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ESSAYS ON THE CENOZOIC OF NORTHERN CHINA

BY

J. G. ANDERSSON.

PEKING
MINISTRY OF AGRICULTURE AND COMMERCE
THE GEOLOGICAL SURVEY OF CHINA
V. K. TING AND W. H. WONG, DIRECTORS

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THE GEOLOGICAL SURVEY OF CHINA

V. K. TING AND W. H. WONG, DIRECTORS.

MEMOIRS. SERIES A. NUMBER 3.

ESSAYS ON THE GENOZOIC OF NORTHERN CHINA

BY

J. G. ANDERSSON Dr. Phil.

LATE DIRECTOR OF THE GEOLOGICAL SURVEY OF SWEDEN,
MINING ADVISER TO THE CHINESE GOVERNMENT AND
CURATOR OF THE MUSEUM OF THE GEOLOGICAL SURVEY
OF CHINA.

With 3 Maps, 9 heliotype Plates and 42 text-figures.

PEKING
1923.

CONTENTS.

Text.

Maps.

Heliotype plates.

INTRODUCTION.

In 1914 the writer of this paper accepted a position in Peking as Mining Adviser to the Chinese Government. During the first years my work was purely technical, devoted to the examination of coal, iron ore, and other mineral deposits. At that time I had no expectation of taking up purely scientific research in this country.

In the early part of 1916 I spent some weeks examining the copper deposits in S. Shansi. After having accomplished this task, I intended to return through Honan by the Lung-Hai railway. When crossing the Yellow River at Yuan-Chü-Hsien on the Shansi-Honan border, I noticed in the N. bank of the river, below the loess, a series of multi-colored clays and marls containing very numerous fresh-water mollusks. A small collection was hurriedly made, and this material, proving the existence of richly fossiliferous Cenozoic deposits underneath the loess, aroused my interest in the study of the sections along the Yellow River and in other parts of N. China where suitable exposures might be found.

A campaign was started for the purpose of finding mammal remains in the Cenozoic deposits, with the special aim of locating and identifying the deposits which had yielded the rich fossil faunas described by Schlosser.

A circular printed in English was sent to missionaries and other foreign residents all over China, and a shorter circular in Chinese was distributed in several thousands of copies by special agents.

A considerable number of missionaries responded willingly to our appeal and rendered very valuable assistance in locating deposits of fossil mammals. Amongst these volunteer co-workers, I want to mention Père Fl. De Preter, of the Belgian Mission, Sunshutsweize, Eastern Mongolia, and the Rev. A. Bertram Lewis of the China Inland Mission, Hotsin, South Shansi. These two gentlemen have been awarded special honours by the Ministry of Agriculture and Commerce for the assistance thus granted to our palaeontological researches.

A number of Swedish Missionaries have rendered me most valuable personal assistance. Amongst them I want to mention Rev. R. Andersson, Honanfu, E.O.S. Beinhoff and M. Ringberg, Mienchih, Maria Pettersson, Hsinanhsien, all in Honan, A. Berg, Yüncheng, Shansi, and J. Eriksson, Hallong Osso, Mongolia. Amongst these collaborators I desire to mention in this place

specially Miss Maria Pettersson, whose energetic assistance in the late fall of 1918, lead to a series of discoveries which proved that fossil mammal hunting in China offers rich prospects of reward.

Parallel with these inquiries through missionary channels, we made extensive inquiries in Chinese druggist shops for the purpose of discovering the whereabouts of the localities from which the supply of medicine bones was derived. This line of investigation proved by no means easy to follow, as in most cases the bones had passed through so many hands that their origin had been lost sight of. However, some valuable information was gathered, especially in the big medicine market places from which the retail druggists draw their supply.

The work of collecting in the localities thus discovered was carried on with the aid of private funds which were supplied from my native country, Sweden. The work was prosecuted in close touch with the Geological Survey of China and with the ready and effective support of the Director Dr. V.K. Ting and the Vice-director Dr. W.H. Wong, with the stipulations that the material thus brought together is to be divided between Swedish museums and the Geological Survey of China, and that the descriptions of all the fossil material are to be published in the Palæontologia Sinica, issued by the Geological Survey.§

In the beginning of 1919 I opened negotiations with my old friend and colleague, Professor C. Wiman of the University of Uppsala for the purpose of obtaining his co-operation in the scientific preparation and description of the rapidly growing fossil mammal material. With the assistance of some of his young associates Dr. Wiman began the work of preparing a series of monographs on the fossil vertebrates collected by us, and I am glad to take this opportunity to record my appreciation of the enthusiasm and untiring energy with which he has carried on this tremendous undertaking.

In 1920 The Swedish Parliament voted the sum of 90,000 crowns as a State contribution to the fossil collecting campaign in China, which had up to that time been carried on exclusively by means of private funds brought together by my friend Mr. A. Lagrelius, Head Intendant of the Swedish Court. Through the good offices of this gentleman a research committee has been formed in Sweden for the support of my scientific work, and the first chairman of this committee

§. It gives me a special pleasure to acknowledge at this occasion my deep indebtedness to Their Excellencies The Ministers of Agriculture and Commerce, to Mr. T. L. Lin, The Director of the Department of Mines and to Dr. Ting and Dr. Wong, the Directors of the Geological Survey, for the unfailing and exceedingly pleasant support which has always been given to my scientific work.

was the senior of the Swedish geographic explorers, Admiral Louis Palander of Vega, whose name is so intimately connected with that of A.E. Nordenskiöld, in their famous exploit, the circumnavigation of Europe and Asia in 1879-1880 on board the "Vega".

After the death of Admiral Palander in 1921, His Royal Highness The Crownprince of Sweden, himself a profound scholar and enthusiastic student of the history of Chinese art, graciously consented to act as chairman of my Swedish Research Committee, and it is under these favorable auspices, that the work has since been carried on.

Recently there have been two important developments in fossil vertebrate research in China.

One is the arrival of Dr. Walter Granger, of the American Museum of Natural History, as chief palaeontologist of The Third Asiatic Expedition under the leadership of Dr. Roy Chapman Andrews. This great scientific enterprise aims at the exploration during a number of years of a large part of Eastern Asia, with special reference to the ancestry of Man. In most courteous and pleasant manner Dr. Andrews has acceded to the desire expressed by Dr. Ting and myself that a regional division of the field of research be made in order that duplication of work may be avoided and the most useful co-operation assured. During the weeks which Dr. Granger spent in Peking in the summer of 1921 before starting out on his first field expedition, we had much pleasant and instructive intercourse with him, drawing freely upon his immense store of experience, especially that concerning the technique of fossil mammal collecting and field preparation. In return for these courtesies we were happy to be able to place our accumulated experience concerning local conditions fully at the disposal of the American Expedition.

My own collecting work has grown to such an extent during the last few years that it became impossible to carry it on in a satisfactory manner together with my service duties, as I only had the aid of Chinese assistants. Under these circumstances I asked Dr. Wiman to find for me a young palaeontologist willing to co-operate with me during a number of years in the excavation of vertebrate deposits. His choice fell upon Dr. Otto Zdansky, a pupil of Professor Abel in Vienna. Dr. Zdansky's arrival in Peking coincided with that of Dr. Granger.

The arrival in Peking of these two distinguished scientists, both bent upon an extensive campaign of fossil vertebrate collecting, has made it desirable to put together in comprehensive shape, my present knowledge of the Tertiary and

Pleistocene deposits of N. China. A further reason for the writing of the present paper is my desire to leave behind a clean table when I start upon the lengthy journey to W. China which I plan to undertake in the near future.

The present paper is only a summary of the field notes of a geologist, who has, by force of circumstances, been brought to undertake an extensive campaign of fossil vertebrate collecting. I an fully prepared to shoulder the responsibility for deficiencies in the geological field observations, still I feel convinced that the palaeontologists, who read this paper in order to gain information about the youngest fossiliferous deposits of China, will look with leniency upon the preliminary and in some cases probably erroneous fossil determinations which were often hastily noted down in the fossil quarry. I have felt that some kind of indication respecting the nature of the fossils is better than nothing, while waiting for the definite identifications by Dr. Wiman and his associates.

Our knowledge of the Cenozoic history of China is still much too imperfect to allow a full and uniform treatment of the topic. For this reason I have given this paper the form of a series of independent essays on different groups of Cenozoic deposits and fossils. In the closing chapter an attempt is made to sum up what we know at present about the Tertiary and Pleistocene history of China.

The reader is advised to consult my paper on the physiography of Northern China, which will appear as Memoir No. 4. Series A of the Geological Survey.

That physiographic paper deals primarily with a certain very limited area. But in addition to the detailed description of the Chai T'ang valley in Hsi Shan, W of Peking, numerous observations from different parts of China have been brought together and, as far as possible, have been synchronized with the more exact stages established in Chai T'ang.

SOME NOTES ON THE NANKING "VOLCANOES".

In the third volume of "China", Richthofen gives on pp. 733-734, a brief description of what he has named "The Nanking Volcanoes", a number of low hills on the north side of the Yangtze river, N.E. from Nanking.

This description, which refers principally to the hill known as Fang-Shan, can be summarized as follows:

(1) The hills in question, Fang-Shan (方 山), Ling-Yen-Shan (靈岩山), Shuang-Nü-Shan (雙女山), Ta-T'ung-Shan (大銅山), Hsiao-T'ung-Shan (小銅山) etc., are volcanic cones (Vulcan-Kegel) built up of doleritic lavas and lapilli-beds.

(2) The bases of each of these volcanic cones is veiled in a mantle of horizontally bedded gravel with pebbles of quartz and quartzitic rocks.

(3) The gravel-beds never contain fragments of the volcanic rocks and no quartz-pebbles were found in the lapilli-beds.

(4) As the gravels are horizontally bedded and the volcanic masses were actually seen projecting out of the gravel-beds, the volcanoes must be older than the gravels and the latter deposited round the bases of the volcanic cones.

Another large area of young basic lavas in the southern border-lands of Mongolia§ was described by Pumpelly and Richthofen. Concerning the basement of this Mongolian basalt Richthofen held the very phantastic view that the basalt locally rests upon the loess, an idea which in this case evidently was derived from mere general considerations§§ rather than from actual observations.

In August 1919 when returning from a summer-trip in Mongolia, I had occasion, at Han-Jo-Pa (漢諾霸) 40 li N. from Kalgan, to make some observations bearing on the interpretation of the basalt lavas. Not only could I prove that the loess(which is certainly post-Pliocene)overlies the basalt, but also found an intercalation of soft, clayey shale with plants (of early Tertiary age§§§) between the basalt flows, and noticed that in that region the basalt rests upon a remarkable series of gravel beds with pebbles derived from the trachyte-porphyries of Kalgan§§§§.

§. R. Pumpelly. Geol. Researches in China, Mongolia and Japan. Smithsonian Contr. 202. 1866.

§§. Richthofen. China. II p. 389-390, footnote.

§§§. R. Florin. Einige chinesische Tertiärpflanzen. Svensk Botanisk Tidskrift. 1920, Bd. 14, H. 2-3. p. 239-243.

§§§§. In 1920 I continued my observations in the Kalgan region and found in the gravels underlying the basalt some few and poorly preserved plant-fossils, apparently of Jurassic age.

When preparing for some weeks fieldwork in the lower Yangtze around Nanking at New Year's time 1920, I read Richthofen's description of the Nanking volcanoes. It seemed to me that he might be mistaken in his interpretation of the gravels, these being not post-basaltic as supposed by Richthofen, but rather older than the lavas, as in the case N. of Kalgan.

During my stay near Nanking I and my assistant Mr. C. Tung devoted the 2–4 January, 1920 to a brief visit to the Nanking volcanoes. The outcome was that nearly every statement given by Richthofen proved to be so fundamentally incorrect, that only the rapidity and limited extent of his visit can explain the astouding inaccuracy of the observations made by that famous explorer.

The conclusions reached by myself and Mr. Tung can be summed up as *follows:*

(1) The hills in question are (possibly with the single exception of Fang-Shan) not volcanoes, but (at least the majority of them) mesas, that is table-shaped remnants of an earlier, much wider extent of basaltic lava-flows.

(2) Only the upper part (1/4 - 1/2 of the height above the surrounding plain) of each hill consists of volcanic material. The lower (and mostly larger) part is built up of beds of gravel, the pebbles of which, as described by Richthofen, consist mostly of quartz and quartzitic rocks.

(3) These gravel beds are not always horizontally bedded as stated by Richthofen. On the contrary they show a dip of 30° or less, mostly to the E. The overlying volcanic tuffs and lavas dip in the same direction, but apparently the dip of the volcanic beds is less steep in certain places than that of the gravel.

(4) The quartz gravel often contains blocks of lava which probably must be interpreted as bombs thrown by the volcano into the still accumulating gravel.

(5) On the other hand, there exist transitional stages between quartz gravel and volcanic tuff, and quartz pebbles are met with in genuine tuffs and even in the coarse volcanic breccias.

(6) The volcanic sequence is, as a rule, closed by basaltic lava-flows which cover the gravel- and tuff-beds.

(7) The loess covers not only the top, but more often also the slopes, of the basalt-hills, which shows that the mountains were carved out by erosion practically to their present shape before the loess was deposited.

As our observations throw some new light, not only upon these so called "Volcanoes", but upon the youngest sedimentary series as well, it has been thought convenient to publish our field notes in spite of their incompleteness.

It is a pleasure to acknowledge the valuable co-operation of my assistant, Mr. C. Tung (董 常), who made such a satisfactory survey of Ling-Yen-Shan, by himself, that upon the occasion of our joint visit the following day, I was able to confirm all of his determinations.

It has long been known that basaltic lavas occur in considerable extent on the lower Yangtze near Nanking. On the south side of the river, their present extent is, however, relatively small. In Fou-Shan (浮 山), Li-Shui-Hsien (溧水縣) Dr. V.K. Ting§ has observed that the basalt lava forms a cap which rests unconformably upon the younger red sandstone (= Richthofen's Deck-Sandstein).

The same relations, i.e. basalt overlying the red sandstone, were noticed during our journey by Mr. Tung in Ch'ih-Shan (赤 山) in Chü-Jung-Hsien (句容縣).

In Chiang-Ning-Hsien there is a very conspicuous mesa-shaped hill known as Fang-Shan (方 山) and lying 30 li S. of Nanking (not to be confounded with the Fang-Shan in Liu-Ho-Hsien on the N. side of the Yangtze). It has been studied by Mr. Tung, who reports that the upper part of this table-mountain consists of basalt, the basement of which cannot be seen as the slopes are covered by loess.§§

V.K. Ting also mentions (l. c. p. 34) that a range consisting of the hills Fang-Shan (方 山), Yachishan (丫髻山) and Wa-Wu-Shan (瓦屋山) seems to be covered by the basalt.

On the north side of the Yang-tze-kiang the basalt is much more commonly distributed. In the one to one million geological map which accompanies V. K. Ting's paper "Geology of the Yangtze Valley" there are indicated extensive, but so far, little known, areas of basalt on the Kiangsu-Anhui border, on both sides of the Tientsin-Pukow railway.

The area examined by Mr. Tung and myself is approximately the same as that visited by Richthofen, with the difference that we travelled further N. to I-Shan (怡 山) at the very border of Anhui province. For the matter of convenience I give the itinerary of our trip, describing the different hills in the order of our visit to them (See the accompanying map fig. 1.).

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§. *V. K. Ting.* Geology of the Yangtze Valley below Wuhu. Whangpoo Conservancy Board S. H. I. Ser. I, No. I. Shanghai 1919. p. 30.

§§. Some additional and very important observations on this hill made in Dec. 1921 by myself and Messrs C. C. Liu and J. C. Chao are mentioned in an appendix to this chapter.

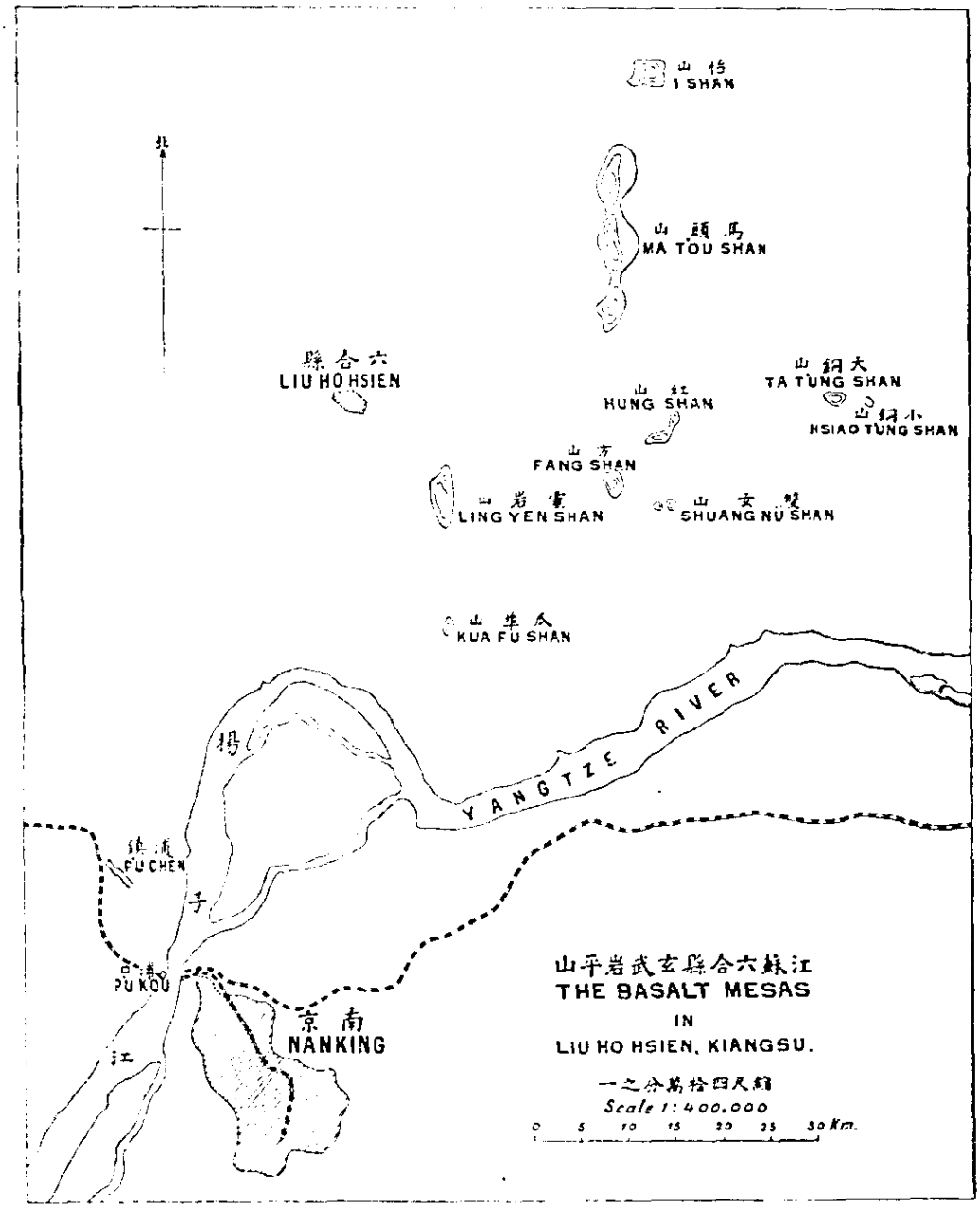

Fig. 1. The Basalt Mesas in Liu Ho Hsien, Kiangsu.

第一圖 江蘇六合縣玄武平岩山

We crossed the Yangtze river from Nanking (Hsia Kuan) to Pukow and began our observations at Pu-Chen. At this place we noticed most of the rocks described by Richthofen (China III, pp. 732-733). The "Deck-Sandstein" covered

by loess is beautifully exposed in two big outcrops, one on each side of the railway. It is a red, soft, thin-bedded sandstone with characteristic spots of reddish brown clayey material (clay galls).

Along the railway we found an outcrop of volcanic rock and close to this place a cut showing the following series of beds:

(a). A breccia-like conglomerate with limestone-pebbles,

(b). gravel with pebbles of limestone and quartz,

(c). a soft white sandstone, all in steep dipping beds.

Our route carried us NE-ward to Liu-Ho-Hsien and from there northwards to I-Shan, a limestone-hill on the Kiangsu-Anhui border where a small iron-deposit had been reported. I-Shan consists of limestone with chert-layers and of numerous quartzite beds interbedded with the limestone. A small conspicuous hill S. of I-Shan is built up exclusively of quartzite.

The strike of the I-Shan limestone was in one place stated to be W 30° S - E 30° N with very steep dip. In another part of the mountain the limestone dips S 30° E 57°.

On approaching I-Shan from the south we saw to the west of this mountain, a low but extensive *mesa*-mountain, which, to judge from the typical shape, is certainly capped by basalt. We never had an opportunity to visit this mesa-hill, but our suggestion as to its basaltic nature was strengthened by the fact that we found basalt in a small hill of rounded conical contour near the SW. side of I-Shan, There are at least two such conical hills on this side of I-Shan, both probably consisting of young volcanic rocks, as we found basalt in one hill and noticed a strongly weathered igneous rock at the base of the other. The same kind of decomposed rock was also met with in an outcrop in a valley between the two southern ridges of the three which together form I-Shan.

E. of I-Shan we saw an isolated hill which, to judge from its *mesa*-shape, is probably capped by a lava-bed.

We had not time enough to undertake a proper survey of the surroundings of I-Shan, but, as shown above, our cursory observations seem to indicate that this mountain forms an isolated remnant of old, strongly dislocated rocks, and that erosion had already given the mountain approximately its present shape before it, or at any rate its lower part, was buried by the young lavas.

From I-Shan we could see, in the south, Richthofen's "volcanoes", Fang-Shan, Ling-Yen-Shan, Hung-Shan etc., rising above the alluvial plain as characteristic silhouettes.

In order to get the long desired opportunity of studying these hills we decided to spend the next night at a small place between Fangshan and Ling-Yen-Shan.

On our way to this place we passed close to a somewhat irregularly mesa-shaped hill, Ma-T'ou-Shan (馬頭山) and here we were able to make some observations which at once overthrew Richthofen's interpretation.

At the SW. corner of the hill we obtained the section shown in fig. 2.

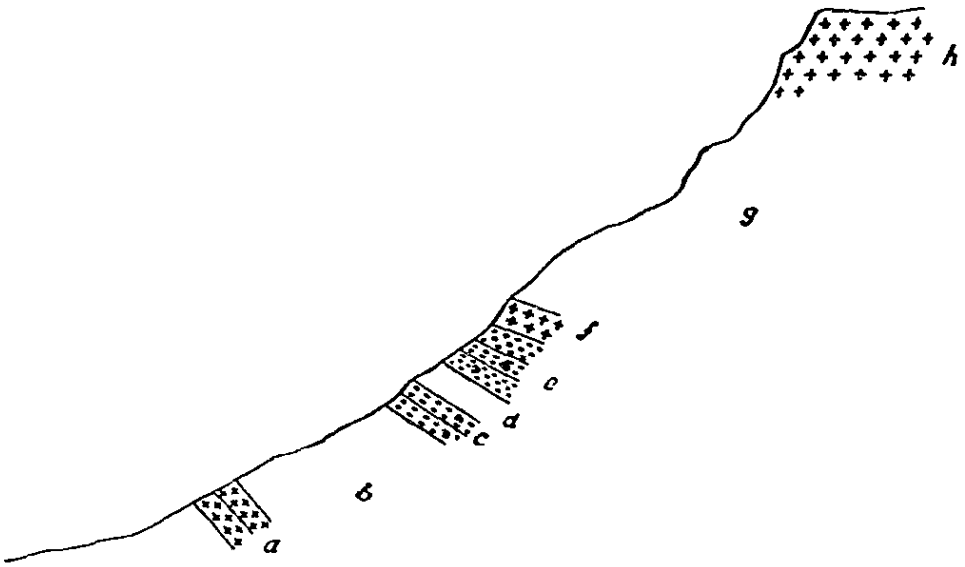

Fig. 2. Section at the SW. corner of Ma Tou Shan.

第二圖 馬頭山西南隅剖面

(a). Bedded basalt§ dipping in easterly direction.

(b). Covered by talus.

(c). Reddish (light pink-colored) gravel with lava-blocks. Dip 30° in easterly direction.

(d). Covered.

(e). Grey gravel with lava-blocks. Dip E 20° N 20°.

