansky	Loc. 1

Family Erinaceidae

Erinaceus sp.	Loc. 1 and 2

ORDER: CHIROPTERA

Family Vespertilionidae

Myotis sp.	
? Vespertilionide gen. et. sp. indet. Zdansky	Loc. 1
Chiroptere incertae sedis Zdansky	Loc. 1

ORDER: CARNIVORA (Fissipedia)

Family Canidae

? *Canis cf dingo* Blumenb.	Loc. 1 (? 3)
Canis sp.	? Loc. 6
Vulpes sp.	Loc. 1, 3, 6

Family Ursidae

Ursus arctos L. (+)	Loc. 1
Ursus angustidens Zdansky (+)	Loc. 1

Family Mustelidae

Mustelide gen. et. sp. indet. (1927 & 1928)	Loc. 1, 2.
Meles sp.	Loc. 1. 2, 3, 6.

Family Hyaenidae

Hyaena sinensis, Owen (++)	Loc. 1

Family Felidae

Sub-family Felinae

Machairodus sp. Zdansky	Loc. 1

Sub-family Felinae

Felis acutidens sp. Zdansky	Loc. 1

Felis sp. (Panther size, Bohlin)	Loc. 1
Felis sp. (Lynx size, Bohlin)	Loc. 1
Felis sp. (Catus ?, Bohlin)	Loc. 1 and 3

ORDER: RODENTIA

Sub-Order Simplicidentata

Family Sciuroidea

Sciuroides indet.	Loc. 1 and 2
Arctomys sp.	Loc. 1
Tamias Wimani Young	Loc. 1 and 2

Family Castoridea

Trogontherium cf, Cuvieri, Zdansky	Loc. 1
Castoroidea gen. sp. indet.	Loc. 1 and a

Family Myoides

Sub-family Cricetine

Cricetulus songarus Pallas. Young 1927	Loc. 1 and ? 2
Cricetinus varians, Zdansky (++)	Loc. 1
Cricetulus sp., Young (1927)	Loc. 2
Cricetulus sp., Zdansky (1928	Loc. 1

Sub-family Microtinae

Microtus? Brandti, Radde (++)	Loc. 1

Sub-family Murinae

Apodemus sylvaticus Pallas (Zdansky 1928) Mus sp. Young, 1927)	Loc. 1 and 2
Micromys sp.	Loc. 1
Murine? indet.	Loc. 1

Sub-family Gerbillinae

? *Gerbillus meridianus*, Pall.	Loc. 1
? *Gerbillus sp.*	Loc. 6

Sub-family Myoteloidinae

Siphneus sp. 1927	Loc. 3

Family Hystricoidea

Hystrix sp.	Loc. 3, Loc. 6

Sub-Order Duplicidentata

Family Leporidae

Lepus cf. oiostolus Hodgson (++)	Loc.	6
Lepus Wongi, Young	Loc.	2 ?
Lepus sp.	Loc.	1, 2, 3, 4, and 5

Family Ochotonidae

Ochotona sp. (Lagomys)	Loc.	1, 2
Ochotona sp. (small form)	Loc.	1

ORDER: UNGULATA

Sub-Order Perissodactyla

Family Rhinocerotidæ

Rhinoceros sp. (Zdansky) (+)	Loc.	1
Rhinoceros sp. (Zdansky)	Loc.	1

Family Equidae

Equus sp. (Zdansky)	Loc.	1

Sub-Order Artiodactyla Loc. 1

Family Suidae

Sus Lydekkeri, Zdansky (+)	Loc.	1 (? 3)

Family Cervicornia

Sub-family Moschinae

Moschus sp. (Bohlin)	Loc.	3

Sub-family Cervinae

Pseudaxis Grayi var., Zdansky (++)	Loc.	1 (2,3,4)
Euryceros sp. (*Cervus Canadensis* Mongoliae Zdansky, 1928)	Loc.	1
?*Capreolus sp.*	Loc.	1

Family Cavicornia

Sub-family Aegodontia

Group: Gazellinae

Spirocerus sp.	Loc.	1

Group: Ovicaprinae

Ovis cf. ammon (perhaps two species)	Loc.	1

Sub-family Bovodontia
Group: Bovinae
Bubalus sp. (*Bibos geron* Matsumoto, Zdansky. 1928) Loc. 1
Bison sp. Loc. 1