(f). Basalt-bed with concentric sphaeroidal structure.

(g). Covered.

(h). Basalt forming the cap of the hill.

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§. The lavas observed in these hills represent a number of nearly related types which for the present purpose are sufficiently defined by the collective denomination basalt.

The interest in this section centres round the almost continuous series c-f; a and h are so distant from this central part of the section, separated from them by waste-covered slopes, that there always is a possibility of dislocations and rock-slides, though there was nothing to indicate such.

But the part c to f of the section is quite sufficient to elucidate the main facts. First of all there is no doubt that c and e are Richthofen's quartz-gravels. The pebbles consist, as described by Richthofen, mostly of quartz and quartzitic rocks including also the most siliceous parts of the limestone with chert-layers. There are also, in smaller number, pebbles of crystalline rocks, of granitic or dioritic type, but they are so strongly decomposed that they mostly crumble into pieces when extricated from the matrix. I am under the impression that the decomposition of these crystalline rocks had largely taken place before the formation of the gravels, which seem to be the transported and sorted residuum from a deeply decomposed rock-ground where the siliceous parts had the best chance to survive.

A glance at the section will suffice to prove that the gravels are overlaid by, and consequently older than at least a part of the lavas. There is direct contact between the grey gravel and the overlying lava-bed f, so there can be no doubt on that point. Provided that there is no disturbance between a and c, there seems to be an older lava-bed (or possibly intrusive sill) underlying the gravel.

That these gravel-beds were deposited after the eruptions had begun, is shown, beyond doubt, by the occurrence of blocks of lava in both gravel-beds. These lava-blocks are in fact a feature of considerable significance. The gravels are as a rule rather fine-grained, partly tending to coarse sand. The pebbles are mostly quite small, of walnut-size or less and the maximum observed in this place is of the size of an average apple. The lava-blocks which occur sparcely scattered through the gravel, attain considerably larger size (at least 30 cm. in length).

Even if the lower specific gravity of the more or less porous lava-blocks is taken into consideration, it seems tempting to assume that these large-sized strangers in the quartz-gravels were not transported by running water, as was the case with the normal pebbles of the gravel, but are genuine *volcanic bombs* which were, during the eruptions, flung into the gravels under deposition.

A feature worth noticing is the eastward dip of the beds a, c, e and f. I obtained the impression that the dip is steepest in the oldest bed (a) and gradually diminishes towards the top. That even the big lava-bed, capping the hill might

have a slight dip to the east, was suggested by the fact that this south-western part of Ma-T'ou-Shan, when seen from the south exhibited an eastward sloping contour.

It is hardly necessary to point out that my observations were much too cursory and imperfect to prove beyond doubt this supposed gradual decrease of dip which would show that a continuous eastward tilting went on contemporaneously with, and probably genetically connected with the volcanic activities. It is worth noticing that, as described below something similar was noticed in Hung-shan§.

Some few tens of metres S. from the place in Ma-T'ou-Shan where the above observations were made, we found another interesting exposure which is given in fig. 3 in a schematic sketch drawn from memory.

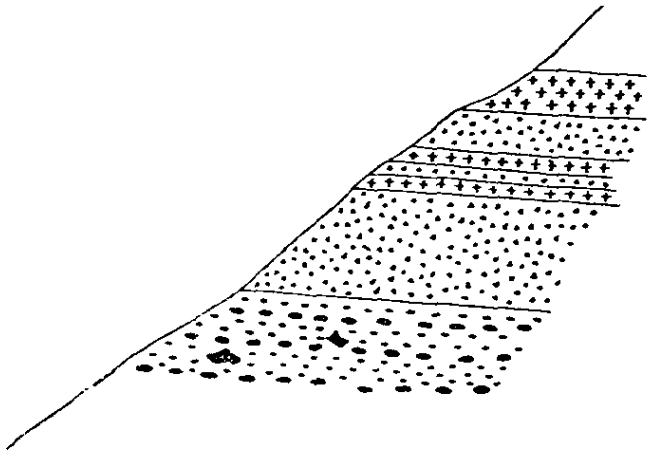


Fig. 3. Schematic section showing alternating tuff-beds and lava flows. Ma Tou Shan.

第三圖馬頭山剖面表示凝灰岩及岩熔質礫石及岩質互相間之層次

In the lower part of the outcrop we again encountered the quartz-pebble gravel with lapilli blocks. The gravel is overlaid by repeated beds of fine-grained, distinctly stratified volcanic tuff alternating with thin sheets of lava. The figure

§. It might be worth mentioning that also the basalt mesas Fang-Shan and Ch'ih Shan on the south side of the Yangtze show a slight tilting in SE. direction.

is not drawn to scale, but the size of the small section can be judged from the statements that the lowest lava-sheet is 6 cm., the middle one 10 cm. and the uppermost at least 30 cm. in thickness.

The eastward dip is in this place very slight, less than 5°.

After having visited Ma-T'ou-Shan on the 2nd of January and stated as described above Richthofen's fundamental misconception of the structure of these hills, Mr. Tung and I decided to spend the following day in examining Hungshan, Fangshan and Ling-Yen-Shan; I went east to Hungshan, Mr. Tung west to Ling-Yen-Shan, and we met in the afternoon in Fang-Shan to compare our observations and study the last named hill together.

Hungshan is, as shown by Pl. I, fig. 1, a typical table-mountain, though in a rather advanced stage of dissection as will be more fully described in the later part of this article.

I visited only the westernmost corner of the hill where I found a beautiful and most instructive exposure (fig. 4) which required some detailed study.

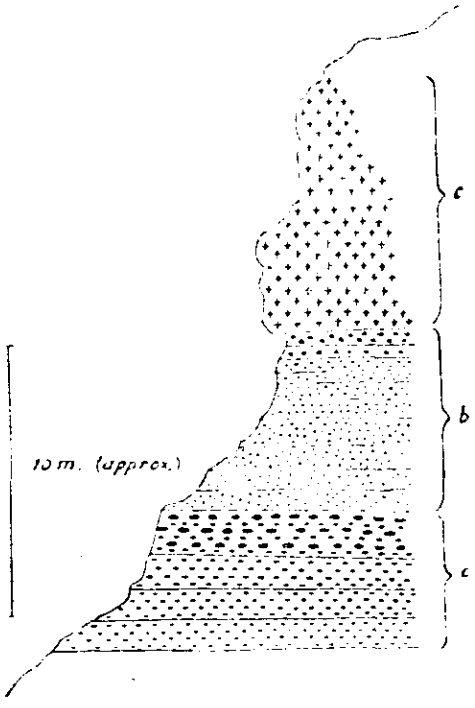


Fig. 4. Section in the W. corner of Hungshan

第四圖西紅山隅剖面

The section may be be described as follows:

a. Yellow, fine gravel or coarse sand with pebbles from walnut to apple-size. Mostly quartz-gravel but some pebbles, all strongly decomposed, consisting of granitic rocks.

The uppermost part of this series of gravels consists of coarser gravel with bigger pebbles.

b. Pink-coloured, mostly fine-grained, beautifully stratified, volcanic tuff with alternating beds of different coarseness. The coarsest material is in the uppermost bed, immediately underneath the lava-bed c.

In this tuff were noticed some small pebbles of quartz.

c. Basalt, the contact towards the underlying tuff shows botryoidal and ropy forms due to surface cooling of the flowing lava.

Lower down in this slope, below the section, is an outcrop of sand with distinct current-bedding. In this sand occur some large pebbles (up to 15 cm. in length).

This sand shows quite a distinct dip eastwards. The gravel in the section (a) also exhibits a dip of 10° E. In the uppermost part of the tuff I could still trace the eastward dip but here it was very slight, less than 5°. Though the observations are much too imperfect to allow any far-reaching conclusions, they apparently point in the same direction as the upward decrease of the eastward dip noticed in Ma-T'ou-Shan as described above.

I will now give some brief notes on Fangshan. Here the conditions are so varied and complicate that much more time would have been needed to fully elucidate the interesting architecture of this hill. The following gives my conception of the essential features.

Fangshan is the highest of these hills. Its general shape is shown by the photograph Pl. II, fig. I, taken from NE between Fangshan and Hungshan.

In contours it is very different from the others and gives, as mentioned by Richthofen, distinctly the impression of a small volcano with a crater open to the north. The larger part of the crater is not shown in the photograph, in fact it forms a shallow depression in which there is a house and some cultivated fields. But the picture shows that the northern wall of the conical hill is missing, having been carried away by erosion.

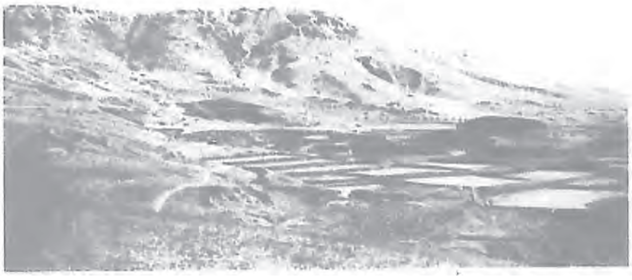


Fig. 1. Southwestern part of Hung Shan.
Only the uppermost part is basalt, all the rest gravel and sand.
紅山西南部 山頂爲玄武岩餘皆砂礫層

Fig. 2. Ling Yen Shan, seen from ENE.
靈岩山自東北望之景

In Fangshan, as in the other hills, the lower part consists of quartz-pebbles, and only the upper part is volcanic material. In fact, on the NE side of Fangshan I saw the most extensive exposure of these gravels, and, though the contact was not directly visible, there was hardly any doubt that an outcrop of volcanic breccia, overlies the gravels.

In another place, on the north side, the contact was clearly visible. The gravel and sand here showed no stratification, which fact may be attributed to volcanic disturbances, especially as a distinct fault was seen traversing not only the sand and gravel but also the overlying volcanic breccia. In this breccia or coarse tuff, large lava-bombs (more than I m. in length) were seen resting directly upon the gravel.

In the volcanic breccia some few rounded quartz-pebbles were noticed. The occurrence in this purely volcanic, chaotically accumulated rock, can hardly be attributed to running water. It seems much more probable that gravel was exposed in the volcanic vent and that some of this material was torn away during the eruptions and ejected together with the genuine lapilli material. This is another striking illustration of the close relationship between the gravel and the volcanic rocks.

Ling-Yen-Shan, an elongated hill, extending N.-S. Pl. I, fig. 2, was studied by Mr. Tung, as already stated, and at the time of our joint visit to this hill on the 4th of January I had practically only to confirm his observations. Mr. Tung's conception of the hill is shown in the section fig. 5. It will suffice for me to add the following detailed remarks.

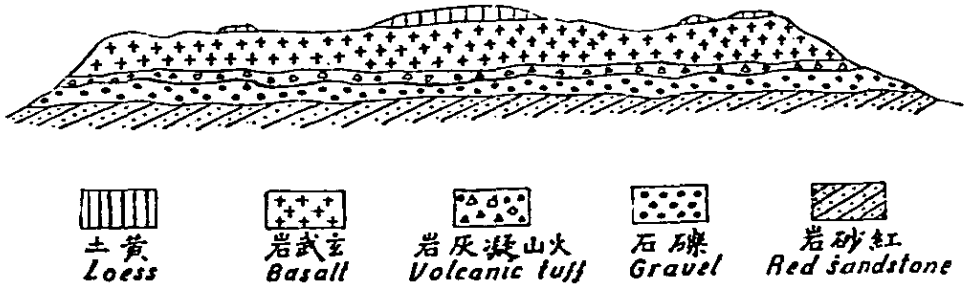


Fig. 5, General section of Ling Yen Shan (communicated by Mr. C. Tung)

第五圖 靈岩山大略剖面 (據董常君報告)

An interesting feature of this hill is the appearance of the red sandstone (Richthofen's Deck-Sandstein) as the substratum of the gravel and the superposed volcanic rocks. In one ravine where I had an opportunity to study it, it is very loose, nearly sandy in texture and intensely pink-coloured.

According to Mr. Tung the sandstone dips gently to the north and is unconformably overlain by gravel.

The gravel is mostly grey-coloured, but in one place where it was seen in direct contact with the overlying volcanic breccia, it had assumed a reddish tint.

Intercalations of sand occur but are subordinate. Part of the gravel is entirely unconsolidated, another part is hardened to conglomerate. Its pebbles are mostly of small size, those of 20 cm. length being rare. Large lava blocks up to 80 cm. in length were noticed in the gravel. They must be interpreted as bombs thrown into the gravel during its period of deposition.

In one place I noticed a bed of tuffaceous conglomerate dipping E 27°, but in this hill the gravel rests for the most part horizontally, according to my own observations, and the information received from Mr. Tung.

The volcanic beds overlying the gravel are partly developed as tuff, partly as volcanic breccia. In the former, quartz-pebbles derived from the gravel are frequent, and even in the coarse breccia I found a couple of small quartz-pebbles.

The basalt in one place on the west side of the mountain exhibits beautiful columnar structure with vertical columns about 10 m. high.

The soil on the top of the hill was named "loam" by Mr. Tung, but I am of the impression that it is only a local development of the loess. Its colour is more reddish-brown than is usually the case with the loess, and Mr. Tung reports that he has found small grains of olivine in this soil, five feet below its surface. This interesting observation confirms my impression, gained from observation in many places in northern China, that the material of the loess is, to no small extent, of local origin.

The thickness of the loess at the top of Ling-Yen-Shan is at least 5 m. and it is cut by ravines in exactly the same way as the typical loess of the north. A norticeable feature is that the partial dissection of the basalt mesa had taken place previous to the deposition of the loess which was laid down upon the hill as we see it today.

8 li S. from Ling-Yen-Shan there is a hill called Kua-Fu-Shan (瓜埠山), in the southern part of which we noticed an extensive exposure of nearly vertically columnar basalt.

This locality is situated at the northern edge of the alluvial plain of the Yangtze river. Further east there are some other small rounded basalt hills with beautiful basalt-columns, in some places vertical, in others horizontal and in still others with a strong bend of the columns.

Fig. 1. Fang Shan from the N. Showing the supposed crater.
自北望方山之似火口噴山

Fig. 2. Shuang Nü Shan, seen from Fang Shan.
自方山之望雙女山

The relationship of these bodies of columnar basalt to surrounding sedimentaries is not known. Possibly they formed the lower part of thick lava flows; another possibility is that they cooled as intrusive sheets in the red sandstone (Deck-Sandstein).

The observations given above prove beyond doubt that the whole volcanic series, tuff, breccias and lava beds were deposited upon a pre-existing quartz-gravel formation. On the other hand, the existence in the gravel of lava bombs, shows that the deposition, or at any rate the redeposition of the gravel continued after the volcanic action had begun.

It may be questioned whether we cannot go a step further. At the south gate of Nanking there is a gravel deposit which in every feature resembles the great gravel formation on the north side of the river, except that there is no cover of volcanic rocks in this place. This Nanking gravel contains, sparingly, small pebbles of agate, these being collected and offered for sale because of their pretty and fanciful colorbanding. The source of the agate is not known, and the occurrence has been mentioned here merely as an indication that there *might* be in the region some amygdaloid lava, older than the Nanking gravel.

In the final article of this series, I will show that the basalt at the southern edge of the Mongolian plateau rests upon gravel with pebbles, mostly of porphyry. Some few, poorly preserved plant fossils seem to show that at least the lowest part of these gravels is Jurassic. In the case of the Mongolian basalt no tuff deposits are known, linking up the volcanic series with the older gravel, as is the case amongst the Nanking "volcanoes". The basalt flows rest directly upon the gravel, and in one instance a dyke of basalt was seen traversing it.

The age of the Mongolian basalt is fairly well known from the occurrence at Han Jo Pa of a shale with early Tertiary plants between two basalt-beds.

The age of the Kiangsu basalt is not known, neither is that of the underlying gravel.

According to Richthofen there occurs at Ch'ing Chou Fu (青州府) and Têng Chou Fu (登州府) in Shantung a basalt, partly forming flows, partly "volcanic" cones. (China II p. 209, 212, 217, 228).

In Manchuria (Fengtien and Kirin) basalt forms immense flows. At Fushun near Mukden the basalt is overlaid by a thick sedimentary series with Oligocene plants (see the concluding article of these essays).

Richthofen described the basalt hills N. of Nanking as "volcanoes". I have stated above that Fangshan might be the remnant of a volcano, but that, so far as the others are concerned there is no foundation for Richthofen's interpretation.

In Pl. II, fig. 2, we see Shuang-Nü-Shan, "The Twins", described by Richthofen. These two conical hills, alike in shape, evidently helped to influence Richthofen, in the idea that he was dealing with "Vulcan-Kegel". I had no time to visit these hills. Richthofen states that more than the lower half of their slopes shows only quartz-gravel whereas the top consists of basalt. From this I judge that they, like the other hills, form remnants of a once widely-extending but now largely destroyed basalt-mesa.

The two most typically mesa-shaped hills among the "Nanking volcanoes" are Hungshan and Ling-Yen-Shan. In both these hills the plateau is more or less deeply incised by ravines, the lobes between which will at a more advanced stage of erosion, appear as entirely isolated hills of the Shuang-Nü-Shan type.

Fig. 6. Contour of dissected basalt mesa. NNW from Ling Yen Shan.

第六圖 靈岩山西北山形剖面

From Ling-Yen-Shan I observed in a direction N 30° W and at a considerable distance, the contour shown in fig. 6. I have no doubt that this is another, partly dissected basalt-mesa. A process of this kind is very graphically illustrated in W. M. Davis, Physical Geography, p. 220, fig. 141.

Long after the above described observations were made, I found on the occasion of a visit to the much debated Feng Huang Shan iron ore deposit in December 1921 an opportunity to make, with Mssrs C. C. Liu and J. C. Chao of the Geological Survey some additional observations on the basalt hill Fang Shan, 30 li south of Nanking. By the kindness of the two gentlemen mentioned I am able here to reproduce the interesting sections which they surveyed at my request.

The road from Nanking to Feng Huang Shan runs within a distance of less than 15 li from the beautiful mesa, Fang Shan. At this distance I could see distinctly some vividly pinkcoloured outcrops at the foot of the hill indicating that the red "Deck-Sandstein" forms the basement of the hill.

In one of the gullies on the southern slope there could also be seen below the basalt and above the supposed outcrops of the red sandstone some white strata which strongly reminded me of the gravel underlying the basalt on the north side of the Yangtze.

I had no opportunity to visit the hill but asked Mssrs Liu and Chao to examine the outcrops indicated by me. They have, as a result of their work sent me a very detailed section from the gully in question, as well as a general section of the whole hill. These are here reproduced (fig. 7 & 8) and need no further interpretation.

It is at once seen that this Fangshan in its geological structure closely resembles Ling Yen Shan and the other basalt mesas on the north side of the river. The only difference seems to be that in the southern Fangshan the basalt rests directly upon the gravel, whereas in the northern basalt hills there is a bed of volcanic tuff between the two. It is by no means improbable that the tuff will also be found in the same position on the south side of the Yangtze. At any rate, the interesting observations made in Fangshan seem strongly to confirm my view that the gravels at the south gate of Nanking, described above, form part of the sub-basaltic gravel-formation which has now been proved to occur on both banks of the Yangtze river.

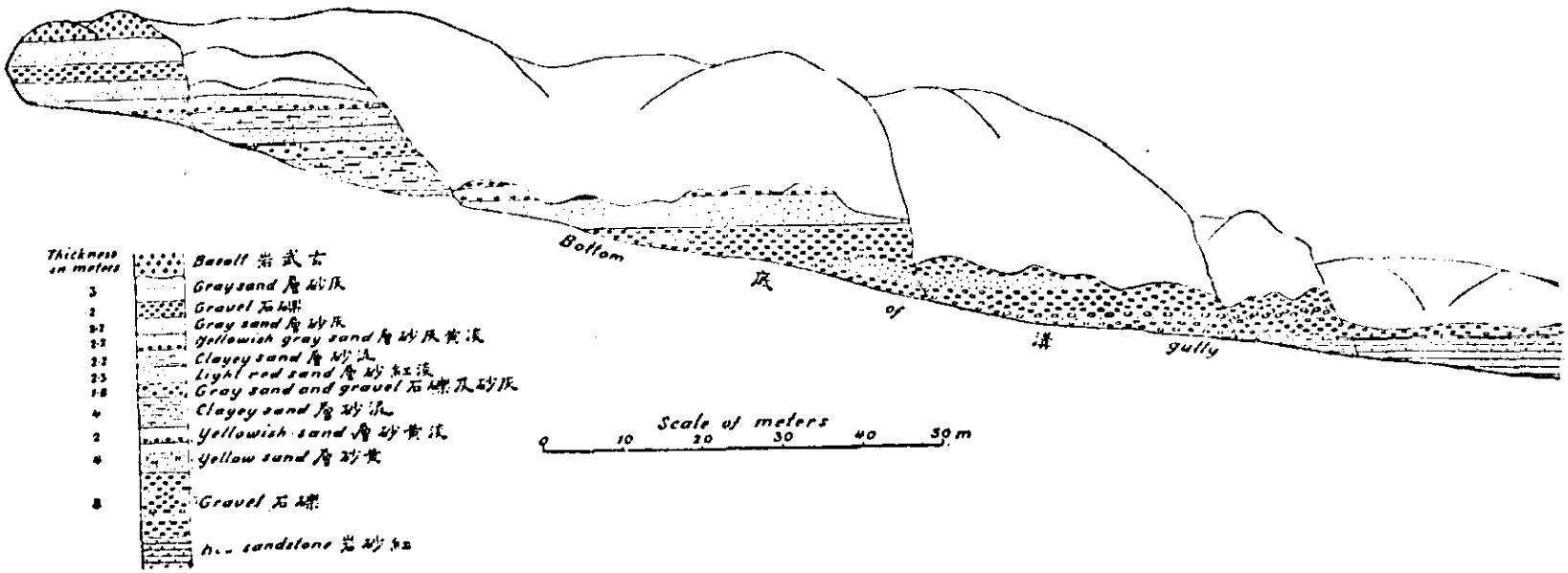


Fig. 7. Detail section from Fang Shan, Chiang Ning Hsien,
(Communicated by Messrs C. C. Liu and J. C. Chao.)

第七圖江甯縣方山洋灰剖面
(據劉季辰趙汝鈞二君報告)

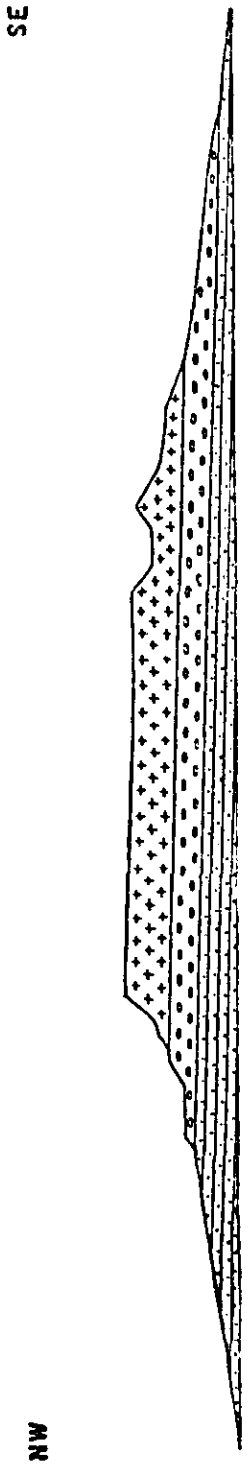


Fig. 8. General section of Fang Shan, Chiang Ning Hsien,
(Communicated by Messrs C. C. Liu and J. C. Chao)

第八圖 江寧縣方山大路剖面
(據劉季辰趙汝鈞二君報告)

THE EOCENE DEPOSITS OF YUAN CHÜ HSIEN, SOUTH SHANSI.

INTRODUCTION.

In May 1916, I crossed the Yellow River at Yuan Chü city (垣曲) on the boundary between Shansi and Honan. In the Northern bank of the river about 4 li SW from Yuan Chü city, I found, beneath loess and gravel, beds of red-brown and multicolored clay together with a bed of marly limestone.

In these sediments there occur numerous fresh-water mollusks, and I realized that I had found a fossiliferous, pre-loessic deposit of noticeable interest. The circumstances did not allow me to remain at the spot for a more thorough survey but a small collection of the fossils was made and forwarded for examination to Dr. N. Hj. Odhner, of Riksmuseum, Stockholm, Sweden.

At the time I sent my material to this expert I was under the impression that the fossils were most likely of early Pleistocene age, but, to my great and pleasant surprise, Dr. Odhner reported that the collection was of much higher interest, being, in fact, the first indication of the occurrence of Eocene deposits in China. An elaborate description of the fossils, under the title "Lacustrine Mollusca from Eocene Deposits in China" was forwarded by Dr. Odhner in 1920, but for several reasons the printing of this paper has been delayed so that it will appear only in the fourth volume of the Bulletin of the Geological Survey of China.

In the paper referred to Dr. Odhner has identified 8 species of fresh-water mollusks, 6 of which are characteristic of the Eocene deposits of France and Western Germany, whereas the two remaining species are new forms described by Dr. Odhner.

During my first and rapid visit in 1916 only a single section of a few meters thickness had been hurriedly examined. The extent and the tectonic features of these Eocene beds, as well as the stratigraphic sequence, remained entirely unknown. There was every probability that a much larger number of mollusk species remained to be discovered, and the occurrence in the first small material of a tiny fragment of a vertebrate gave some hope of still more interesting possibilities.

It was my intention to return to this promising area at the earliest possible date, but for various reasons I had to wait until 1921 for such an opportunity. I arrived at Yuan Chü April 29 and stayed there until May 13, devoting this time principally to the study of the stratigraphy and tectonic of the Eocene beds.

In the following pages I will give a brief description of the geological map of the Eocene area surveyed by me on the scale 1:100,000 (map 1).

TOPOGRAPHY.

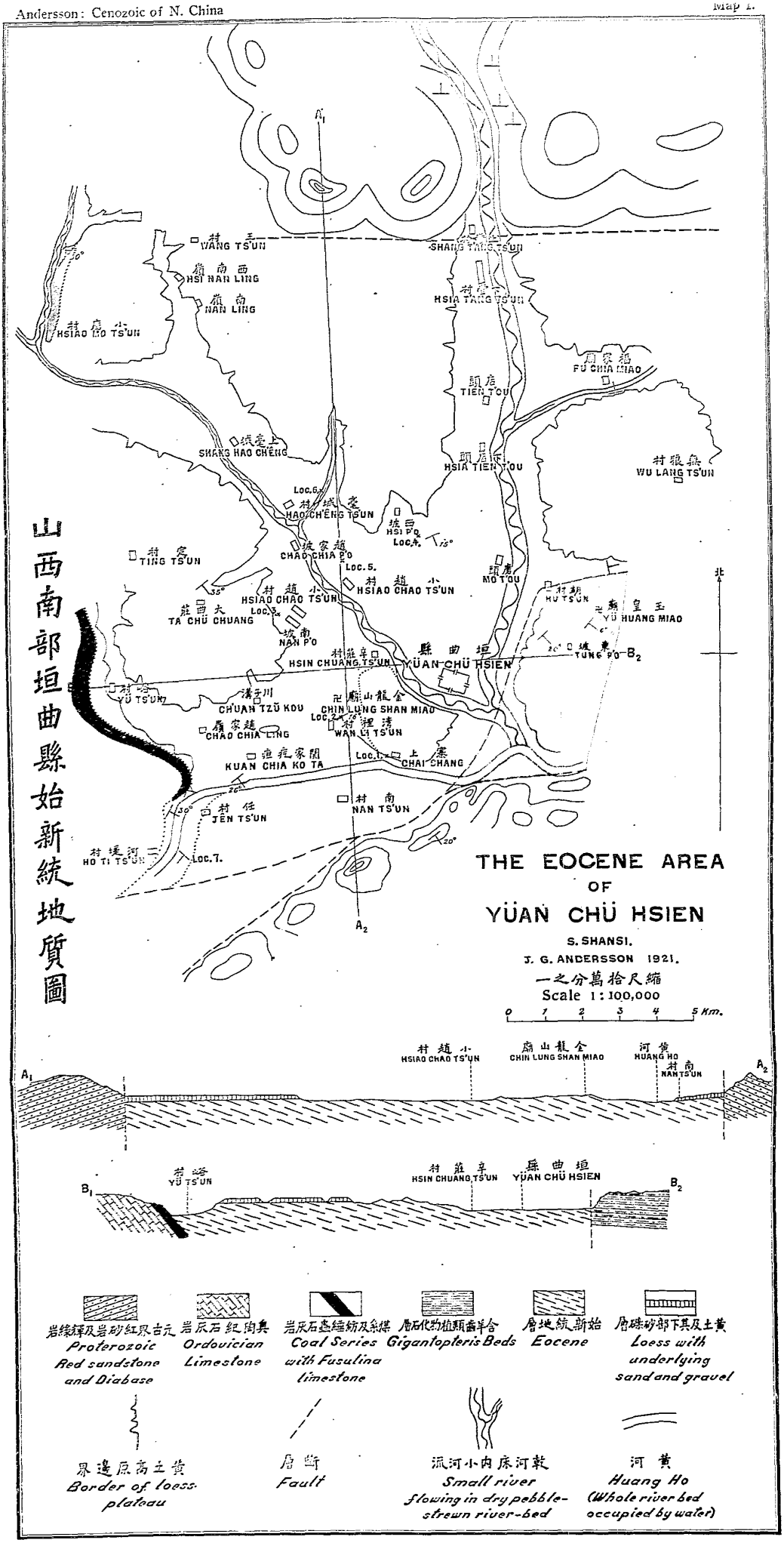
The Eocene area is situated almost entirely in Yuan Chü Hsien, Shansi province, on the north side of the Yellow River. An outcrop of Eocene rocks was noticed on the south side of the river SSW from the village Jên Tsun(任村), and, to judge from the topographic conditions, there is no doubt that a narrow strip of Eocene rocks extends from the said village eastwards to a point approximately south of Yuan Chü city. This small area on the south bank of the river belongs to Mien Ch'ih Hsien of Honan province. From the Yellow River the Eocene deposits extend northwards a distance of 13 km. to the hills north of Shang T'ang Tsun (上堂村) village. In E-W direction the width of the Eocene area is 10-14 km.

The region occupied by the soft and easily eroded Eocene sediments forms a comparatively low and open landscape surrounded by high hills on the North and West and especially the South where in some distance the mountains rise to form a dominant range, probably consisting of Ordovician limestone (Pl. III).

Through the Eocene area flow two convergent rivers which meet at Yuan Chü city and discharge their water into the Yellow River. Most of the year these rivers carry very little water, but their pebble-strewn beds lie in marked valleys which, with their numerous side ravines, deeply dissect a once continuous and nearly level plateau lying at an altitude of 100-200 meters above the level of the Yellow River at Yuan Chü city.

A third tributary of the Yellow River flows near the Western edge of the area mapped, in an equally deep, but much narrower valley.

To sum up this description, the essential topographic feature of the Eocene area is a plateau-land, situated at an altitude of 100-200 meters above the Yellow River and deeply dissected by the river valleys which have cut down into it. The interior structure of this plateau is shown by the sections adjoined to the map from which we learn that the tilted Eocene beds are overlaid by horizontal layers of sand, gravel, and loess.


山西南部垣曲縣始新統地質圖
THE EOCENE AREA
OF
YÜAN CHÜ HSIEN
S. SHANSI.
J. G. ANDERSSON 1921.
縮尺一之分萬拾尺
Scale 1 : 100,000
0 1 2 3 4 5 Km.
WANG TS'UN
SHANG TANG TS'UN
HSI NAN LING
NAN LING
HSIA TANG TS'UN
HSIAO HO TS'UN
FU CHIA MIAO
TIEN T'OU
SHAKS HAO CHÊNG
HSIA TIEN T'OU
WU LANG TS'UN
HAO CHÊNG TS'UN
HSI P'O
TING TS'UN
CHAO CHIA P'O
MO T'OU
HSIAO CHAO TS'UN
HU TS'UN
TA CHÜ CHUANG
YÜ HUANG MIAO
NAN P'O
HSIN CHUANG TS'UN
YÜAN CHÜ HSIEN
TUNG P'O
YÜ TS'UN
CHUAN TZŬ KOU
CHIN LUNG SHAN MIAO
CHAO CHIA LING
WAN LI TS'UN
KUAN CHIA KO TA
CHAI CHANG
NAN TS'UN
JÊN TS'UN
HO TI TS'UN
Loc.1.
Loc.2.
Loc.3.
Loc.4.
Loc.5.
Loc.6.
Loc.7.
A1
A2
B1
B2
北
HSIAO CHAO TS'UN
CHIN LUNG SHAN MIAO
HUANG HO
NAN TS'UN
YÜ TS'UN
HSIN CHUANG TS'UN
YÜAN CHÜ HSIEN
岩綠輝及岩砂紅界古元 Proterozoic Red sandstone and Diabase
岩灰石紀陶奧 Ordovician Limestone
岩灰石蟲縫紡及系煤 Coal Series with Fusulina limestone
層石化物植類齒羊合 Gigantopteris Beds
層地統新始 Eocene
層礫砂部下黃及土黃 Loess with underlying sand and gravel
界邊原高土黃 Border of loess plateau
層斷 Fault
流河小內床河乾 Small river flowing in dry pebble-strewn river-bed
河黃 Huang Ho (Whole river bed occupied by water)

The largest remnant of the old plateau is situated N of Yuan Chü city, extending from Hsi P'o (西 坡) 7 km. N to the foot of the sandstone hills.

Another relic of this ancient plateau is met with NW from Yuan Chü city, extending to the limestone hills which form the western boundary of the Eocene area. This region is more dissected and irregular than the one first mentioned.

Again, on the Eastern side of the river valley, extending down from the north to Yuan Chü city we meet another expanse of the old plateau which is remarkably uniform to the south of the village Fu Chia Miao (福 家 廟). E of this place there extends a comparatively low-lying country which, in topographic features, very much resembles the Eocene area. At first I thought that the Eocene beds extend far to the east of this place, but some observations made with a field-glass seem to indicate that in SE direction from the above mentioned place we meet outcrops of the same soft beds of the upper Paleozoic, which I have studied in some detail in the low hills E of Yuan Chü city.

Everywhere to the NW and W of Yuan Chü city there are numerous deep ravines which have sharply incised the old plateau and which offer splendid sections through the Eocene beds. In fact these branching ravines are so numerous that I had time to search only a small number of them and consequently it is quite possible that interesting stratigraphic and palaeontological discoveries remain to be made in this intricate net-work of deeply cut, narrow gulleys.

TECTONIC FEATURES.

It has already been said that the Eocene forms a low-lying area surrounded by much higher hills in N, W and especially in the S. Evidently the Eocene is a sunken area limited by great fault-lines in the N as well as in the S. In the E and W the boundaries are more obscure and difficult of interpretation, as will be shown in the following pages.

The plump rounded hills which rise to the N of the Eocene area consist of beds of red Pre-Cambrian quartzitic sandstone which is underlaid by amygdaloid diabase and porphyries of many varied types. The sandstone dips gently to the N and, a little further northwards, just outside the area shown in the map, I found in 1916, E of the village Hsü Chia Chuang (徐 家 庄) a small area of fossiliferous Cambrian.

On the S side of the Yellow River we meet a wild, deeply dissected mountainous region. The hills nearest to the river consist of the Pre-Cambrian sandstone and lavas described above, but the commanding ridge, which rises further south, with lofty jagged peaks, certainly consists of the Ordovician limestone which I actually observed 40 li further down the course of the Huang Ho, where the river cuts through the limestone range in a narrow canyon.

After crossing the river-bed to the E of Yuan Chü city we meet in the steep slope of a low mountain a well-exposed series of nearly horizontally bedded, locally variably dipping, greenish-gray sandstone and grayish-green or subordinately dark-colored, crumbling shales. From this series I made a small collection of plant fossils which I believe to be the *Gigantopteris* flora, so characteristic of a certain zone of the uppermost Palaeozoic. It is evident that this body of young Palaeozoic beds is bounded on the W by a fault-line dividing it from the Eocene area. Further N, to the N of the temple Yü Huang Miao(玉皇廟) there is another fault-line running approximately W-E and separating the young Palaeozoic beds from the easternmost part of the Eocene area. Here the fault plane is beautifully visible, with strongly disturbed patches of Eocene beds hanging on the steep slope of the up-throw Palaeozoics.

North of this place the exact boundary of the Eocene is not known, but as indicated above, it is fairly well proved that older rocks, probably young Palaeozoic, meet at no great distance to the eastward.

On the Western boundary of the Eocene area the conditions are rather complicate and difficult of explanation. I have studied this boundary only in three places, near the village Hsiao Mo Tsun (小磨村) in the N.W. part of the area mapped, at Yü Tsun (峪村) and further S. at the Yellow River.

Two km. N. of the village Hsiao Mo Tsun I found very hard and fresh outcrops of a syenitic rock. A short distance further S., in the same river valley, I observed beds of limestone, mostly dark colored but partly turned into marble, a process of metamorphism apparently due to the action of the igneous body nearby. The limestone could be followed for some distance S., but then near the N end of the village Hsiao Mo Tsun there are dumps of old coal mines. To the S. of this village, in the S. bank of the small river valley, there are high cliffs of Eocene beds. In one place furthest NW, I noticed coarse conglomerate dipping 25° E.; about 2 km. further SE, I noted 0.5-3 m. thick beds of gray conglomerate, alternating with layers of red-brown clay and soft clayey sandstone.

SE. part of the Yuan Chü "Graben" of Eocene beds. 層地統新始之塹地南東曲垣西山

The highest range in the distant background is Ordovician limestone. The lower range immediately on the south bank of the Yellow River is Proterozoic red sandstone. The hill at the left side of the picture is Gigantopteris beds. The lowland in the foreground is Eocene, overlaid to the right by a terrace of gravel and loess.

Between this place and the village Yü Tsun, 7 km. further S., the conditions are unknown to me. At the last named village the east bank of the river valley consists of Eocene beds dipping 27° ESE. On the W side, the hills are much higher and consist of the Palaeozoic coal series, in the bottom of which there are one or more beds of Fusulina limestone. This young Palaeozoic rests in its turn upon a gray thick-bedded, non-fossiliferous limestone, probably of Ordovician age. All these beds are strongly dislocated.

Some km. further S. at the place where the small river valley opens towards the Yellow River, I made some observations which seem to throw light upon the obscure relations between the Palaeozoic and the Eocene beds. The condi-

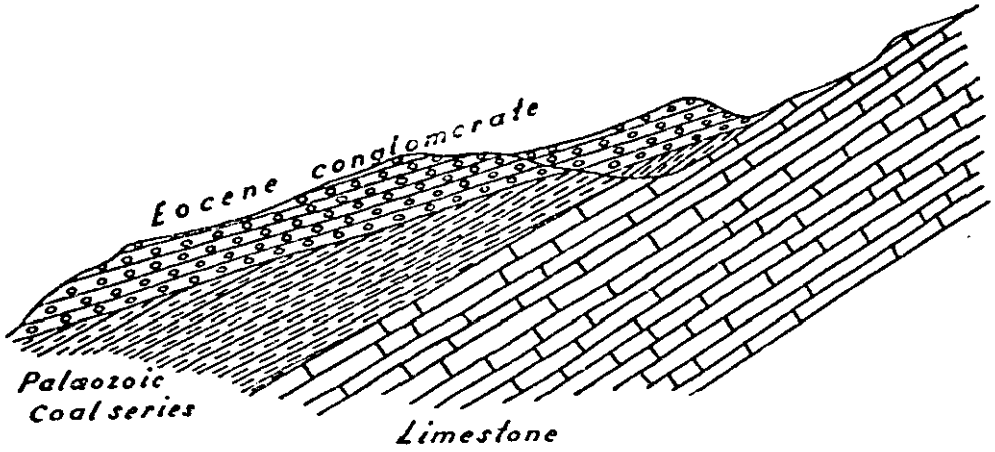


Fig 9. Eocene conglomerate unconformably overlying the Palaeozoic coal-series and the Ordovician limestone. S. of Tsun Tsun Yü.

tions are clearly shown in fig. 9 and in Pl. IV, fig 1. which will indicate the relationship of those rocks better than any description. The dip of the limestone is 50° in E direction. The dip of the Eocene series, which forms the uppermost part of the section, is more gentle, 30° SE. Between the limestone and the Eocene beds is the coal series, as indicated most clearly by the dumps of old abandoned coal mines. The dip of the coal series is mostly conformable with that of the underlying limestone but locally there is considerable disturbance.

It seems to me impossible to assume a fault-line between the Eocene and the Palaeozoic rocks. More probably the Eocene was deposited upon the Palaeozoic series, partly at the side of a pre-existing hill of limestone, as indicated by the fact that in this place the pebbles of the Eocene conglomerate consist almost exclusively of limestone. This assumption that the Eocene deposits were laid down unconformably between hills of the older rocks, also explains the

insignificant thickness of the coal series in this section. Evidently most of the coal series was eroded until the underlying, more resistant limestone was reached.

In other places the Eocene conglomerates contain mostly pebbles of the Pre-Cambrian red sandstone, a fact which goes far to show that these oldest members of the geological sequence were locally laid bare by erosion before the deposition of the Eocene series.

When all these observations are taken into consideration, it seems highly probable that already in pre-Tertiary times the area was dissected by fault-lines causing a broken topography and exposing different members of the geological sequence to erosion.

It is possible that the contact between the Eocene beds and the older rocks along the W boundary of the Eocene area, is due partly to unconformable superposition and partly to faulting.

Furthermore, it seems possible that the fault-lines along which the large post-Eocene dislocations have taken place, were in existence already in pre-Tertiary times, or in other words, that the post-Eocene dislocations have followed old lines of weakness.

Within the Eocene area the dip is mostly to the SE with an average of 22°. This regular dip refers to an area between Yuan Chü city on the east, the Yellow River on the south, Yü Ts'un on the W. and Ting Tsun to Hsi P'o on the N. *In the area thus circumscribed the dip is so uniformly to the* SE, with angles varying from 15° to 35°, that it is permissible to calculate the approximate thickness of the Eocene series here remaining.

From Ta Chü Chuang (大 咀 庄) in NW to Chai Shang (寨 上) furthest SE, the distance is 6.5 km. following the direction of the dip. With an average dip angle of 22°, this would give an aggregate thickness of 2,400 m between these two points. Nowhere within the Eocene series, have I noticed any large strike-faults which could seriously interfere with this calculation, nevertheless, the facts upon which this estimate is based are so few, that I would not like to state at this time that this series has such an immense thickness. Half of the calculated amount may be a fairly safe minimum, so, for the present, we must be satisfied with the statement that the thickness of the Eocene series in Yuan Chü Hsien is more than 1,000 m.

It has been stated above that there are very few indications of faults within the Eocene series. In fact, the only place where I have actually seen some small faults is NE from Hao Ch'eng Ts'un. In the NW corner of the Eocene area

Fig. 1. Eocene conglomerate unconformably overlying Palæozoic beds.
Yuan Chü Hsien, NE. of Ho Ti Tsun. (Compare fig 9, p. 29)
上之層地界生古于合整不若礫統新始北東村堤河縣曲垣

Fig. 2. Gently dipping Eocene sands and marls. Yuan Chü Hsien, Chin Lung Shan Miao.
斜傾之層灰泥及層砂統新始廟山龍金縣曲垣

south of Hsiao Mo Ts'un the dip is to the E; in the SW corner, opposite Ho Ti Ts'un the dip seemed to be towards the SW; this observation has to be confirmed by a visit to the place, as I only saw this locality from a distance through the field glass.

At Tien T'ou, 7 km. N from Yuan Chü city, I studied, in a ravine, red shales with inter-bedded layers of limestone, the whole series dipping 10° S.

3 km. E from this place, at Fu Chia Miao, there were alternating beds of conglomerate, sandstone and clay dipping 25° in N direction.

I have previously metioned the conditions E of Hu Ts'un where the Eocene beds are separated from the Palaeozoic rocks by a big fault, in the vicinity of which the down-thrown Eocene is strongly disturbed so that dips changing from W to E were noted within a small distance.

STRATIGRAPHY.

The sediments which build up the Eocene series are very varied in lithological character.

Conglomerates play an important role in this series, especially in the lower part, where they are more or less dominating and mostly coarse, with pebbles of fist size or even as much as a foot in diameter. In the upper part of the series the conglomeratic intercalations are less frequent, mostly not so thick and with pebbles of smaller size. It is evident that in the beginning of the sedimentation cycle, hill slopes, from which pebbles could be washed down, were frequent, while the streams were powerful because of the steep grade. In the course of time, as the sedimentary series grew to a thickness sufficient to fill the valleys and cover the lower hills, the role played by the coarse clastics became much reduced, especially as the lessened grade gave the streams less power of action.

In the bottom of the series is found unstratified clay, mostly red in color, but often variegated, with irregular, green, branching patches. This clay is interbedded with the conglomerate beds.

In the upper part of the series, the same red-brown clay or shale is found, sometimes in beds of up to 30 m. in thickness. Interbedded with this clay is a whitish sand, often exhibiting current bedding. In this sand there are subordinate layers of conglomerate, and these thin strips of conglomerate often contain some remains of vertebrates.

Interbedded in this series of clay and soft sandstone or sand, there are thin, regular beds of greenish or bluish-gray, mostly marly limestone. These limestone layers, which mostly attain a thickness of 30 to 100 cm. are very conspicuous and in certain sections, W and NW from Yuan Chü city, several such regular limestone beds can be seen at varying intervals, one above the other (Pl. IV, fig 2).

As will be more fully described in the following, these beds of marly limestone are the layers which offer the best prospect for the fossil hunter. Nearly all contain the shells of ostracoda and some of them are rich both in mollusks and fragments of vertebrates.

In a single place, locality 6, NE from Hao Ch'eng Ts'un, there is a deposit resembling a coal bed in the Eocene series. The place is situated about 1 km. from the village in question in a side valley running NE. The "coal bed" is best developed in the W wall of the valley where for a distance of 77 m., one can follow a dark-colored bed, half a meter in thickness. A small development of the same dark-colored bed was also seen in the E wall, close by some small dislocations. We were told that the dark substance in this bed would burn but that the smoke was foul-smelling. The substance was too much weathered to permit an opinion regarding its original nature. It was rich in gypsum, and in its lower part some very beautiful gypsum crystals were found. The substratum of the "coal bed" is a yellow, somewhat clayey sand and its roof a bluish-gray plastic clay. One meter above the dark bed there is a layer with numerous fossils, amongst which *Planorbis pseudammonius* is frequent, proving that the "coal bed" is simply a local intercalation in the upper part of the Eocene series.

FOSSILS.

The mollusks collected by me in 1916 which gave Odhner the material from which he deduced the Eocene age of these beds, was found in a section in the N bank of the Yellow River below the village Chai Shang (寨 上) and immediately to the E of locality 1 on my map.

The mollusk material forwarded to Odhner came partly from the marly limestone, partly from the clays. This material has been discussed in detail by Odhner in his paper entitled "Lacustrine Mollusca from Eocene Deposits in China" published in the Bulletin of the Geological Survey of China. The following species were identified or described by Odhner:

Planorbis pseudammonius Schloth.
Planorbis pseudammonius Schloth *var. leymeriei* Deshayes.
Pl. sparnacensis Deshayes.
Pl. chertieri Deshayes.
Physa cf. lamberti Deshayes.
Euchilus deschiensianum Deshayes.
Ceratodes sinensis Odhner n. sp.
Eupera sinensis Odhner n. sp.

With the exception of the two last mentioned new species this fauna is characteristic of the Eocene of France and Western Germany and certainly presents substantial evidence to prove the Eocene age of the beds in question. It is with great pleasure that I record my appreciation of this important discovery by Dr. N. Hj. Odhner which is certainly one of the most remarkable in recent stratigraphical research in China. It has given a powerful impetus to a continuation of the work in the field with the result that we now realize the existence of a well-defined Eocene area with a thickness of at least 1.000 meters of Eocene sediments.

Besides the mollusks determined by Odhner, the first consignment of fossils also contained spors of *Chara,* according to the kind communication of Professor K. A. Grönwall.

The new and much larger lot of fossils from these Eocene beds, which I collected with my Chinese assistant Yao, in May 1921, has not yet been carefully examined. However I have had an expression of opinions on the mammal material from Dr. W. Granger, the well-known expert on Eocene vertebrates, and Dr. O. Zdansky has given me some preliminary determinations of the lower vertebrates. I gladly acknowledge my indebtedness to these gentlemen.

As shown in the stratigraphic chapter, the lower part of the Eocene series consists of conglomerates inter-bedded with red and variegated clays. Practically no fossils have been found in this lower part, except some few, entirely insignificant bone fragments.