ORDER: PROBOSCIDEA
Family Elephantidae
Elephas sp Loc. 1

ORDER PRIMATES
Family Cercopithecidae
Sub-family Cercopithecinae
Macacus anderssoni (det. Black) Loc. 1,2,3.
Family Hominidae
Sinanthropus pekinensis (Black & Zdansky) Loc. 1

(2) *Chief Characters and Geological Age of the Chou Kou Tien Fauna*

In its general characters (e.g. absence of any truly archaic form, presence of *Equus*, modern characters of the Deers etc.) the Chou Kou Tien fauna is evidently of Pleistocene age. If however we try to compare it more closely to the other known Pleistocene or Uppermost Pliocene faunae of North China, two points seem actually to be clear:

a) First, the Chou Kou Tien fauna is undoubtedly older than, and almost entirely distinct from the Loessic fauna. The most characteristic forms of the Loess (*Rhinoceros tichorhinus*, *Bos primigenius*, *Hyæna crocuta*, *Cervus elaphus*, etc.) are lacking and are replaced by distinctly different forms. As already clear by their stratigraphy, the Chou Kou Tien deposits are palæontologically older than the Middle Pleistocene.

b) Second, many of the Chou Kou Tien forms are identical with those occurring among the Sanmenian basal Pleistocene fauna of the Sangkanho basin in the Nihowan beds (13), e.g. *Hyæna sinensis*, *Rhinoceros cf. sinensis*, *Equus sp.*, *Siphneus tingi* (the latter not yet reported from Chou Kou Tien, but found in the contemporaneous clefts of Tangshan). On the other hand, the most archaic forms of Nihowan (e.g. the big *Hipparion* and *Chalicotherium*) are not found in Chou Kou Tien. Further in Nihowan there commonly occurs a very distinctive flattened-antlered Deer (cf. *Cervus tetraceros* Boyd Dawkins) in place of *Euryceros*; and the round-antlered Deer

(cf. Rusa) do not seem to have reached the *Pseudaxis* (*Sika*) stage (four tines in the antlers) recovered in Chou Kou Tien. Also the small primitive *Bison* of Nihowan is not found in Chou Kou Tien.

If these faunistic differences exceed, as it seems, the range of variation which could be attributed to the different ecological conditions obtaining after the Pliocene in Nihowan and in Chou Kou Tien, we must conclude that the Chou Kou Tien fossils represent a fauna connected with, but clearly younger than the Nihowan Sanmenian fauna. The Nihowan fauna is still intermediate in certain respects between that of Tertiary and Quaternary times. The Chou Kou Tien fauna, however, is probably the true North China Lower Pleistocene fauna.

APPENDIX: SUMMARY OF THE UPPER CENOZOIC FORMATIONS IN NORTHERN CHINA.

In order to make clearer to the reader the presumable place of the Chou Kou Tien deposits in the Cenozoic series, we have reported, in the preceding table, the chief stratigraphical and palæontological data concerning the Pliocene and Pleistocene formations of Northern China and Eastern Mongolia. See Table I.

The most important fact emphasized by this provisional table is the division of the actually known mammalian fauna into three well separated blocks, corresponding respectively. to the Loess; to the Lower Pleistocene and the Uppermost Pliocene taken as a whole*; to the Lower Pliocene;—nothing being distinctly known about the Middle Pliocene.

As just pointed out above, the Chou Kou Tien fauna appears clearly as a subdivision of the middle block. The evidence is interesting, first because of the fact that the Chou Kou Tien deposits prove to be the more closely connected with the late Pliocene than with the Loess; and, secondly, because we can hope to discover, in the lower subdivisions of the same faunistical block (namely in the high fossiliferous beds of Nihowan), some immediate ancestor to the *Sinanthroupus*.

It might be noted that, while the Lower Pliocene faunistical block shows *western*, and the Loessic block *northern* affinities, the middle (Nihowan Chou Kou Tien) block is marked by some distinct *southern* influences.

* This middle block would correspond roughly to the Polycene of Dr. Grabau. (v. A Summary of the Cenozoic and Psychozoic deposits with special reference to Asia. Bull. Geol. Soc. China, Vol. VI Nos. 2-3, 1927 pp. 151-264.)

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Explanation of

Plate I

PLATE I.

Figure 1. Chou Kou Tien Localities 1 and 2 from the north.

Figure 2. Chou Kou Tien Localities 1, 2, 3 and 4 from the east.

Figure 3. Panorama of Chou Kou Tien Localities from the east.