In the upper part, the sediments are, on the average, more fine grained, sands with subordinate conglomerate beds, red clay, and interstratified between these, thin, regular layers of marly limestone. The red clay is entirely barren, and in the sand and conglomerate, bone fragments are only rarely met with, mostly in a very fragmentary state. The only place where fossils in some number were found

in this kind of sediment was at locality 3 near the village Nan P'o (南 坡). Here some comparatively big bones were found, but all very brittle and fragmentary. According to Dr. Zdansky, most of these bones belong to reptiles, but one piece certainly indicates a mammal.

By far the best sources of fossils are the thin marly beds which are interbedded in the barren sediments. In many cases these layers of marl contain, almost exclusively, *ostracoda*, and, less abundantly spors of *Chara*.

Other marl layers are quite full of mollusks, among which *Planorbis pseudammonius* stands out as a conspicuous giant. With this accumulation of mollusk shells are found in smaller numbers, and very fragmentary, bones of vertebrates; these are brown or black in color, soft in texture, and probably consist of phosphorite.

Some few fish scales have been identified, but the overwhelming majority of the vertebrate remains belong to reptiles, among which Dr. Zdansky has distinguished two species of *Trionyx*, and some few fragments of a small crocodile.

Mammal remains have been met with in the marls only in one section, locality 1, situated at the Yellow River, close by the place where the first fossils were found in 1916. The scanty mammal material consists only of a couple of jaws and some isolated teeth among which Dr. Granger has identified:

An Artiodactyl, represented by a fairly complete lower jaw, a molar from the upper jaw, possibly belonging to the same specimen, and besides this, some isolated molars. These teeth have a strong resemblance to *Ancodon (Ancodus)*.

A *Lemuroid* or *Insectivore*, fragment of a lower jaw, and a couple of isolated teeth.

An *Insectivore* (?), a tiny jaw without teeth.

A *Rodent*, an incisor.

These fossils were identified from the collection which I brought home in May 1921. In December the same year Dr. Zdansky visited Yuan Chü Hsien for fossil collecting in the Eocene series.

He carefully explored the locality two li above Jen Tsun on the right bank of the Yellow River opposite Ho Ti Tsun which I had only seen from some distance, but reported to Dr. Zdansky as a place worth visiting.

In a series of bluegreen and chocolate-brown marls dipping 15° towards W. 35° S, Dr. Zdansky found numerous remains of a Rhinocerotid related to *Amynodon*, as well as some few remains of a small mammal species and fragments of *Chelonia* and a gastropod *(Planorbis)*.

SOME VERTEBRATE DEPOSITS IN INNER MONGOLIA.

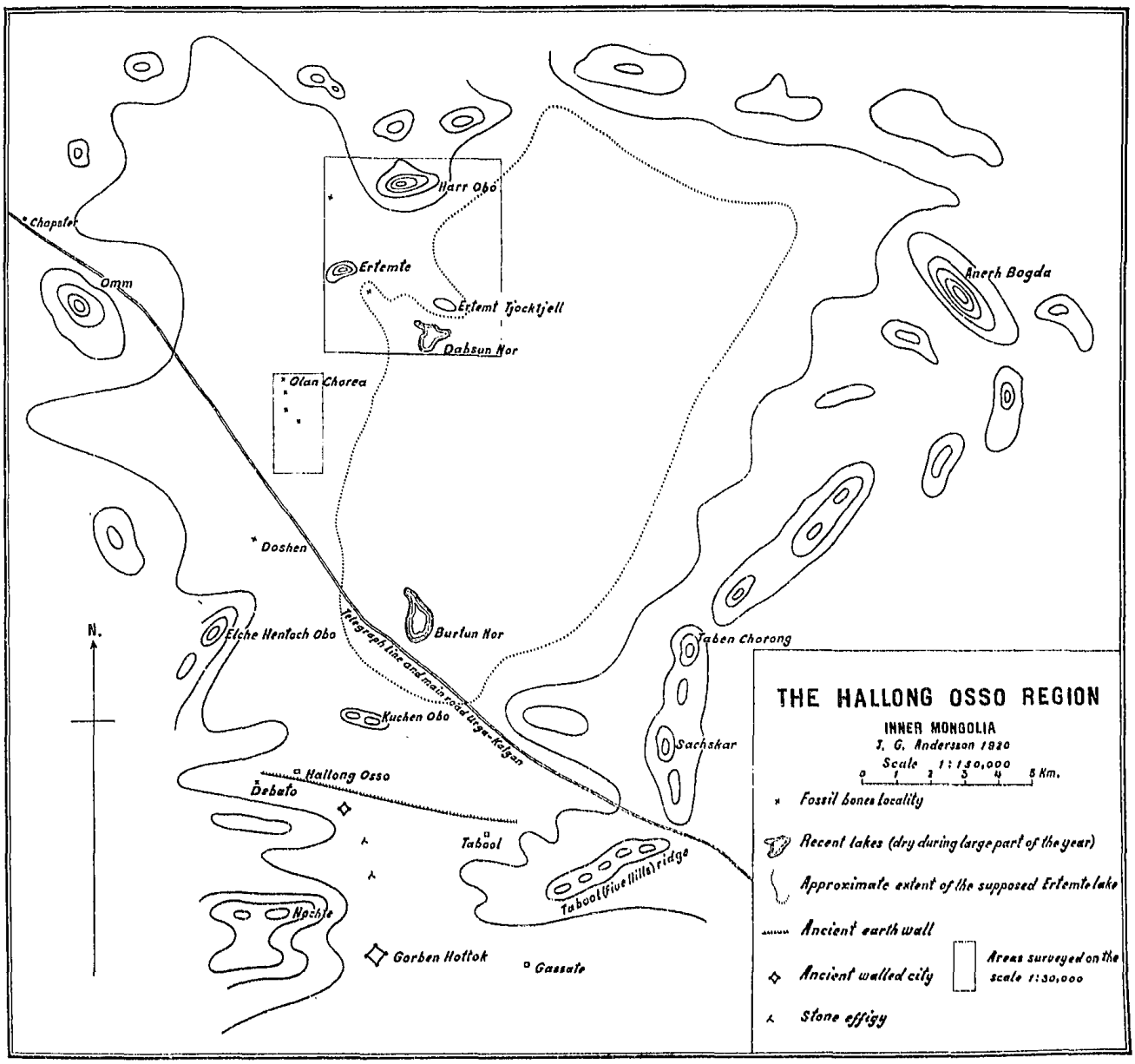
So far as I know, no systematical search for vertebrate fossils has as yet been undertaken in Inner Mongolia.

A brief paper on a small collection of mammal bones said to have come from Mongolia was published by Lydekker in the Records of the Geological Survey of India, Vol. XXIV, part 4, 1891. However, the whole assembly of fossils is such that I rather doubt that they come from Mongolia, but instead, more probably, from those Sino-Mongolian border-lands which, topographically, belong decidedly to China proper. Fossils like those in the Lydekker collection are, for instance, frequently collected in Northern Shansi, not very far from the Mongolian border.

During his journey across the Gobi desert from Urga to Kalgan, in 1892 Obrutcheff found S. of the salt lake *Erdene Dabbas*, teeth of a Rhinocerid which was determined by Suess as a *Rhinoceros* or *Aceratherium*§. As will be shown in the following pages, fragments of *Rhinoceros* and *Aceratherium* teeth have been found in large numbers in certain localities within the area which I examined.

In 1916, I commenced, with the support of the Geological Survey, researches on the Cenozoic deposits of Northern China. After a couple of years of preparatory work with comparatively meagre returns, I, at last, in the late autumn of 1918, met in the province of Honan with considerable success in the search for fossil mammals. The rich harvests of such fossils, both of Pliocene and Pleistocene age which I obtained at that time, encouraged us to continue the campaign, and I consequently decided to carry my investigations into Inner Mongolia during the following summer. In the early spring of 1919 I asked Mr. F. A. Larson, the well-known expert on Mongolian affairs, to engage for me a Mongol, who would be able and willing to undertake a reconnaissance trip with the purpose of discovering what knowledge there might be of fossil bones amongst

§. W. A. Obrutcheff. Central Asia, Northern China and Nan-Shan. St. Petersbourg 1900. (Russian) Vol. I, p. 88-89.


Harr Obo
Chapalor
Erlemte
Omm
Erlemt Tjocktjell
Dabsun Nor
Aneth Bogda
Olan Chorea
Doshen
Telegraph line and main road Urga-Kalgan
N.
Elche Hentoch Obo
Burlun Nor
Taben Chorong
Kuchen Obo
Sachskar
Hallong Osso
Debefo
Tabool
Tabool (five hills) ridge
Nachte
Gorben Hottok
Gassate
THE HALLONG OSSO REGION
INNER MONGOLIA
J. G. Andersson 1920
Scale 1:130,000
0 1 2 3 4 5 Km.
Fossil bones locality
Recent lakes (dry during large part of the year)
Approximate extent of the supposed Erlemte lake
Ancient earth wall
Ancient walled city
Areas surveyed on the scale 1:30,000
Stone effigy

the local population. A young Mongol named Haldjinko, was consequently engaged for the purpose, through the mediation of Mr. Larson, and this Mongol soon became a very good fossil hunter. A small collection of fossil mammal remains, mostly the horns of deer, was brought to Peking by Haldjinko in May, before my departure for Mongolia, and in spite of the very fragmentary character of the material, it gave some prospects of success, at the same time proving that the fossil bones in Mongolia are preserved in a way very different from those of China proper. The Mongolian bones are heavy, hard and dark in color. As later pointed out by Prof. Wiman, they very likely consist of phosphorite, though it ought to be mentioned that many of them are characterized by remarkable hardness, possibly indicating a considerable content of silica.

On my arrival in the Hallong-Osso region (115 km N N W of Kalgan), in July 1919, Haldjinko took me to a number of localities, where bones had been found by him, but the material collected was mostly very fragmentary and of little interest. After a period of small progress, another Mongol collector named Jensen brought in a lot of fossil bones, among which I discovered the molar of a big beaver-like rodent. This find gave a powerful impetus to our search. It was soon learned, that this interesting tooth had been found during the digging of a well at a place called Ertemte, about 35 li north of Hallong-Osso. Furthermore it was learned that the best deerhorns collected by Haldjinko in the early spring had come from that locality. New excavations were at once started at Ertemte, and it soon became clear that a micro-fauna consisting mostly of rodents occurs in a sandy deposit within a certain layer at a depth of three meters.

The excavations at Ertemte were continued in the autumn, long after I had returned to Peking, under the able and energetic supervision of Rev. Joel Eriksson, and quite an extensive collection of the Ertemte micro-fauna was brought together§.

The following year, 1920, I eagerly returned to Mongolia, principally for the purpose of continuing the search for fossil mammals. At the time of my arrival in the later part of June, an extensive trench had been dug into the Ertemte deposit under the supervision of Rev. Eriksson, and this gave us a much clearer understanding of the mode of occurrence of the fossil bones.

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§. Rev. Eriksson, a member of the Swedish Mongol Mission at Hallong-Osso, has in most able and enthusiastic manner participated in my collecting campaign in the Hallong-Osso region. In recognition of the distinguished services thus rendered by him, the Royal Swedish Academy of Science has awarded him the larger Linné medal in silver. It gives me a special pleasure herewith to acknowledge my gratitude to Rev. Eriksson.

Later on a number of test pits were opened in a neighboring place called Olan Chorea, and here also a fairly good harvest of fossils was obtained. At Harr Obo, some few li north of Ertemte, another interesting locality was found, where the bones occur in a red clay, the whole thing reminding one very much of the Hipparion beds of China proper.

Fossils have also been brought together from a large number of localities within a radius of 100 to 150 li, in all directions round Hallong-Osso, but the three localities mentioned are still by far the richest, and alone have made the research for fossil mammals in Mongolia worth while.

In July 1920, I started northwards from Hallong-Osso into the Gobi region, to a point some distance north of P'ang Chiang. The hopes for new harvests of fossil mammals in these more northern regions were not realized, although we obtained some big leg bones, probably of an elephant, which had been found in a sand-deposit about half way between Hallong-Osso and P'ang Chiang (see below p. 45-46).

During the time which I spent in this excursion at P'ang Chiang, my collector Jensen had undertaken a reconnaissance trip eastward to the immediate surroundings of Dolonor, but the outcome was practically negative.

This shows the conditions under which we carried out our investigations for fossil vertebrates in Inner Mongolia. In the following pages I will give a brief description of the more important vertebrate localities, principally to amplify a paper, now in preparation by Dr. A. Söderström of Uppsala, on the vertebrate remains collected by us. A fuller treatment of this topic, dealing also with the topography and general geological structure of the region as well as a discussion of the present and ancient biological and climatic conditions of these regions will be published later when the reports of the zoologists and botanists working on the recent material which I collected are received.

In the following description of the localities I will begin with the group which I consider to be the oldest, and then proceed to the younger deposits.

Most of the names of fossil vertebrates mentioned below are only preliminary identifications made in the field and are no doubt subject to revision. Still they will serve to give some idea regarding the composition of the fossil faunas.

Harr Obo.

As shown on the map of the Hallong Osso region (Map II), this place is situated 3 km. (5 li) NNW from the Ertemte bone locality. The spot where the bones were found is situated 3 li west from a rather famous hill called Harr Obo, at the top of which stands one of those conspicuous Mongol shrines which are called Obo.

The bone locality is situated on nearly level ground in which there is a very slight irregular depression, that might mark an intermittent watercourse. In this small depression a hole had been dug to obtain water for the herds, and during this process the bones were found. The matrix is a red clay not unlike the Hipparion clay of northern China. In this clay there are numerous calcareous concretions which are 1 to 3 dm. in length. These concretions often show very conspicuous, brownish black surfaces, possibly due to a thin coating of manganese matter. The interior is often hollow, and sometimes contains numerous small calcite crystals. The fossils are mostly found in these nodules, and it is quite evident that on the formation of the cavities the fossil remains were often fractured, so that for instance the rhinocerid teeth are broken into narrow sharpedged pencils, which are spread over a considerable area within the nodule.

In this locality, was found a considerable portion of a Rhinocerid (Aceratherium?) skull, as well as numerous big bones, which probably also belong to this type. Besides these remains of Perissodactyla, there were found some interesting Artiodactyle teeth, reminding one very much of types belonging to the Hipparion fauna.

Harr Obo is the only locality where the red nodule-bearing clay has been found to contain fossils. However this type of deposit is of quite common occurrence in the Hallong Osso region. For instance, at Tabool, 10 li ESE from Hallong Osso, the red clay is exposed close to Mr. Larson's house. In a well-digging between Tabool and Hallong Osso the same deposit has been observed, in this case also containing numerous calcareous nodules, characterized by the remarkable black surface. At Debato, some few li W of Hallong Osso, red clay with nodules was observed in a small river cut. This place will be more fully described in a following paragraph.

Amongst the numerous small collections brought me by Mongols, there are some which seem to indicate the same fauna as that collected at Harr Obo. Four localities are especially worth mentioning in this connection:

1: Tjel in Gol, 120 li N. from Hallong Osso. From this place I have received fragmentary teeth of *Aceratherium* and *Hipparion*.

2: Bonk Tjaggan, 20 li North from Olan Chorea. Some *Rhinocerid* teeth, some fragmentary *horse* teeth, and big leg bones have been found here.

3: Tjaggan ör Ich, which flows to Tjaggan Nor. Numerous fragments of *Aceratherium* teeth.

4; NW from Anguli Nor, 70 li S. to W. from Tabool, at the river Da Tjin Gol which flows to Tjaggan Nor. *Horse* and *Aceratherium* teeth, some of them fairly perfect.

The teeth and bones collected in these four places have been found washed out in small water-courses. Consequently we do not know the kind of sediment in which they were originally imbedded, but it is quite possible that a systematic search in these places would reveal deposits similar to Harr Obo.

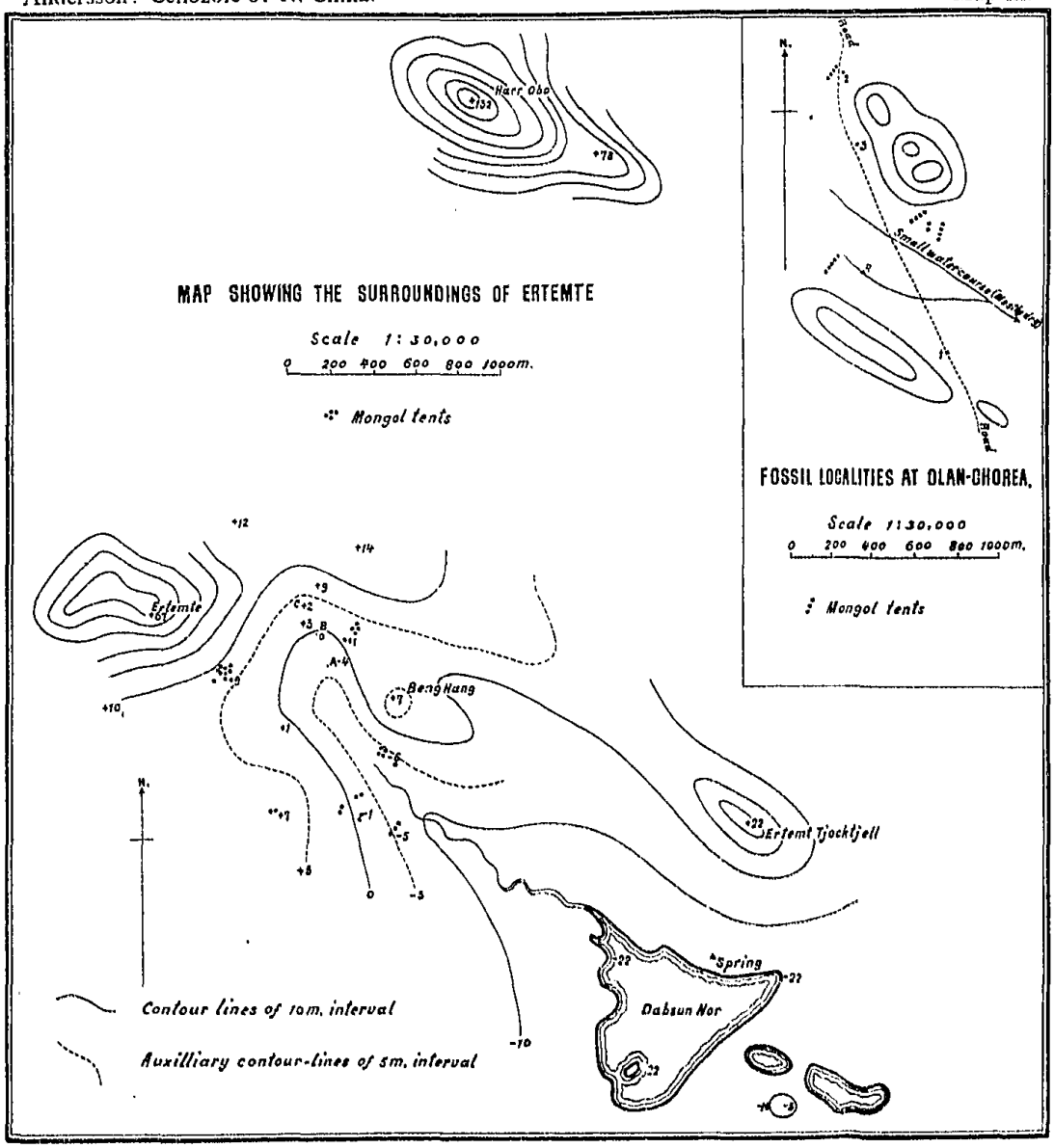
Ertemte.

Only 5 li SSE of Harr Obo lies a bone deposit which is entirely different in several respects from that first mentioned. The bones occur in a fine, loose sand, the bone-bed is very rich in freshwater shells, and the vertebrate remains form a microfauna, astoundingly rich in individuals as in species.

Ertemte is a small hill south-west from Harr Obo. The bone deposit lies in a slight depression to the east of this hill as shown on the detailed map on the scale 1: 30,000 (Map III). In the map are marked three diggings named A, B and C. Originally the deposit was discovered during the digging of a well near B. Some excavations for fossils were undertaken in 1919 near the points B and A.

In 1920 a big trench (B) was dug through the deposit in approximately SW—NE direction as shown by the adjoined section. This trench had a length of 24 meters and a maximum depth of nearly 6 meters. A very large collection of fossils was made in this trench. Later in the summer a new trench was opened at C, but here the sand was found to be entirely barren. Then a digging was made at point A and here again we found in abundance, the same species as in the trench B.

The sediment in this deposit is a withish, locally rather clayey sand, with indistinct stratification. The bottom of the sand was not reached in any of our diggings, but by the side of the original well-digging, which was partly refilled at the time of my first visit, I collected a sample of reddish clay, which may indicate that red clay occurs underneath the sand.


Harr Obo
+152
+78
MAP SHOWING THE SURROUNDINGS OF ERTEMTE
Scale 1:30,000
0 200 400 600 800 1000m.
Mongol tents
Ertemte
+61
+12
+14
+9
+2
+3
+11
+10
Beng Hang
+7
+1
+8
0
-8
-10
Ertemt Tjocktjell
+23
Spring
+22
Dabsun Nor
Contour lines of 10m. interval
Auxilliary contour-lines of 5m. interval
N.
FOSSIL LOCALITIES AT OLAN-CHOREA.
Scale 1:30,000
0 200 400 600 800 1000m.
Mongol tents

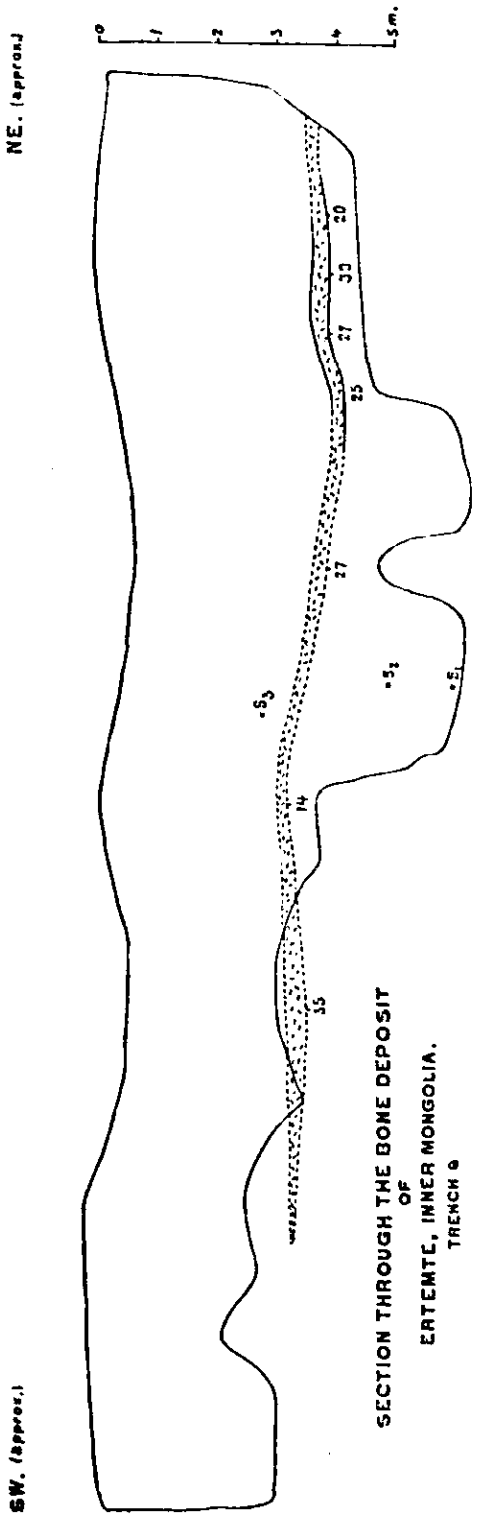


Fig. 10. Trench B through the Ertemte bone deposit.

The sand is almost barren, except a narrow bed at a depth of about 3 meters. This richly fossiliferous layer varies in thickness from 14 to 35 cm., as is clearly shown by the section. Outside of this bone-bed some few fossils were found in two places, namely freshwater mollusks in clayey sand at the place marked S2 and several big teeth probably of a *Bovine*, which were obtained about 60 cm. above the bone-bed in the SW. part of the section.

The bone-bed is rather different in appearance from the barren sand below and above: The sand-grains are much coarser and the sediment is partly gravel-like with pebbles of waterworn bone fragments. It also contains numerous small rounded calcareous nodules, several cm. in diameter. Certain parts of the bone-bed are hardened by calcareous incrustation so that hard slabs of some size can be taken out. In other places the bed is rich in soft plastic clayey or marly substance which often adheres to the fossils. Nearly everywhere are numerous small fresh water shells, mostly gastropods of several different species, but also a few bivalves. Intermixed with these shells there are numerous bones and teeth, mostly of very small size. Most of the vertebrate remains in this deposit are of a chestnut brown color with a lustrous polish on the surface and in a state of preservation, which can justly be called perfect. The substance in these beautiful little bones is probably phosphorite as pointed out by Professor Wiman after he had received the first consignment from this locality.

Unfortunately these beautifully preserved little bones and teeth occur in a pitifully broken state, and it appears as if some unknown force had reduced the material to an approximately uniform size. For instance, I never found a single complete *Rhinoceros* tooth, but only fragments, mostly of small size. The numerous deer antlers are always more or less broken, skulls of the deer have never been seen, and jaws, tolerably complete, have been found only in a couple of instances. Single beautifully preserved deer-teeth are however amongst the common features of the deposit. In this connection it may be worth mentioning that though the bones sometimes show sign of having been rolled and worn, generally every little detail of the pretty teeth stands out in ideal distinctness. More complete remains of the smaller-sized rodents, such as entire leg-bones and jaws, are commonly found, but of this group we often find only isolated molars or incisors. Very rarely complete jaws of the large-sized beaver occur, whereas numerous complete jaws of small rodents are found. It may be added that not a single fairly complete skull has ever been found, whereas jaws of the smaller animals are rather common.

In the above outline of the mode of preservation, I have indicated some of the more important groups which are represented in this fauna. It ought to be added that rodents occur in overwhelming majority, but that some few teeth and jaws of small carnivores and insectivores have also been found. There is moreover a great abundance of very tiny bones, which Dr. Söderström has identified as belonging to *frogs*. In addition there are also found some small biconcave vertebrae which I think belong to fishes, and finally it may be noted that a few small fragments of *Struthiolithus* shells have been gathered.

Olan Chorea.

At this place a number of fairly good bone-deposits have been found by small excavations undertaken by Haldjinko. These localities are indicated on the detailed map (Map III) of Olan Chorea as 1, 2, 3, and 4, these numbers being given in the order in which the deposits were found.

Olan Chorea 1 is on the NE slope of a small elongated hill consisting of decomposed Archean rock. On the slope of the hill there is a cover of red clay with numerous stones, and it looks as if the bones had come from this stony clay, though they were actually collected in the washout after the rains. Hence there was no section where the conditions could be distinctly observed.

In localities 2, 3, and 4, excavations were made, and in two of these holes sections were measured which are reproduced in the adjacent diagram. The record of these sections is as follows (from the bottom upwards):

LOCALITY 2.

		Thickness in cm.
a:	Tough clay, with numerous nodules in the bottom.	80-115
b:	Clay and coarse sand passing into gravel. These different types of sediment occur irregularly mixed with one another. In the sand and gravel bones were found.	70-90
c:	Fine gravel and coarse sand with bones.	35-40
d:	Gravel with sandy and clayey irregular intercalations. In this gravel there also were bones.	45-70
e:	Clay with sand and gravel and clayey sand. No fossils.	125

LOCALITY 4.

a:	Fat tough clay, no bones.	101

b: Clay with small nodules. 10

c: Fine gravel with numerous bones. 55

d: Surface-gravel, possibly of much younger age, with few bones. 60

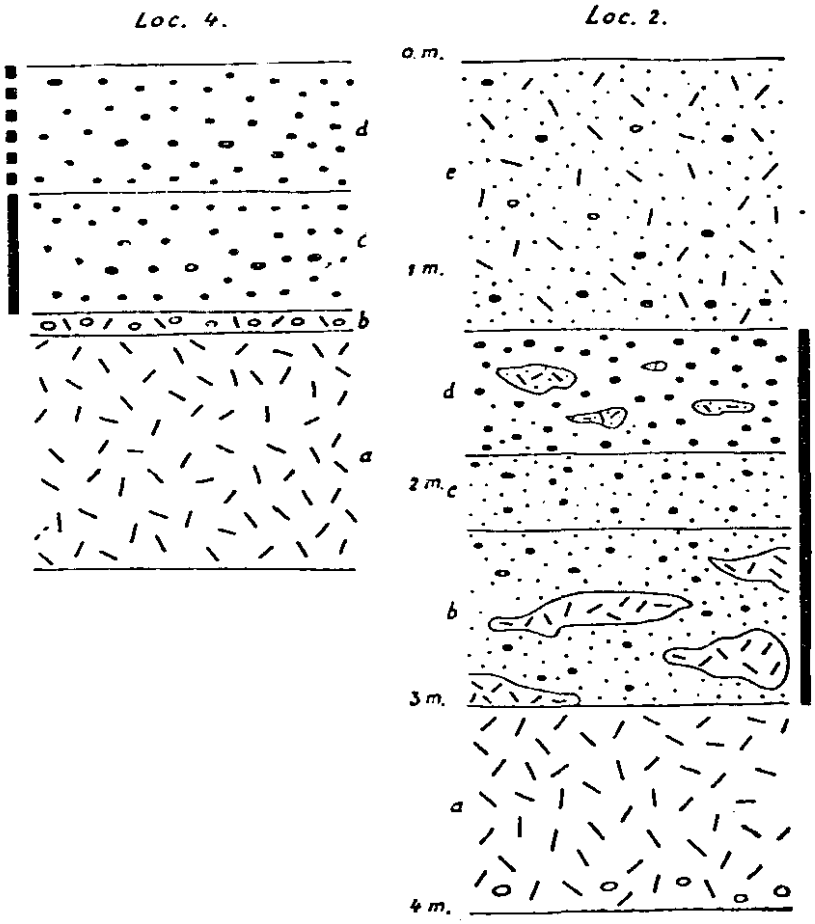


Fig. 11. Sections of localities 2 and 4, Olan Chorea.
For detail description see the text.
The black columns indicate the levels which yielded bones.

It was specially noticed that in locality 2 the whole series was grayish-yellow with a shading in red. The fossils found in Olan Chorea are very much the same as in Ertemte, the latter being by far the most prolific of these localities. It is worth mentioning that in Olan Chorea, beaver teeth are less common than in Ertemte and that fragments of *Struthiolithus* shells are far more common in Olan Chorea.

Localities which probably belong to the Ertemte fauna have been recorded as follows:

Fig. 1. Bone excavation at Olan Chorea, Loc. 2, Inner Mongolia.

內蒙古採集化石情形

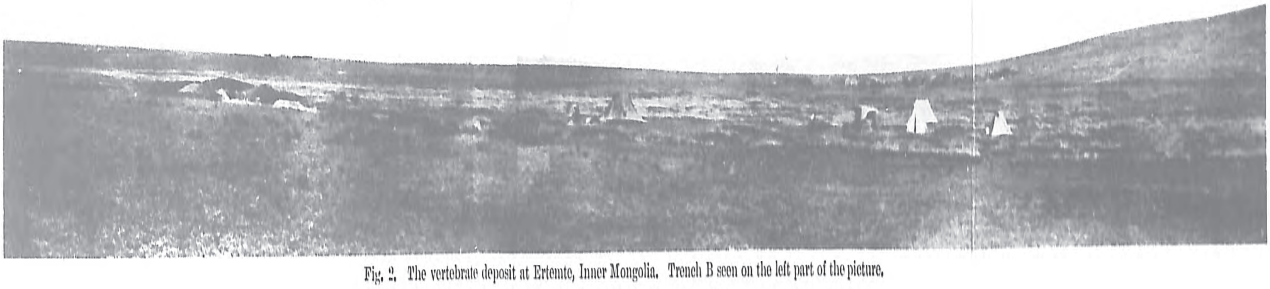


Fig. 2. The vertebrate deposit at Ertemte, Inner Mongolia. Trench B seen on the left part of the picture.

內蒙古化石積層

Doshen 10 li north of Hallong Osso. In this place excavations had been made for a well. The sediment seems to be a reddish clay with gravel grains and whitish concretions with irregular surface, 2-3 cm. in diameter. From this locality I obtained a deer-antler, a rather large carnivore canine, several pieces of *Struthiolithus* shells as well as teeth and bones of rodents.

Debato, near Hallong Osso. This locality is in a small river-bed which has been cut down several meters in a broad valley. Like most of the water-courses in Mongolia this river-bed is dry, except for occasional cloud-bursts. Its sides are mostly covered with grass but the water-course is indicated by patches of sand and gravel in which the bones were found.

In the convex bends of the river-course there are small cliffs, at most four meters high, of red clay with calcareous concretions.

In some places there are also exposures of sand and firmly cemented, fine gravel. In the upper part of the water-course a few bone pieces were found in this gravel.

South of Tabool, 5-6 li, bones were collected at the surface, partly high up on a valley slope consisting of gravel and sand, partly on level ground amongst pebbles, probably derived from some gravel deposit.

Olan.

This locality is situated 80 li NW. from Hallong Osso and about 10 li SE. from Bogda in Gol, a place near the eastern side of the Kalgan-Urga road.

The bone locality is in a valley facing N 30° E. This valley is filled with distinctly stratified sand, and in this sand deposit an intricate system of ravines is cut down to a depth of about 15 meters. This net-work of small ravines or canyons very much resembles the loess-topography of northern China. Nowhere else in that part of Mongolia which I visited, did I see ravines cut down to such depth and extent, and topographically this locality is an entirely unique feature so far as my observations in Mongolia enable me to judge.

As previously mentioned, the material in this deposit is yellow sand with very distinct stratification. Nothing resembling loess was seen there, and it may be worth mentioning in this connection that I saw no real loess deposits in Mongolia. It appears that the loess is just as rare or entirely absent on the Mongolian plateau as it is a dominating feature all over northern China, even close up to the edge of the plateau itself.

In the bottom of the Olan sand deposit there are layers and lenses of angular gravel. The stratification of the deposit is very distinct, and often intercalations, probably somewhat clayey, thin as paper sheets, are seen interbedded between layers of pure sand. Occasional current-bedding was noticed but as a rule, the stratification is regularly horizontal. In one spot a singular phenomenon was observed, namely a zone with sharp folding of the layers. Above this zone, as well as underneath it, the bedding was perfectly horizontal.

In this sand-deposit very large bones have been collected by the local Mongols on several different occasions, and I have been able to purchase three lots of such bones. Judging from their size, they appear to belong to an elephant.

At the time of my visit no bones could be found, but I was shown the place where some of them had been collected. It was about half way up from the bottom of the ravine in perfectly horizontally stratified sand.

The Mongols told me that new bones become visible from time to time after the big summer rains.

In the summer of 1919 a Mongol brought me a considerable part of a *Rhinoceros* skull which evidently had been found in sand, to judge from the abundant quantities of sand still attached to the specimen. It was said to have come from a place called Dïsek or Diske located 120 li north from Hallong Osso. In its comparatively modern appearance with little or no mineralization, this *Rhinoceros* skull closely resembles the bones from Olan, and I tentatively assign them to the same geological group.

I have now described all vertebrate localities in Inner Mongolia which I have visited and examined. Besides the places thus mentioned, I have received small lots of bones from many other localities which are however, far too little known to be worth mentioning in this connection.

I will now try to indicate the relative geological age of these different deposits. Because of the almost complete lack of natural sections in the gently undulating Mongolian steppe it is very difficult to determine the relation and age even between localities situated close together.

Apart from a single communication received from Dr. Wiman on the preliminary examination of the Ertemte fauna, I have no other palaeontological evidence than my own preliminary, and in some cases possibly erroneous field determinations. Under these conditions the reader will understand that the statements given below are to be accepted as merely provisional,

Vertebrate deposits of the Hallong Osso region.

PLEISTOCENE } Olan and Diske, sand with *Elephas* and *Rhinoceros.*

PLIOCENE AND LATE MIOCENE {
Ertemte—Olan Chorea, sand and gravel with a microfauna: *Castor* and other *rodents, Cervavus, Struthiolithus,* etc. In Ertemte also *Amphibians, Fishes,* and *freshwater mollusks.*
Harr Obo. (also Tjel in Gol, Bonk Tjaggan, Tjaggan ör Ich, Anguli Nor.):
Red clay with *Aceratherium. Hipparion* and *Artiodactyla* the whole closely resembling the Hipparion fauna of China proper.

To the youngest group of vertebrate deposits I assign those of Olan and Diske. In both these cases the bones are found in sand, and the bones themselves have a very modern appearance with little or no mineralization. I feel inclined to refer these two deposits provisionally to the Pleistocene.

The horizon of Harr Obo (together with the probably similar but little known localities Tjel in Gol, Bonk Tjaggan, Tjaggan ör Ich and Anguli Nor) is certainly the oldest amongst the Mongolian mammal deposits. At Harr Obo the bones are found in a red clay with calcareous nodules. This red clay is a widely distributed sediment in the Hallong Osso region, and in the sections Olan Chorea 2 and 4, the red clay with nodules occurs underneath the clayey gravel and sand which contains bones of the Ertemte type. From these sections I conclude that the Harr Obo fauna is somewhat older than the Ertemte fauna, still the difference in age may not be very great. If I am right in assuming that the fossils from Harr Obo (Tjel in Gol etc.) are species belonging to the Hipparion fauna, the age of this deposit is of course settled, but it is entirely possible that I am wrong in my field identifications.

In order to bring out fully the contrast between the Harr Obo macrofauna and the Ertemte microfauna, it ought to be mentioned that the bones and teeth from Harr Obo etc. are grayish white, whereas the teeth and bones from Ertemte etc. are chestnut-brown to nearly black and consist of phosphorite.

Concerning the Ertemte fauna I have received a preliminary communication from Dr. Wiman dated Feb. 11, 1921. He reports that Dr. Söderström,

who was engaged in describing the Ertemte fauna, had identified the following types which form only a small part of the numerous species:

Talpa
Lagomys, numerous
Castor n. sp.
Lepus,
Dipus,
Cervavus,

The last named animal is a primitive deer occurring in the *Hipparion* fauna of Honan, and for this reason, Dr. Wiman is evidently inclined to consider the *Beaver* fauna of Mongolia as approximately contemporaneous with the *Hipparion* fauna of northern China. It is to be hoped that the scientific examination of the fossil material will definitely settle the relation of the Harr Obo fauna to the Ertemte fauna and of these two Mongolian faunas to the Hipparion fauna of northern China. At present I can only state that the Ertemte sand must be somewhat younger than the Harr Obo clay, to judge from the evidence furnished by the Olan Chorea sections.

Since, as noted above, the fossils in Ertemte, Olan Chorea etc. are always singularly fragmentary, it might possibly be said that these deposits are only secondary and that the bones have been washed out from some primary deposit. This is a view I held strongly at the beginning of my field work, but as the number of localities grew and I was never able to find this hypothetical primary deposit, I have been forced to believe that the localities of the Ertemte-Olan Chorea type must be accepted as primary and that the vertebrate remains are fragmentary from some reason other than redeposition.

As there are palaeontological indications that the Harr Obo and Ertemte faunas are only slightly different in age, both approximately corresponding to the Hipparion fauna, it would be natural to suggest that Harr Obo is the primary and Ertemte - Olan Chorea the secondary deposit. This is impossible because the immense masses of small bones constituting the Ertemte fauna have never been found with the big Ungulates of the Harr Obo clay. Also, in Harr Obo the teeth are grayish white, whereas in Ertemte, the vertebrate remains are chestnut-brown to black phosphorite.

When all facts are taken into consideration it seems at present more reasonable to interpret Ertemte as a primary deposit.

Let us now turn to a most fascinating problem, namely the mode of formation of the Ertemte bone deposit. When in 1919 I thought that I had identified a beaver molar in this deposit, an identification which has since been fully confirmed, I felt, I was facing a palæo-climatic problem of singular interest.

At present the Hallong Osso region is a typical steppe, where trees are exceedingly scarce, occurring only in small groups in some sheltered rock ravines. Otherwise the whole area is an open rolling grass-land. There are no permanent water courses, and the lakes are more or less saline and entirely dry a large part of the year with a thin crust of salt, which is replaced by water only after occasional rains

The finding of a fossil beaver, a type indicating forests and water, certainly invites continued research and thoughtful consideration.

The occurrence in the Ertemte deposit of large masses of *frog* bones is a further indication of aqueous conditions (I collected two recent species of frogs and toads in Mongolia, but they are of rare occurrence).

The immense abundance of fresh water shells in the Ertemte bone bed is a further evidence of the aqueous nature of this deposit. Provided I am right in the determination of certain biconcave vertebræ as belonging to fishes, there is a very strong combination of facts indicating that the Ertemte sand is a fluviatile or lacustrine deposit.

As shown by the detailed map, there is nothing in the local topographic conditions to indicate a water course, sufficient to lay down a deposit of this kind. Further down the valley a small intermittent stream flows down to Dabsun Nor as shown on the map, and a slight indication of a water course is still seen at trenches A and B. But above C there extends an entirely flat plateau at an altitude of 12-14 meters above the datum level of the map where no indication of a water course can be found.

The topographic environments of the Ertemte deposit are more likely to indicate a deposition in a bay of a lake (marked approximately by the zero contour-line).

Under the assumption that the Ertemte bone sand is deposited along the shore of a lake, I have tried to indicate in the 1: 150.000 map (Map II) the approximate extent of the ancient Ertemte lake. The dotted line marking the contour of this lake is not based upon accurate levellings, and in the very shallow undulations which are characteristic of this topograpy, the eye of the observer (even when supported by a good levelling mirror) is liable to make considerable

mistakes. Still, I think that the line in question approximately indicates a contour line passing through the Ertemte deposit. From the map we see that a flat depression extends 12 km. to the S. and E. of Ertemte. In the deepest part of this depression we meet with two small salt lakes, Dabsun Nor near Ertemte and Burtun Nor in the southernmost part of the depression.

In an effor tto gain new evidence on the interesting problem in question, I dug two trenches at a place called Darchuei, situated 2 li east from Burtun Nor. In these trenches I found a few insignificant bone fragments as well as a complete specimen and some fragments of a bivalve. The stratigraphic conditions in these trenches are shown by two adjoining figures (f. 12 & 13), which exhibit in the bottom clay or clayey sand and gravel and above this bottom-layer a sequence of gravel and sand with distinct stratification and a sharp folding of the layers. It is difficult to explain how such narrow folds could be formed in a deposit of this kind. It is rather tempting to think of the lateral pressure which can be executed by the ice on a frozen lake, but this explanation is merely tentative.§ The bones and mussels collected in this place were found in the stratified gravel.

The field observations at Ertemte and Darchuei are evidently not sufficient to solve the question whether the Ertemte sand is a fluviatile or lacustrine deposit. It is to be hoped that the examination of the fossil remains, specially the mollusks will help to illuminate this problem.

From the map it appears that the Olan Chorea, Doshan and Debato deposits occur at a somewhat higher level than the Ertmte bone sand. In Olan Chorea, which is the best known of these deposits, the bones occur in clayey gravels or sands, mixed with gravel, and in this case, not a single fresh water shell has been noticed with the bones. The type of deposit seems to indicate that it is formed on dry ground where soilflow and washouts during the rains my have contributed to form the deposits.

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§. Dr. A. W. Grabau has called my attention to a posible explanation of these contorted layers, namely that they represent a subaqueous-gliding deformation (compare Grabau: Principles of Stratigrapy, page 780 and following). Dr. Grabau has at the same time pointed out that the occurrence of these contortions, if they are due to the process suggested, forms the conclusive proof that the beds in question are of subrquatic origin. This would give a further proof of the existence of the ancient Ertemte lake, which my palaeontological studies, outlined above, have lead me to believe in tentatively.

At the present moment I hardly feel inclined to go so far as to consider my few and imperfect observations on the contortions, sufficient to serve as basis for so far-reaching a conclusion. But I feel the full strength of Dr. Grabau's argument and take this occasion to express to this distinguished colleague and highly esteemed friend my deep obligation for this suggestion, as well as for many others of the same valuable kind.

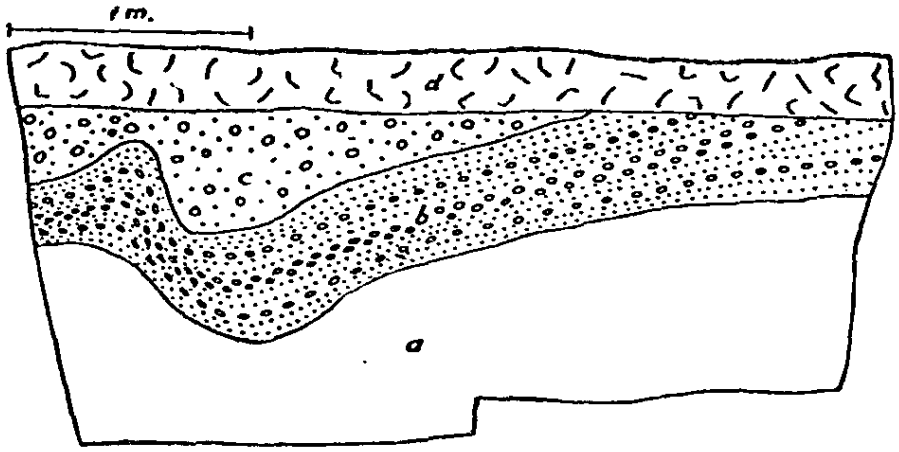

Fig. 12. Contorted layers at Darchuei.

a. Clay.
b. Stratified gravel and sand.
c. Gravel and sand without distinct stratification.
d. Humus.

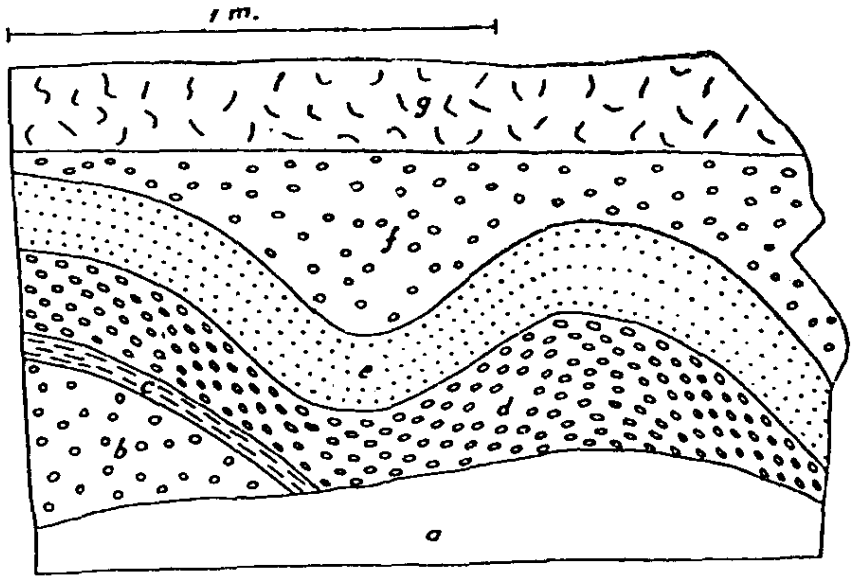

Fig. 13. Contorted layers at Darchuei.

a. Fine clayey sand with lenses of gravel.
b. Gravel without distinct stratification.
c. Clay.
d. Stratified gravel.
e. Stratified sand, partly ochre coloured.
f. Gravel without distinct stratification.
g. Humus.

If my interpretations are correct, Olan Chorea forms a drier type of deposit when compared with the markedly aquatic Ertemte sand. In this connection it may be of interest that in Ertemte, the beaver teeth are much more common than in Olan Chorea, and that in the last named place fragments of ostrich eggs are much more common than in Ertemte.

If the Ertemte sand was deposited in an ancient lake, it means, as clearly shown in the map, that the climate of that period was immensely different from that of the present time, for this region is now characterized by treeless vegetation and small residual salt lakes.

When the palaeontogists, who are now working on the mollusks and vertebrates collected at Ertemte, have given their verdict on the question *fluviatile* or *lacustrine*, it will be time to decide, what further field research in the shape of new trenches and accurate levellings should be undertaken in order definitely to solve the far reaching problems raised by the discovery of the Ertemte deposit.

It has been mentioned above in the description of the sand with *Elephas* at Olan that there occurs a zone with sharp folding of the layers. Above this zone, as well as underneath it the bedding is perfectly regular and horizontal. This may be tentatively explained as another case of subaqueous-gliding deformation in the same way as has been suggested by Dr. Grabau for similar phenomena in sand-gravel deposits within the area of the supposed old Ertemte lake (See above page 50).

If this explanation is valid it proves the limnic origin also of the Olan sand, which I have tentatively interpreted as of Pleistocene age. This again would prove a watery climate for Inner Mongolia also in Pleistocene time in much the same way as we have tried to prove it for the Pliocene Ertemte deposit.

The age of the Olan sand is so far a mere guess, and its geological features are studied only in a very cursory way. No fresh-water shells were noticed in this deposit and the reference to Grabau's way of explaining the contorted beds is here made only as an observandum to future explorers.

ON THE OCCURRENCE OF FOSSIL REMAINS OF STRUTHIONIDÆ IN CHINA.

INTRODUCTION.

In a paper "On remains of *Struthiolithus chersonensis* from Northern China" in Bulletin of the Museum of Comparative Zoology. Harvard College. Vol. XXXII. No. 7. 1898, C. R. Eastman reported the remarkable discovery of a fossil bird egg of very large size which had been found in Northern China not far from the city of Kalgan. A detailed description of the specimen was given and it was identified with the fossil egg which had been found about 1857 in the district of Cherson in South Russia and described by Brandt under the name *Struthiolithus chersonensis*. 1)

In 1915 another specimen of *Struthiolithus* was found in the Province of Honan and subsequently sold to the American Museum of Natural History in New York. A brief note on this specimen is given in the American Museum Journal, Vol. XVII, No. 6. pp. 421, 1917.

In a paper on "Dragon-Hunting in China", in "Far Eastern Review", Nov. 1919, J. G. Andersson reported briefly on the occurrence of *Struthiolithus chersonensis* in China. It was mentioned that something like 15 specimens of these big fossil eggs were known to the writer. Some measurements were given, proving that the lehgth of these eggs ranges from 173 to 186 millimeters and that consequently they are considerably larger than the eggs of recent ostriches. The age of the extinct Chinese ostrich was not definitely known but it seemed most probable that the eggs came from the loess.

In two preliminary notes on his fossil excavations in eastern Kansu, Père E. Licent reported the discovery amongst the fossil mammal bones of some objects, which he at first interpreted as pieces of pottery but in the second note supposed to be eggs of a big bird. 2)

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1). Brandt, A. Über ein grosses Vogelei aus der Umgegend von Cherson. Bull. de L'Acad. Imp. des Sci. St. Pétersbourg, T. XVIII, pp. 158-161. 1873.
2). La Politique de Pékin, August 29, 1920 (the article is dated July 17), and a second note dated August 20, 1920.

Recently another specimen of *Struthiolithus*, found in northernmost Honan, has been described by B. A. Bensley. 1)

These are the scattered notes which have so far appeared in scientific literature on one of the most interesting remains of fossil vertebrates found in China.

There is no doubt that since most remote times, hundreds of these big bird eggs have been unearthed by the farmers or washed out by the heavy summer rains. I have not had opportunity to find out whether there exist any reports on these eggs in Chinese literature, but it is worth mentioning that there is, in the Art Museum in the Forbidden City in Peking, a *Struthiolithus* egg which according to the label belonged to Emperor Chien-Lung's collection.

In the course of the extensive researches on fossil vertebrate remains, which have been carried out by me and my Chinese assistants, during the last four years, we have collected several specimens of *Struthiolithus*. While on my journey in Honan, in April and May 1921, I obtained the long-sought opportunity of examining a number of deposits where *Struthiolithus* eggs had been found.

The material collected by me is now in the hands of Dr. C. Wiman of Uppsala, who, with his associates, will, in due course prepare paleontological monographs on these collections. In the case of the *Struthiolithus* remains there are, however, such numerous field notes and other observations, in addition to the material in Dr. Wiman's hands, that I have considered it necessary to put all these data together in comprehensible shape in order to make it available, not only to Dr. Wiman, but also to other scientists interested in these remarkable fossils.

It will be seen from the following pages that the question of the age of the *Struthionidæ* remains in China is both obscure and complicated. It is my hope that this note will help to throw some light upon these problems. When once the material collected by me and by Père Licent is fully described by Messrs Wiman and Boule it will be interesting to see how their determinations of the affinity of these fossils will agree with the conclusions here reached from scattered and imperfect field observations.

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1). "An Egg of Struthiolithus Chersonensis Brandt", University of Toronto Studies, Biological Series. No. 19, Toronto, 1921.

STRUTHIOLITHUS SHELLS, CERTAINLY OR PROBABLY OBTAINED FROM THE LOESS.

In the following chapter I have brought together all my own field notes, as well as the few statements in the scientific literature on *Struthiolithus* shells which have certainly or probably been derived from the loess. The localities are arranged in geographical order beginning with Shantung.

Find 1.

Province: Shantung.
District: Chang-Chiu-Hsien (章邱縣).
Village: Sha-Wan-Tsun (沙灣村), situated 16 kilometers south of Tsao Yüan Chuang (棗園庄) station of Shantung railway

In this place my collector Yao (繳中和) met a farmer in 1919 who reported that, 7 years earlier, when preparing a terrace for cultivation, he found, at a depth of 5 to 6 ft. below the surface, 4 eggs lying close together and probably indicating an old bird's nest. Two of the eggs were taken out unbroken and kept for some time in the man's house, but, as they were considered of no value, they were used as stoppers for some pottery vessels containing oil, to protect the contents against the dust. The children of the house sometimes played with these remarkable stoppers and so they were broken. Consequently we could secure only a fragment of a shell.

This is the story as told, not only by the finder himself, but also by other villagers to Yao and his guide when they visited the place the 1st of April 1919. The following day I went there accompanied by Mr. S. H. Tsao of the Shantung Mining Board, Yao, the guide and two soldiers. We made enquiries in the most friendly way, but found the situation totally changed. The man who, on the previous day had told the story of the find and handed to Yao the fragment of an egg, now denied all knowledge of the thing. When hard pressed he admitted that he had had the eggs in his house, but said that they had been found many years ago by his grandfather. Other villagers were also very reserved; they expressed the opinion that the objects in question were "Dragon eggs", and it is probable that they feared that the appearance of foreigners, soldiers, etc. would lead to measures which might endanger the ground around their family tombs.

No further information could be gained and we had to leave the place after a rapid examination of the locality.

The village Sha Wan Tsun is situated in a small depression surrounded by limestone hills, the slopes of which are covered by the usual red clay, probably of Pliocene age.

The place where the eggs were found is situated on the west side of the road leading from the north to the village.

The prevalent rock in these hills is the ordinary Ordovician limestone, but around the terrace in question as well as lower down in the slope I noticed a kind of tuffaceous limestone, mostly whitish but with varieties in rose etc. This tuffaceous limestone is probably quite young, most likely of Pliocene age.

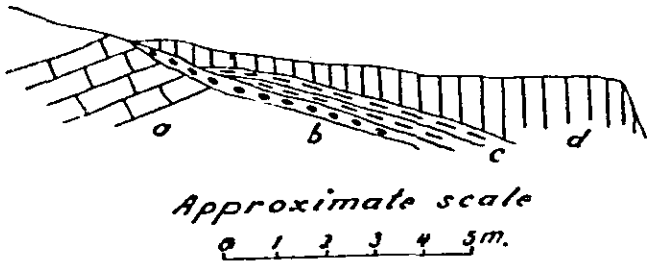

Fig. 14. Section at Sha Wan Tsun. 第十四圖 沙灣村剖面圖

(a) Tuffaceous limestone.	(a) 泥質灰岩
(b) Conglomerate.	(b) 砂礫岩
(c) Red clay.	(c) 紅土
(d) Reddish loess.	(d) 黃色紅土

As shown by the adjoined section (fig. 14) the tuffaceous limestone was in one place overlaid by a thin bed of conglomerate or gravel and this is covered by red clay. The youngest sediment is loess-like, but somewhat reddish in colour. It was impossible to state with certainty in which kind of soil the eggs were found.

Find 2.

Province: Chihli.
District: Hsi Ning Hsien.
Village: Yao Chia Chuang.

This specimen of *Struthiolithus* is of special interest as being the one through which the occurrence of this remarkable species in China was first made

known to the scientific world. The egg was brought by Rev. James H. Roberts, to the U.S.A., and there sold to the museum of Harvard University, Cambridge, Mass. It was described by Eastman in an article in the Bulletin of the Museum of Comparative Zoology, Harvard, Vol. XXXII. No. 7, 1898, and this has been until recently, our chief source of information on the occurrence of *Struthioiithus* in China.

The circumstances of the find are recorded by Eastman as follows; "Four or five years ago, a Chinese farmer, while working at the foot of a bank of earth about six meters high, dug out what he considered to be a pair of "dragon's eggs". One was broken, the other entire, and, presuming the latter to have some commercial value, he took it with him to Kalgan, and disposed of it to Rev. William P. Sprague, one of the American Board missionaries residing there. Rev. James H. Roberts, a brother missionary who has also spent many years in China, was present when the egg was sold, and on revisiting this country last spring, brought the specimen with him on behalf of Mr. Sprague, to be offered for sale to some scientific institution. Eventually it was purchased for the Museum of Comparative Zoology, where it is now deposited.

"The Chinese workman who found the egg was well known to the servants of the missionaries as a man living in Yao Kuan Chuang. This is a small village in the district of Hsi Ning, about fifty miles southsouthwest from Kalgan by road, but somewhat nearer in a straight line, as that region is very mountainous. Subsequently Mr. Sprague visited the exact spot where the eggs were dug up, in company with the man who found them, and thus satisfied himself of the authenticity of the discovery."

In the correspondence which I have had with Rev. Roberts who is now retired and living in U.S.A., he has, in a letter of Feb. 17, 1919, given me some notes on the find, which do not quite agree with those given by Eastman. Rev. Roberts' note runs as follows; "The egg was found in the autumn of the year 1895, by Chinese farmers in the district of Hsuan-Hua-Hsien, near the village of Ch'ing-K'o-Ta, (125 Li) one hundred and twenty five li (or Chinese miles) south-west of the city of Hsuan-Hua-Fu, and (8) eight li northwest of the market town of Hua-Sao-Ying-Tzu. Said farmers brought it to Kalgan, and sold it to Rev. W. P. Sprague for (300) three hundred cash,—equal to about eighteen cents U.S. gold at that time. The farmers said that the egg, and portions of another broken one like it, had been dug up, in digging under a bank of clay or loess, at a depth of (20) twenty feet below the surface."

In order to clear up this point I addressed a second letter to Rev. Roberts who very kindly wrote me a communication dated Oct. 11, 1921 408 So. Main St. Silver Lane. Conn.

From his letter I reproduce the following passages together with a sketch-map drawn by him to elucidate the situation of the finding place of the egg:

"Yao Kuan Chuang is probably a mistake for Yao Chia Chuang. There is a little village called Yao Kuan Chuang, but I believe that it has no relation to our present subject. One man, recently reported as still living, is a sure clue to the locality in which the egg was found, viz., my former cook, named Chin Ts'un Te, who lives in the village of Erh-Ma-Fang, (2) two li west of the market-town of Hua-Sao-Ying-Tzu. The man who found the egg was his brother-in-law, a member of the Kalgan (Congregational) Church, who afterward, because of a dispute regarding a piece of land, became a Roman Catholic. Mr. Charles S. Heininger, of the Methodist Protestant Mission in Kalgan, wrote to me in a letter dated Aug. 27, 1921, that Chin T's'un Te is "at his home in Erh Ma Fang".

"I was well acquainted with the man who found the egg, though I cannot recall his name at this time".

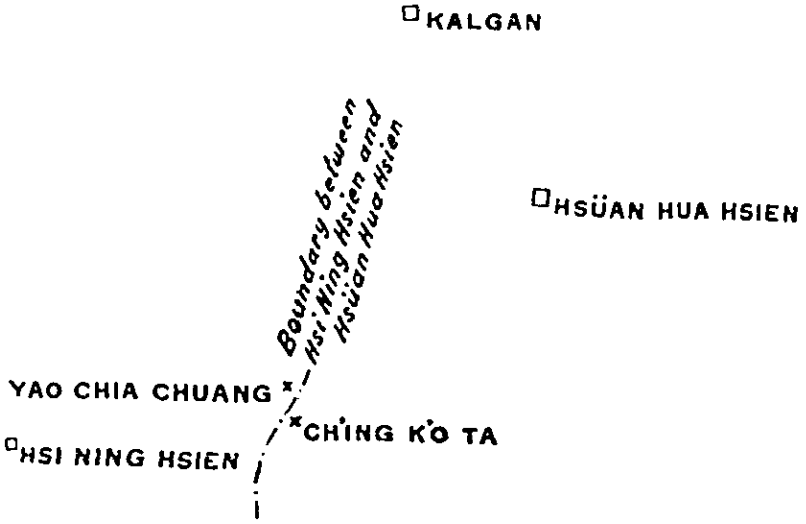

Fig. 15. Sketch-map to show the position of the villages Ch'ing K'o Ta in Hsüan Hua Hsien and Yao Chia Chuang in Hsi Ning Hsien.

"You will see, by the enclosed map, that the boundary between Hsi Ning Hsien and Hsüan Hua Hsien (counties) runs up between the villages of

Ch'ing K'o Ta and Yao Chia Chuang.' I cannot tell on which side of the boundary the egg was found, but believe it was found nearer to Yao Chia Chuang than to Ch'ing K'o Ta. (Ch'ing K'o Ta is 125 li from Hsüan Hua Fu (or Hsien) city, and 8 li N.W. of Hua-Sao-Ying-Tzu.)

"The egg was found near Yao Chia Chuang, which is near Ching K'o Ta, the former being 10 Li to the north. The former is under the jurisdiction of Hsi Ning Hsien, and the latter is under that of Hsüan Hua Hsien."

Find 3.

Province: Chihli.
District: Ching Hsing Hsien (井陘縣).
Ching Hsing coal mine.

When my collector Yao came to this mine in May 1919 he procured from a workman a small piece of an egg which had been found about ten days previously. When discovered, the egg was complete, but it had been broken while being handled by inquisitive people, so that Yao was able to get only this small fragment.

The find had been made at a spot less than 50 feet from the mouth of the pit, where excavation had been made in the loess in order to obtain material for filling in the mine. The egg was found at the very bottom of the loess wall which is here about ten feet high and consists exclusively of loess with no gravel.

Find 4.

Province: Chihli.
District: Chü-Yang-Hsien (曲陽縣).
Village: K'ou-An (口安).

In Sept. 1919, there came to my house in Peking, a curio dealer who offered for sale a *Struthiolithus* egg, the biggest I have ever seen, measuring 186 millimeters in length. He stated that it had come from T'ai-Ku-Hsien in Shansi. On the following day he returned with the different information that the egg had come from K'ou-An in Chü-Yang-Hsien of Chihli province.

These contradictory statements make the whole question of the origin of this specimen somewhat doubtful, but it is possible that one locality refers to the place where the egg was found, the other to the home of the man who had acted as intermediary in the deal.

It was said that two eggs had been found, washed out by a flood, but that one of them had become broken.

Find 5.

Province: Shansi.
District: Wu-T'ai-Hsien (五台縣).
Village: Yang-T'ai-Chuang (羊台莊).

In Jan. 1919, a Struthiolithus egg was offered for sale in Peking. The price was much too high, but I was given a chance to take a photograph and some measurements of the specimen.

It was stated that the egg had been found at a village called Yang-T'ai-Chuang, 13 Li NW. of Wu-T'ai-Shan, probably counted from the temples on the summit of that famous mountain.

The surface of the egg was stained by red earth and had calcareous concretions firmly attached to it in several places.

Find 6.

Province: Shansi.
District: P'ing-Lu-Hsien (平陸縣).
Village: Liang-Chia-T'an (梁家灘).

With the assistance of Rev. A. Berg, a Swedish missionary, in Yün Cheng, Shansi, I have obtained two eggs, one complete, one broken.

Concerning the complete egg it was said that it was found in 1911 near the above village. The find was made one li east of the village and 1.5 li from the Yellow River at the depth of one foot below the earth's surface.

Though originally complete, the second egg was broken during the transport to Yün Cheng. Whence it came is not clearly stated but, as both eggs were brought by the same man, it is likely that they both came from one locality.

Find 7.

Province: Honan.
District: Wu-An-Hsien (武安縣).

In this district two *Struthiolithus* specimens have been obtained by a resident missionary, Rev. Harold M. Clark. One of these specimens has been described by B. A. Bensley in a paper on "An Egg of *Struthiolithus Chersonensis* Brandt", University of Toronto Studies, Biological Series, No. 19, 1921.

In this paper the following statement is made:

"Concerning the present specimen, Mr. Clark states that he obtained it from a native friend who is a travelling collector and dealer in curios. There is no exact information as to the geological setting. The egg was originally owned, and probably obtained, by a native workman in the village of Chuan Hu, in the extreme northern part of Honan, near the Pe Chi Li boundary. It was later borrowed by some rich relatives and taken to a neighbouring village of I Cheng, some ten miles distant, where it was exhibited at fairs. After purchasing the specimen, Mr. Clark heard of the existence of a very large egg in this village and was able to establish that it was the one in his possession."

It is stated that Mr. Clark also obtained a second specimen but it is not very clear whether the two eggs were found together.

Another missionary, Rev. G. H. Bruce, living at the same place has, in the absence of Mr. Clark on furlough, given me the following supplementary information:

"As far as I can learn the eggs were found in the neighbourhood of I Cheng, a market-town about 40 li due north of Wuan (Hsien) city. They are reported to have been washed out of a loess clay bank by heavy rains."

From this last communication it seems highly probable that the two eggs belong to the same find.

Find 8.

Province: Honan.

District: Cheng Chow.

When passing through Cheng-Chow, the junction station of the Kin-Han and Lung-Hai railways in Honan, in Dec. 1918, I saw, in the home of a missionary doctor, Mr. A. C. Louthan, a specimen of *Struthiolithus* and was courteously given opportunity to take some measurements of this shell.

According to Dr. Louthan's statement the egg was found not far from Cheng Chow when sinking a well. Further details on the locality were not available.

Find 9.

Province: Honan.
District: Ho Yin Hsien (河陰縣).
Village: Han Wang Chêng (漢王城).

In May 1922 my collector Bai bought a complete *Struthiolithus* egg in Ho Yin Hsien in Honan. The village Han Wang Chêng, where the egg had been obtained, is situated 12 li NE of the district city, and the find was made at a small place named Mo Ch'i Ling (磨棋嶺) 4 li E of Han Wang Chêng.

Find 10.

Province: Honan.
District: Ssŭ-Shui-Hsien (汜水縣).

An egg of *Struthiolithus* was bought in 1919 for the Museum of the Geological Survey, and the man who sold it gave the following statement about the locality:

"A fossil egg was found at Monshan sometime in June, 1917, and was sold to Peking. About June 1918 two eggs were again dug out at the south escarpment of Monshan and about 30 feet underneath the surface. One of the eggs is now at Chengchow and the other is brought to Peking. The discovery of these two eggs was caused by washing away of the soil and consequently the white part of the shell was seen on the surface of the ground."

Monshan(忙 山) is a hill-range ten li south from Ssŭ-Shui city.

Find 11.

Province: Honan.
District: Kung-Hsien(鞏 縣).
Village: Chao-Kou (趙 溝).

During a trip on the Yellow River in May 1921, I was told that there was, in Chao-Kou, a complete "Stone egg", and during a visit to that settlement I was courteously shown the egg which had been found about 20 years ago floating on the Yellow River just below the village.

Chao-Kou is situated in a narrow ravine cut down in the loess. This ravine opens to the north towards the Yellow River. The loess plateau, extending on both sides of this ravine, forms a high steep cliff-like river bank, specially on the up-river side, and it is very likely that the egg had been washed out from this loess cliff, which is constantly being eroded by the swift current of the river.

The discovery of the egg floating on the surface of the Yellow River was considered by the villagers as an omen full of significance. They demanded 100 dollars for the specimen, and when I offered a twentieth of that sum, they politely declined every bargain, pointing out that the egg was the common property of the village and that they would use 100 dollars for the erection of a small temple in commemoration of the remarkable event.

It is interesting to note that the circumstances of this find are similar to those of the original specimen of *Struthiolithus chersonensis* in South Russia. In that case also the egg was found floating on the surface of a stream.

Find 12.

Province: Honan.
District: Hsin An Hsien (新安縣).
Village: Ts'ai Chia Chuang (蔡家莊).

From a village in this place I bought a perfect *Struthiolithus* egg.

The small village referred to is situated on the eastern side of a big ravine running N-S. From this big ravine a small side ravine extends eastward, and the finding place is on the northern side of the small ravine, 100 meters NE from the house of the finder, whose name is Liu Ch'ang (劉 長). The man indicated the exact spot where the egg had been found, in a vertical cliff formed artificially through excavation of the loess for household and agricultural purposes. Above the spot where the find was made there are 2 meters of gray loess and below this level about two meters of loess-like but somewhat reddish material.

Two eggs had been found, but one of them was broken during the excavation.

The complete egg has some typically loess-like incrustations.

Find 13.

Province: Honan.
District: Hsin An Hsien (新安縣).
Village: Hsia Kuo Yü (下郭峪).

When staying in Hsin An Hsien in April 1921, I was told of the existence of a "Stone egg" at the village Hsia Kou Yü, which lies 20 li NNE from Hsin An city. I visited this settlement and collected the following data:

The village is situated on the northern side of a small valley, on the south side of which there is a steep wall of red sandstone. The northern side is a more gentle, loess-covered slope. Close by there are loess cliffs, 6 to 7 meters in height, the lowest part of this loess being somewhat reddish in colour.

Two eggs were found about 10 years ago, during excavations for the erection of a building. The find was made 10 to 15 feet below the original earth surface in a somewhat reddish but otherwise entirely loess-like sediment. One of the eggs was broken during excavation, the other was carefully kept and shown to me. The price demanded was so high that I left it with the owner after having taken some measurements.

Find 14.

Province: Honan.
District: Hsin An Hsien (新安縣).
Village: Tung Huang Nü Yüan (東黃女院).

Numerous fragments have been forwarded to me of a *Struthiolithus* egg obtained from a village Tung Huang Nü Yüan (東黃女院) situated 15 li S. of Hsin An Hsien city. The find was made in a ravine named Jên Keng Kou (任坑溝) located 3 li S. of the village referred to.

Find 15.

Province: Honan.
District: Mien Chih Hsien (澠池縣).

A specimen of *Struthiolithus* is in the possession of the American Museum of Natural History in New York. In a letter of Nov. 12th 1919, Dr. F. A. Lucas, Director of that museum, has kindly given me the following note on the specimen: "Our own egg was purchased from Mr. Peter Bahr who spends a great deal of time in China collecting objects of art, etc. The information he gave in regard to the egg is as follows: 'The man who brought it to me, in June 1915, said that it was found by his brother near Mienchih in Honan on the borders of Shensi Province, and that it was sticking out on the bank of the Yellow River.'"

The statement that the find was made near "Mienchih in Honan on the borders of Shensi Province" should probably be interpreted as meaning Shansi instead of Shensi, as Mienchih Hsien is far away from the borders of Shensi Province, but extends in the north to the Yellow River, at the northern side of which is Yuan Chü Hsien of Shansi Province.

Find 16.

Province: Honan.
District: Mien Chih Hsien (渑池縣).
Village: Fêng Ming P'o (凤鳴坡).

From this village which is located 22 li N from Mien Chih city I have obtained an egg through the kindness of Rev. M. Ringberg in Mien Chih Hsien. In April 1921 I had an opportunity to visit the place and collect the following data:

The egg was found two li east from that village in an exceedingly narrow ravine extending N-S and opening towards the Mien Chih plain. The find was made in the northernmost part of this ravine, near its upper end at the bottom of the ravine, 17 meters underneath the level of the ground at the edge of the ravine. The material is everywhere loess-like but shows vaguely a kind of stratification due to a variation in color in different levels of the loess. A bed of calcareous concretions was found at the very bottom of the ravine about 10 meters north of the finding place, otherwise no concretions were seen in this section.

The sediment in which the discovery was made is loess-like but slightly multi-colored. Everything goes to prove that it is genuine loess. Some land shells *(Helicidæ)* were collected in the same level.

Find 17.

Province: Honan.
District: Mien Chih Hsien (渑池縣).
Village: Kuo Yü Kou (郭峪溝).

In a curio shop in Mien-Chih city I bought, in 1921, a broken *Struthiolithus* egg. The owner of the shop gave me information as to the village Kuo Yü Kou where the egg had been found. Some few days later I went to this village which is 10 li NW from Mien Chih city.

The discovery was made in 1917 when digging a cave to be used for a store-room, close by the house in which the finder lives with his family. Two eggs had been found during this excavation. One occurred in the middle of the cave four meters below the surface. This specimen was complete when in situ, but was somewhat broken during the excavation. That is the specimen bought by me in Mien Chih city.

Broken pieces of another egg had beed noticed by the man in the wall of the cave, and these fragments were still in situ and were shown to me. In this way I had the pleasure, for the first time, of excavating a *Struthiolithus* egg and of proving beyond doubt that they occur in loess. This broken egg was found one meter inside the mouth of the cave and about five meters below the surface of the earth in absolutely typical loess. In this case the egg was broken before burial as fragments were scattered in the loess about a foot apart. I also collected numerous land mollusks around the spot where the excavation was made.

Find 18.

Province: Honan.
District: Mien Chih Hsien (澠池縣).
Village: Yang Shao Tsuh (仰韶村).

In a paper under the title "An early Chinese Culture" in the Bulletin of the Geological Survey No. 5, I have described an extensive prehistoric site of Æneolithic type at Yang Shao Tsun in Mien Chih Hsien of Honan province. Over an area more than 600 meters in length and nearly 500 m. in width the Tertiary red clay and locally the loess is covered with a culture stratum, 1-5 meters in thickness which contains stone and bone implements as well as innumerable fragments of pottery of many varied types.

In the spring of 1922 my collector Pai, when excavating in the culture stratum for collecting artifacts and pottery, found in one place in the typical ashy culture soil not less than 83 fragments of *Struthiolithus* shells. One of these fragments attains a length of as much as 69 millimeters, but most of them are very small, some few have been found to fit together, and it is very likely that they all belong to one specimen as they were found close together.

This find raises a number of important issues. When questioned, Pai absolutely maintains that the find was made in the "ashy earth", the characteristic culture stratum. Pai is very familiar with the site and its soil, so there is little probability that he is mistaken in his statement.

Under these circumstances is seems unavoidable to assume that someone of the ancient Yang Shao dwellers had the egg in his hands and reduced it to fragments. Two alternatives have then to be taken into consideration:

1) That *Struthiolithus* still lived when the Yang Shao culture stratum was formed and that the egg shell fragments are refuse from a successful hunt for the big eggs.

2) That a fossil *Struthiolithus* egg had been found by the Æneolithic man, much in the same way as we make such finds as the present day.

As has already been indicated in some of the local descriptions and will be more fully shown in the following, I consider the *Struthiolithus* eggs to be a characteristic fossil of the loess.

With our present imperfect knowledge it is impossible to state the exact age of the loess, but is seems most probable that it represents the Middle Pleistocene, that is the period of Palæolithic Man in Western Europe. From the Palæolithic to the end of the Neolithic is an immense period of time, and it is hardly probable that a bird, like the ancient Asiatic Ostrich, survived until the dawn of historic time, even if we take into consideration that the unbroken topography of the loess steppe actually still prevailed at the time of the Yang Shao culture, and that the site contains indubitable remains of a *Hystrix* which seems to have in more recent time disappeared from this area.

A direct proof that the Yang Shao dweller handled an already fossil shell is seen in a loess-like calcareous incrustation upon the outside of two of the fragments indicating that the shell was probably obtained from the loess which is common in the surroundings of the site.

Our exploration of the Yang Shao site has lead to the remarkable conclusion, that the big ravines surrounding the site have been cut down during a period later than the formation of the site. This seems to make it less likely that the Yang Shao dwellers could have come across a specimen of these eggs which are mostly found in the ravine walls. But as a find of *Struthiolithus* has been made also near Yang Shao Tsun in very shallow depth in the loess, it is by no means improbable that one of these eggs could have been washed out in the shallow water courses of the Yang Shao period.

Just as the loess has formed the soil from which grew up the Chinese culture, so it seems that the index fossil of the loess, the *Struthiolithus* shells, have been in the hands of the Chinese from the earliest times.

I felt much impressed when for the first time I saw in the Art Museum of the Forbidden City Emperor Chien Lung's *Struthiolithus* specimen, but that find is a discovery of yesterday when compared with the fragments found in the Yang Shao site, which seem to prove that the Man of those distant days was musing on those gigantic shells much in the same way as is the case with the farmer of today.

Under the above numbers 1-18 I have brought together all the finds of *Struthionidæ* eggs in N. China which seem to belong to *Struthiolithus chersonensis* and which probably are of approximately the same age.

I have not tried to undertake a close study of these specimens which have come into my hands on widely different occasions. Those, which have been bought by me have been shipped to Dr. Wiman in Uppsala with the exception of one (No. 10) presented to the Museum of the Geological Survey of China and another handed over to Dr. G. D. Wilder (No. 16). It is expected that the material of *Struthiolithus* eggs now in Dr. Wiman's hands will be carefully described by him or one of his associates.

In the meantime I will be satisfied to give here some measurements of the eggs which have passed through my hands. I do this specially because I have been able to measure some specimens (finds 5, 8, 11 and 13) which were not obtainable through purchase but which, thanks to the courtesy of the owners, were offered to me for taking of the desired measurements. In the table (p. 69) I have also included the measurements (No. 2 and 7) which have been published by Eastman and Bensley.

All in all, I have been able to communicate here measurements of 12 eggs of the Chinese fossil ostrich. In a small table (p. 70) I have given the maxima and minima as well as averages of these measurements together with the measurements of the Brandt type specimen from Russia as well as some measurements on eggs of the modern *Struthio camelus*. It will be seen from this condensed table that the dimensions of the Chinese *Struthiolithus* in dimensions well accord with those of the Russian type specimen. At the same time we see that all eggs of *Struthiolithus* are in every measurement bigger than the eggs of the modern ostrich. It thus seems probable that these fossil specimens all belong to a species somewhat larger than *Struthio camelus*.

	Locality	Kind of Sediment.	Number of eggs.	Longitudinal axis mm.	Equatorial circumference mm.	Major circumference mm.
1.	Shantung, Chang Chiu Hsien, Sha Wan Tsun.	Red clay and reddish loess.	1	—	—	—
2.	Chihli, Hsi Ning Hsien, Yao Chia Chuang.	"Clay or loess."	2	180	465	514
3.	Chihli, Ching Hsing Hsien, Ching Hsing coal mine.	Loess.	1	—	—	—
4.	Chihli, Chü Yang Hsien, K'ou An.	——	2	186	492	537
5.	Shansi, Wu T'ai Hsien, Yang T'ai Chuang.	——	1	183	486	530
6.	Shansi, P'ing Lu Hsien, Liang Chia T'an,	——	2	168	452	485
7.	Honan, Wu An Hsien.	"Loess-clay"	22	181	458	513
8.	„ Cheng Chow.	——	1	180	462	524
9.	„ Ho Yin Hsien, Han Wang Chêng.	——	1	184	460	520
10.	Honan, Ssü Shui Hsien, Mon Shan.	——	2	173	442	493
11.	„ Kung Hsien, Chao Kou.	Probably loess.	1	—	479	535
12.	„ Hsin An Hsien, Tsai Chia Chuang.	§ Loess.	2	180	449	508
13.	Honan, Hsin An Hsien, Hsia Kuo Yü.	Reddish loess.	2	—	468	516
14.	Honan, Hsin An Hsien, Tung Huang Nü Yüan.	——	1	—	—	—
15.	Honan, Mien Chih Hsien.	——	1	—	—	—
16.	„ Feng Ming P'o."	§ Loess.	1	179	479	518
17.	Honan, Mien Chih Hsien, Kuo Yü Kou.	§ Loess.	2	—	—	—
18.	Honan, Mien Chih Hsien. Yang Shao Tsun.	Secondary in Eneolithic culture site, primarily probably in loess.	1	—	—	—
			Averages	179	466	516

§ Indubitable finds *in Loess*, examined by J. G. Andersson.

		Longitudinal axis mm.	Equatorial circumference mm.	Major circumference mm.
Struthiolithus chersonensis of China. 12 specimens measured.	max.	186	492	537
	min.	168	442	485
	aver.	179	466	516
Struthiolithus chersonensis of Russia. Brandt's specimen.		180	460	520
Struthio camelus. 3 specimens measured.	max.	164	424	471
	min.	160	412	460
	aver.	162	419	464

In a special column of the table page 69 I have indicated the number of eggs met with in each find. We infer from this column that in one case four eggs were found together, in 7 or probably 8 other cases two eggs are reported; in the remaining 9 cases only a single egg has been made known. With reference to this last-mentioned group it ought to be remembered that in some of these cases so little is known about circumstances of the finds that possibly in some of these cases more than one egg might have been unearthed without this fact having come to my notice. Consequently it may be safe to say that in about every second find of these eggs more than a single specimen has been discovered. This is certainly a significant circumstance indicating that the finding places in many cases were nests in which the eggs for some reason have not been allowed to hatch.

A further conspicuous feature is that nearly all the eggs are complete when in the soil. Some few have been broken by careless excavation; only in a single case (No. 17) have we been able to state, that an egg was in broken state

already in situ. It is certainly a startling fact that these thin empty shells have been able to withstand the pressure of the surrounding loess. It seems rather likely that groups of eggs were buried during dust-storms in the eolian sediment and that this gentle way of deposition accounts for the fact that the eggs are nearly always unbroken. It is interesting to note that in all the cases where *Struthionidæ* eggs are found in Pliocene deposits of fluviatile (or otherwise non-eolian) nature the eggs are always found as broken fragments.

In the above discussion it has been anticipated that the *Struthiolithus* eggs have come from the loess. In a column of the table page 69 I have given the available data as to the sediment in which the eggs have been found. In several cases the sediment is of indifferent nature, reddish loess or loess-like clay. But in three localities, marked with an § in the column, I have personally been able to prove that the eggs were found *in loess*. Specially convincing is find 17, where I was able to excavate a broken egg from typical loess. From these facts I think it safe to assume that *Struthiolithus chersonensis* belongs to the loess fauna. As fossil vertebrates are generally very rare in the loess, I will go a step further and say that *S. chersonensis* is the index fossil of the loess.

STRUTHIONIDÆ-REMAINS BELONGING TO THE HIPPARION-FAUNA.

Shansi, Pao Te Hsien.

In a letter of January 11 1921 Dr. Wiman reports an interesting find amongst the material sent to him from the Hipparion beds at locality 30, T'ai Chia Kou (戴家溝) in Pao Te Hsien, NW Shansi on the Yellow River. This region is the most famous of the districts which provide the Chinese medicine market with "dragon bones" for medical use. The fossil remains of the Hipparion fauna occur in an excellent state of preservation, and one of my collectors, Chang, has brought from the several bone pits, rich consignments of bones which are now in Dr. Wiman's hands for examination. Among the specimens was a slab of clay with some bones slightly visible which, when prepared, proved to be the pelvis of a big Ostrich bird.

As far as hitherto known, no other *Struthionidæ* remains have been obtained from the Pao Te Hsien region in spite of the careful examination of this area which has been recently undertaken by Dr. O. Zdansky. Consequently it seems that the species is of rare occurrence.

2. Kansu, Ching Yang Fu.

In "La Politique de Pékin" for the 29th of August 1920, there appeared an article reporting a most interesting palæontological find made by the distinguished French naturalist, Père E. Licent, S. J.

In easternmost Kansu, 45 kilometers north from Ching Yang Fu (慶陽府), at a place called Hsin-Chia-Kou (辛家溝), Père Licent discovered a rich deposit of fossil bones which were excavated by him most carefully and with brilliant result.

The numerous fossil mammals thus unearthed were designated by Père Licent as "une contribution à l'étude de la fauna quaternaire de ce pays," thus indicating his opinion as to the age of these fossils.

He also considers that he found in this place traces of very early Man, and, amongst other objects, are mentioned "En trois points différents, des débris de poterie fine, très dure, mince, non ornée, pris entre les ossements. Un des trois gites présentait une cavité de 15 cm."

This communication was written on the 17th of July, when the excavation was only partly completed. On the 20th of August when the excavation at Hsin-Chia-Kou was finished, Père Licent wrote a second report which has been printed as a separate leaflet, a copy of which has been presented to the writer of this paper.

In this second communication there is a further note on this supposed pottery; "Un nouveau fragment, de ce qui semblait être de la poterie, assez considérable, a été trouvé au milieu des ossements. Le manque de toute trace de bord, d'anse et de fond a éveillé les premiers doutes sur la nature de ces débris. L'acide chlorhydrique les dissout entièrement."

In a foot-note he adds the following important remark:

"Coque d'oeufs énormes peut-être." From this statement it is clear that Père Licent had found out the probable nature of these objects, and in a letter to him of Oct. 18th 1920, I wrote; "I think it very probable that the objects which you first guessed to be pottery are fragments of the shells of *Struthiolithus*."

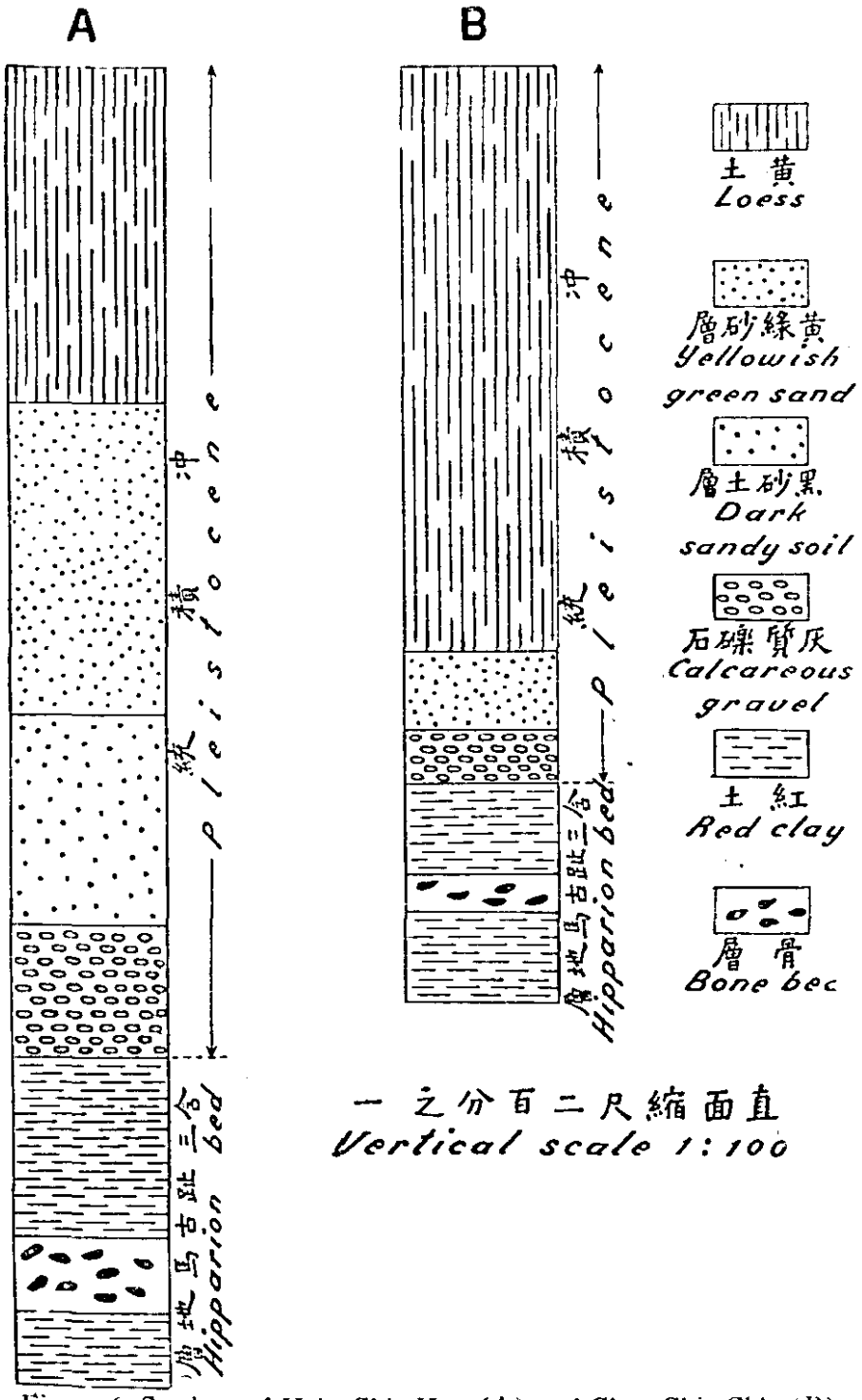

Fig. 16. Sections of Hsin Chia Kou (A) and Chao Chia Ch'a (B). (According to Pere Licent).

第十六圖 辛家溝(A)及趙家杈(B)之村狀剖面圖 (據李桑神父)

In June of 1921, when Père Licent had the collection arranged in his scientific laboratory in Tientsin, he most courteously invited me to see it, and it gave me great pleasure to study, under his guidance, this extensive and admirable material. On this occasion two things became clear to me:

1. That the fragments of big bird's eggs are very similar to *Struthiolithus*.

2. That the vast majority of the large fossil mammals in the Licent collection belongs to the *Hipparion* fauna. *Hipparion* is numerous and several other forms are identical with those collected by us in the Hipparion beds of Honan and Shansi.

In his second report Père Licent mentions the discovery of another deposit at Chao Chia Ch'a. He has given geological sections from both these deposits which are quoted below.

Hsin Chia Kou (辛家溝)

"Terre arable	néant
Terre jaune avec nodules calcareux petits	8m. 60
Terre sableuse, jaunâtre et verdâtre	8m.
Terre noire sableuse	5m. 50
Couche de cailloux calcareux, par endroits superficiellement noircis, non éclatés, arrondis, atteignant 25 cm	3m. 40
Terre rouge, avec zones d'allure irrégulière très dures, incrustées de calcaire: "pai kiao gni"	4m. 70
Couche à ossements	2m.
Terre rouge	?"

Chao Chia Ch'a(趙家杈)

"Falaise de terre jaune avec terre noire à la base. (Hei kiao gni)	15m.
Sable verdâtre, jaunâtre, bleuâtre,	2m.
Cailloux calcareux	1m. 40
Terre rouge	2m. 30
Couche ossifère	lit d'ossements lacunaire sur un mètre de hauteur.
Terre rouge	?
Grès pourprés	?"

It is evident that there is much similarity between these two sections and I have tried in the adjoined diagram to bring them together, at the same time indicating the probable geological age of the different layers.

In both his reports Père Licent states that the bird's eggs are found "Entre les ossements.", or "Au milieu des ossements.", as the expression is, in the second paper. These statements, combined with my identification of the big mammal bones as belonging to the *Hipparion* fauna, make it evident that the egg shells found by Père Licent are decidedly different in age from the true *Struthiolithus chersonensis,* which is, as shown above, a fossil of the loess. My rapid examination of Père Licent's material only sufficed to prove the general similarity of his shells with *Struthiolithus.* It remains for the more careful examination which will be undertaken by Professor M. Boule in Paris, to make clear the identity of these shell fragments which, to judge from the stratigraphic evidence may be found more nearly related to the Struthio-like bird, the pelvic bones of which have been identified by Professor Wiman from *Hipparion* beds of Pao-Te-Hsien in NW Shansi.

3. Shansi, Hsiang Ning Hsien.

(Doubtful whether belonging to this geological group).

In Dec. 1919, my collector Liu made in Southern Shansi in Hsiang Ning Hsien (鄉寧縣) at the place called P'an-T'ao-P'o (蟠桃坡), situated 2 li NE from the district city, an interesting collection which can be described as follows.§

The collection consists of three different groups of elements:

1. Big horse teeth and large leg bones, some of them embedded in gray reddish loess-like "clay" with spots of deep, red-brown fat clay.

2. Numerous fragments of an ostrich egg; some pieces seem to have been incrustated with hard clayey substance after they were broken. The earth attached to some of these fragments very much resembles that surrounding the horse teeth and big bones of group 1.

3. Numerous small rodent teeth and bones; the earth attached to some of them is very like that of groups 1 and 2.

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§. Locality 34 of our locality register.

Liu makes the remark that the bones of group 1 were found inside the earth, whereas groups 2 and 3 were lying on the surface of the very steep slope.

The sediment mostly resembles a reddish clay but it is not impossible that it is a reddish variety of the loess.

At present, as the fossils are not determined, it is not possible to form a definite opinion as to the significance of this find. As indicated by the finder, it is possible that the egg shell fragments are younger than the teeth and bones included in group 1. In this case it is probable that they are identical with *Struthiolithus chersonensis* and date from the loess period. On the other hand, it is possible that all the fossils in this find belong to the *Hipparion* fauna, in which case these egg shell remains may have to be compared, not with *Struthiolithus chersonensis*, but with the fragments of egg shells found by Père Licent in the Hipparion beds of Eastern Kansu.

4. Struthiolithus-like shell fragments from Mongolia.

In another of these essays, "Some Vertebrate Deposits In Inner Mongolia", I have described some fossil fragments which have been named, in that article, "*Struthiolithus* shells".

These fossils were found in the Hallong Osso region of Inner Mongolia, at Ertemte, Olan Chorea, and Doshen. They occur in gravel and sand mixed with clay (Olan Chorea and Doshen) or fine sand with fresh water mollusks (Ertemte). The egg shells occur with a characteristic mammal fauna, the most remarkable components of which are *Cervavus, Castor n. sp,* and a number of small rodents. This fauna is considered to be nearly contemporaneous with the *Hipparion* fauna.

The *Struthiolithus*-like remains are always broken into small fragments of some few cm. length. There is little doubt that these objects belong to the shell of some big bird's egg, probably a member of the *Struthionidæ*. In certain cases at least, these Mongolian egg shells are thinner than the true *Struthiolithus chersonensis* of China proper, and I am under the impression that the Mongolian specimens belong to a smaller species.

DEPOSITS OF CALCAREOUS OOZE AND TUFA AT TABON ARSHAN, INNER MONGOLIA.

Towards the end of my sojourn in Inner Mongolia in the summer of 1920, I made an excursion from the 12-20 of August to the edge of the Mongolian plateau 100 km. WSW of Kalgan, in the company of Rev. J. Eriksson of the Swedish Mongol Mission.

On the 16th we travelled from the Fish-river (Djaggaste) southward in order to visit a coal mine at Tjaggan Obo. The Mongol who acted as our guide told us about a famous spring, or better five springs (Tabon Arshan in Mongol or Wu-Ko-Chüan (五個泉) in Chinese), which was to be seen close by the road some five km. before reaching Tjaggan Obo.

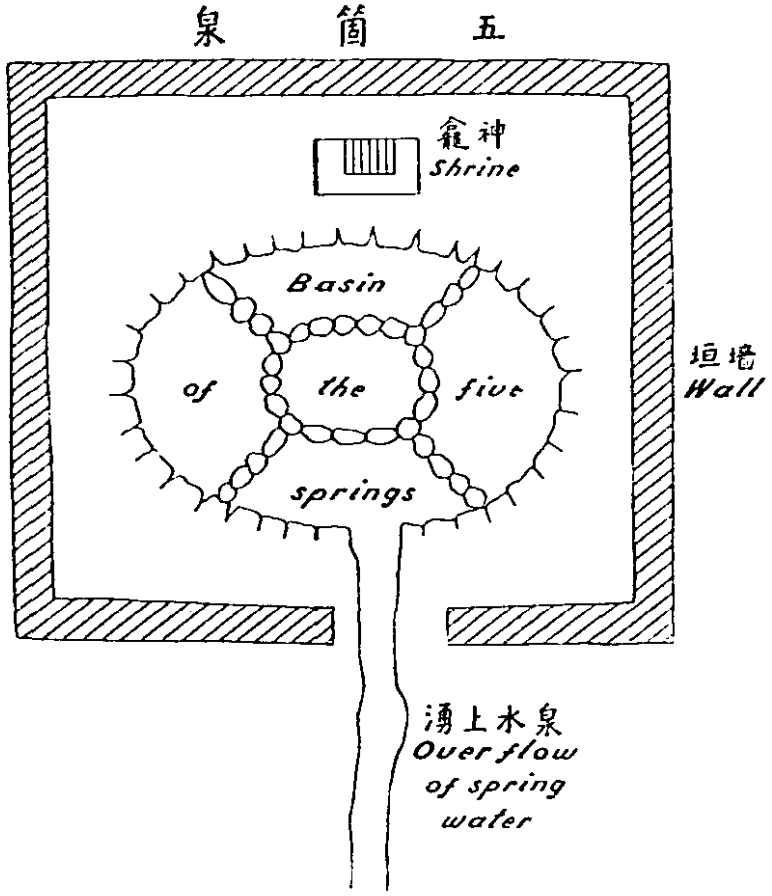

Fig. 17. The spring basin, Tabon Arshan.

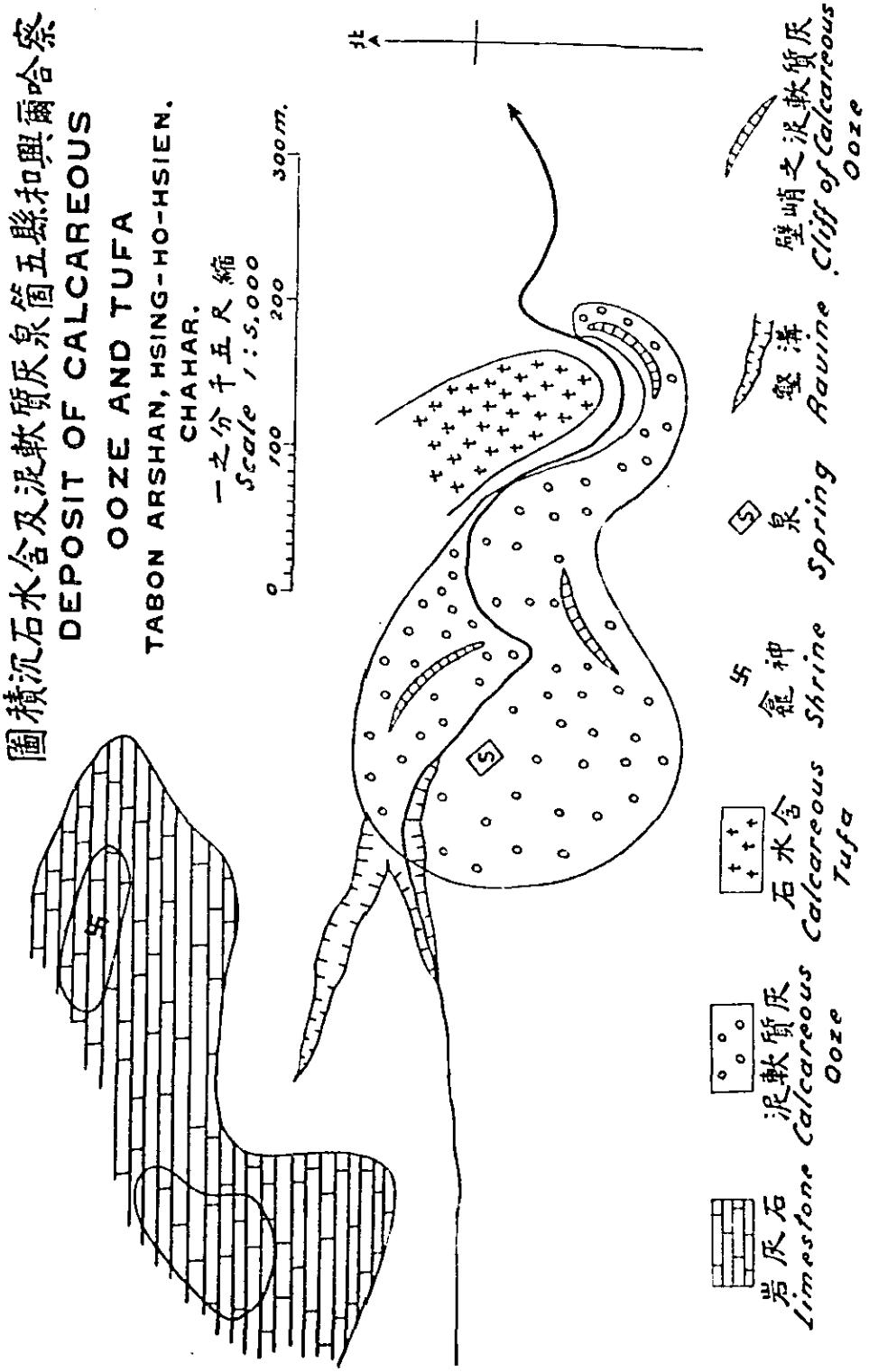

Fig. 18. Deposit of calcareous Ooze and Tufa at Tabon Arshan.

The spring is only a few hundred meters from the road along a small brook descending from some limestone hills. The place where the water flows out of the ground is surrounded by a wall, and a small shrine is built behind the spring. The spring-basin which is built of stone blocks is divided into five compartments approximately as shown in fig. 17. These are "the five springs" in which the water intermittently bubbles up from the ground, at one time in one, and the next time in another part of the common basin. It is said that the taste of each of the five springs is different, and in fact I think that I noticed that at least two or possibly three of them yield waters of different tastes, one being of a specially palatable, sour refreshing kind. Unfortunately I had no means of testing the water or bringing a sample, so I am unable to state the precise nature of this remarkably pleasant water.

The water from the spring flows away in a small streamlet which joins the little brook. It was, at the time of our visit, considerably colder than the water in the brook. It may be added that the latter flows at the surface only for some tens of meters above the point where it joins the spring water. Higher up its flow is underground, trickling through the gravel.

From a geological point of view this spot possesses a special interest because of the deposits of calcareous sediments around and below the spring. It is partly surrounded by cliffs, 3.0-3.7 m. high which exhibit a whitish, calcareous ooze (in Swedish *kalkgyttja* or *bleke*) with very numerous shells of small fresh-water mollusks. In most places the ooze shows a rather distinct stratification. The observed maximum thickness of the ooze is 3.7 m., and throughout it is rich in mollusk shells.

Large masses of the once continuous ooze deposit have been removed, and it seems probable that the deposit is dug up by the farmers and carted away to be used as a fertilizer. But all evidence goes to show that the larger part of the removal of the ooze-deposit is due to erosion by the little brook which has cut the cliffs shown in the figures and in the map.

It looks as if the spot, where the spring now wells forth, was once buried beneath several meters of ooze as indicated in fig. 19. When we notice how the spring is located in the centre of the upper and broader part of the ooze deposit, it may well be questioned whether there is not some genetic connection between the spring and the formation of the ooze. Very likely the small area occupied by the ooze deposit once formed a pool fed partly or largely by the spring and teaming

with mollusks. At the bottom of this pool the ooze was formed in evergrowing layers. The real connection of the spring water with the deposition of the calcareous mud will evidently not become understood until we know the composition of the former. It is needless to point out that my rapid and superficial survey of this rather unexpected deposit is by no means adequate to solve the problem of its origin regarding which we can at present only form vague conjectures.

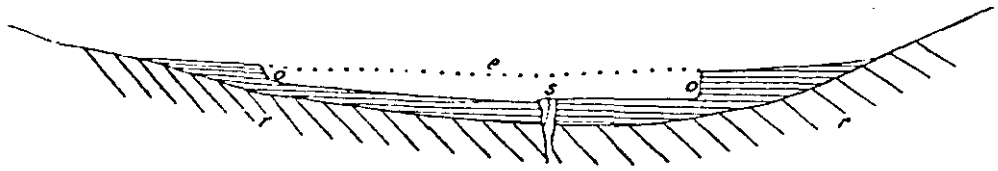

Fig. 19. Section through the ooze deposit of Tabon Arshan.

第十九圖　五箇泉灰質軟泥剖面圖

(r) Rook-floor. (r) 底部岩石
(s) Spring. (s) 泉
(o) Ooze. (o) 灰質軟泥
(e) Original surface of ooze-deposit. (e) 灰質軟泥層舊面

If I am right in the assumption that the place once formed a pool of nearly stagnant water fed by the spring, and that later the brook has gained in importance as an eroding factor, it seems likely that these local changes of conditions may be due to a change of climate which will be better understood when the material of the molluscan fauna has been closely studied.

Besides the calcareous ooze there is another lime deposit of recent date, namely tufa, which is best developed on the north side of the brook where it makes a bend surrounded by a narrow tongue of the ooze deposit.

The calcareous tufa is hard, whitish grey in colour, often of botryoidal structure or with contours which clearly indicate the embedded plant remains. The plants collected in this tufa are rather poorly preserved, only some few leaves seem to offer a chance for a specific determination. Besides the plants there are a number of gastropod shells, probably Helicid land-shells, which are excellently preserved.

I had no time to follow the extent of the tufa deposit towards the slope of the limestone hill on the NW but very likely it extends some distance uphill in that direction.

A priori, it seems most likely that the two adjacent deposits of calcareous matter, the ooze and the tufa, are approximately contemporaneous, in which case the ooze represents the subaqueous deposit in a nearly stagnant pool, whereas the tufa is formed by lime-charged water trickling down from the nearby limestone hills.

It is to be hoped that these interesting problems will be more fully elucidated by the examination of the mollusks and plants collected from these deposits.

While expressing my regret for the superficial nature of my examination of this interesting locality, I want to thank my good companion and friend Rev. J. Eriksson who with my collector Liu, made the whole collection from the tufa, while I, in the meantime, devoted my time exclusively to the ooze.

SOME PEAT-BOGS IN THE PEKING PLAIN.

So far as known peat is of comparatively rare occurrence in China.

In certain parts of Yunnan peat deposits are numerous and utilized as a local source for the production of fuel.§

From southern Manchuria Richthofen reports the occurrence of peat-bogs which are in certain places worked by the local population.§§

These are the only notes which I have been able to find about the occurrences of peat in China. In the semi-arid region of Northern China deposits of this kind could hardly be expected, and the discovery of a number of veritable peat-bogs in the open Peking plain and the existence of a noticeable local peat industry unknown to mining circles in the immediate vicinity of the capital is something of a surprise.

Several years ago one of my private assistants, Chen, told me about the existence of what he named grass coal (草煤) in San Ho Hsien (三河縣), 70 li E. of Peking. He also brought me a specimen of typical peat.

Pressure of other work prevented me from visiting the place until in May 1922 when Chen brought in a most remarkable find, namely the easily recognizable skull of a *water buffalo* which had been found in one of the three peat-deposits reported to occur in San Ho Hsien and the adjacent Chi Hsien (薊縣).

While the occurrence of peat in the dry Peking plain is an unexpected and remarkable phenomenon, the finding of remains of a water buffalo, an animal characteristic of the watery region of southern and central China is a truly astounding discovery.

During the period from the 11-13 of May 1922 I made with Chen a motorcar trip to the peat-deposits, and my observations on this journey will be briefly described in the following.

From Peking we travelled to Tungchow on the good motor road, crossed the Yün Liang Ho (運糧河) and then continued the journey on country roads, very little fit for motor traffic. Our route was all the time in the open plain which

§. A. Lecâre. Etude geologique et minière des provinces chinoises voisines du Tonkin. Extrait des Annales des Mines. Oct.—Nov. 1901. P. 42.
§§. Richthofen. China II. P. 111.

Peat-deposit at Pu Lao Ting, San Ho Hsien, Chihli.
三河縣不老淀泥炭

at this period of the year, near the close of the rainless season, presents a very arid appearance, this being accentuated in some places on crossing small areas of dune sand.

When approaching San Ho city the mountains on the north become more distinctly visible. The actual distance from the city to the nearest hill-ranges is stated by Chen to be about 30 li.

The peat deposit first visited by us is at Pu Lao Ting (铺老汀), 7 li. S. from San Ho city. It is situated in a slight depression of an estimated depth of 2-3 meters.

The peat was dug in numerous pits, and the area where excavations had been in progress has a length of 500 meters. Outside this area two isolated pits were seen, one further north, another to the east.

As shown by the section (see below) the thickness of the peat in this place is 1.25 meters with an overburden of 2.95 meters of ooze and loess-like soil.

The peat has been worked during the last 15 years as a local supply of fuel. The excavation is made in rectangular open pits, and the work is carried on only from early spring to the beginning of the summer rains, when the pits are flooded and mostly entirely demolished.

On Pl. VI is shown how the pits lie close together forming in fact a nearly continuous trench. In the foreground of the picture are the wasteheaps of the removed over-burden and in the back-ground the stacks in which the peat is piled up for drying. These piles are made in a size that they represent a dollar's worth of dried peat. I could not make out the exact weight of such a pile but was told that it is more than thousand chin or Chinese catties (600 kg.) I believe that this figure is considerably exaggerated.

At the time of our visit there were 12 pits working, and I was told that more than a hundred men were occupied in this industry. The peat is sold to consumers within a radius of not more than 40-50 li.

As shown by the sections, the thickness of the peat in this locality is considerably greater than at the two other places to be described below. But it is stated by all parties even the workmen at Pu Lao Ting, that the peat here is of an inferior quality when compared with that of the two other localities.

Pu Lao Ting, the locality already described, is situated 70 li E. of Peking and 5 li S. of San Ho city.

The second place is located 20 li E. of San Ho city, and the nearest village is Wu Pai Hu (五百戶). The peat deposit is 2 li S. of this village.

The peat is here found in entirely level ground, without any such depression as was noticed in Pu Lao Ting.

In some places there is a single seam, 60 cm. thick but in others there are two thin seams, each of 20 cm. thickness separated by a parting of 30 cm. This is the section reproduced in the diagram fig. 20. The overburden is 1.8 m thick.

This deposit was known and worked more than 15 years ago, before operations were begun in Pu Lao Ting. The peat is dug in parallel trenches, In spite of the dry season the work was much hampered by water. The production is here very small occupying only about twenty men.

The third peat locality is situated 20 li. E. of Wu Pai Hu and is located in Chi Hsien (薊縣), 25 li WSW from the district city. The name of the place is Mu Chuang Tzŭ (謨莊子).

In this place also the peat deposit is in the level plain without any indication of a depression. The peat area is here comparatively very large, about 2 li in E-W and 2½ in N-S direction. Over this area there are very numerous working places, according to local information about 100 pits. As there are 7-8 workmen for each pit, that would make 7-800 men occupied in this industry. This is the earliest known of the three peat deposits and is said to have been discovered more than a hundred years ago.

The thickness of the peat is 30-70 cm. with an overburden of 2.85-4.6 meters of sand, loess and lower down ooze.§

Where the overburden is not too heavy, the peat is excavated in the same way as at Pu Lao Ting. Open pits, of rectangular shape 4x7 meters are dug with complete removal of the overburden. When the peat in such a pit is exhausted, the pit is filled with the overburden from a new pit opened nearby.

Where the overburden is too thick, another method of working is preferred. A narrow vertical shaft is sunk down to the peat. From the bottom of this shaft short tunnels are driven into the peat bed.

In addition to the three places here mentioned, I was told that peat also occurs in Ping Ku Hsien (平谷縣) at a place named Kao Tsun (高村) 8 li S. of the district city. I did not visit this place.

§. A dark soil, probably composed largely of microscopic plant remains, which in these sections underlies and overlies the peat, is here named ooze, which is, as far as I know the nearest English word for *gyttja* that is in Swedish the exact expression for this kind of organic sediment which is a common occurrence in Scandinavian peat-bogs.

In fig. 20 are given sections from the different peat-localities mentioned above. I shall describe these sections in some detail.

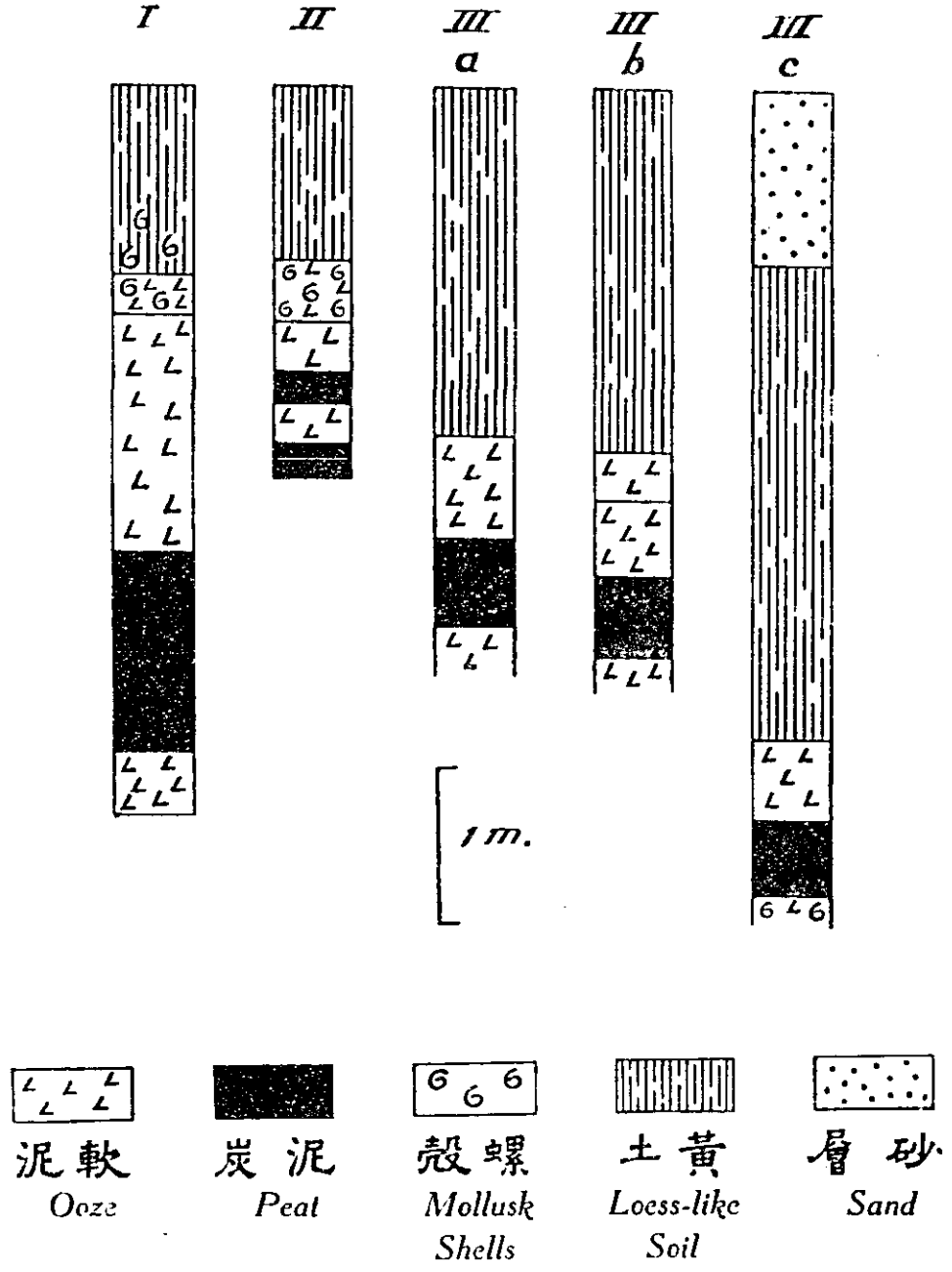

Fig. 20. Sections through the peat deposits of Pu Lao Ting (I), Wu Pai Hu (II), and Mo Chuang Tzu (III).

环湖淀(I)五百戶(II)及漠莊子(III)草煤層柱狀剖面圖

I. Pu Lao Ting.

1.	Inferior peat or ooze with intermixture of peat	m. 0.40
2.	Peat	1.25
3.	Dark ooze with a few visible macroscopic plant remains (sample at 20 cm. from the bottom of the bed)	1.50
4.	Dark ooze with freshwater shells (sample 10 cm. from the bottom)	0.25
5.	Yellowish grey, somewhat clayey soil. In the lowest part numerous freshwater shells.	1.20

II. Wu Pai Hu.

1.	Lower peat-bed, bottom not visible, thickness (according to the workmen)	m. 0.20
2.	Grey ooze	0.25
3.	Upper peat	0.20
4.	Dark ooze	0.30
5.	Yellowish grey ooze with a few freshwater shells	0.40
6.	Loess-like soil.	1.10

III. Mo Chuang Tzu.

Section a.

1.	Grey ooze (sample) thickness not known	
2.	Peat (sample)	m. 0.48
3.	Ooze, in the lower part dark, in the upper light grey and somewhat sandy.	0.65
4.	Loess-like soil.	2.20

Section b.

1.	Grey ooze, thickness unknown	
2.	Peat	m. 0.50
3.	Grey ooze	0.40
4.	Dark ooze	0.30
5.	Loess-like soil.	2.30

Section c.

1.	Dark ooze with freshwater shells, thickness not visible	
2.	Peat	m. 0.50

3.	Dark ooze	m. 0.50
4.	Loess-like soil	3.00
5.	Sand	1.10

A review of these sections will show that in their essential features the three peat-deposits exhibit the same stratigraphic sequence, the peat-bed is both over-and underlaid by the organic deposit which is here named ooze and which is considered as indicating more watery conditions than the peat. The details of the floral and hydrological development of these peat-bogs will not be known until the samples collected by me have been carefully examined by the paleo-botanists.

In all the sections the peat is covered by a bed of loess-like, sometimes clayey, sometimes sandy soil. In the section III c. this loess-like soil is covered by a bed of real sand.

This overburden of loess-like and sandy material covering the peat and adjacent subaqueous deposits is certainly a washout from the hill-ranges in the north of the peat-localities. The formation of this cover can be explained either as indicating a change of climate which closed the peat formation and caused clastic sediments to be spread out over the subaqueous deposits, or as the result of Man's activity who has cut away the virginal forests, thus causing the summer-rains to assume torrential effects, which were unknown as long as the woods covered the hills and gave shelter to the swamps which occupied the most watery places of the plain.

The latter explanation, ascribing the covering of the peat with loess-like clastics to changes worked by Man, may be considered as the more likely as shown by the following description of the vetrebrate remains and artifacts found in these deposits.

When I now proceed to mention the vertebrate remains and human artifacts found in these deposits, I can only present a very general report. A considerable collection of vertebrates has been made, together with a small series of artifacts, but neither of these has been sufficiently studied to permit a definite statement, and this must be postponed until the several specialists have worked up the material. In fact, this note has been prepared merely to give the details of the field survey that these may serve in guiding the specialists in their laboratory work.

Vertebrate remains have been found only in the first peat locality, Pu Lao Ting, where they are very common and occur in some cases in the uppermost part of the peat-layer, but mostly in the bottom layer of the big ooze bed, immediately above the peat. Among the considerable material collected, the following types could be recognized in the field: *small artiodactyla*, probably *deer, cattle?, pig, dog*, and bones of *large fishes*. The most remarkable of the mammal finds is a nearly complete and very easily recognized skull of a *water buffalo*. This skull was found in 1921 in a pit which is now largely filled, but it was clearly stated that the skull came from the "hei t'u", the ooze, immediately above the peat. The significance of this find will be discussed, after we have considered the artifacts.

The principal archæological finds are as follows:

1. Arrow or small lance head of deer antler, found in the ooze, immediately above the peat.

2. Three-edged arrow point of bronze, with very long tang of iron (common type among Chinese antiquities).

3. Heavy harpoon-like instrument of iron.

(2) and (3) were found in the ooze immediately above the peat.

4. Heavy broad, socketed celt of iron, nearly, but not quite symmetrical. Probably transversely hafted. Entirely different from the modern carpenter's Pen (Andersson: An early Chinese Culture Pl. IV. fig. 3) A similar but smaller type is known in bronze. Found in the upper part of the ooze.

5 & 6. Chisel? and hook of iron. In the ooze.

7-10. Flat arrow point; two other objects, possibly arrow points; one knife, all iron. All these objects found in the loess-like top-layer.

11. Simple wheel-made grey bowl. In the ooze.

12. Small pottery urn, 8 cm. high. Found in the ooze, about 2 feet above the peat.

The discovery was made four years ago, the urn at that time being filled with cash, all of which have been lost.

13. Pottery plate with zigzag pattern upon the rim. In the loess-like top layer.

Several of these artifacts (7-10 and 13) were found in the loess-like top-layer of the section. They are of little consequence for the determination of the age of the peat-deposit.

All the rest of the artifacts were derived from the ooze, mostly from its bottom layer, close above the peat.

These artifacts cannot be older than the Han dynasty as several of them (2-6) are entirely or partly made of iron. According to the statement given in Mr. H. C. Chang's Lapidarium Sinicum§, iron was first known in China in the last few centuries of the Chou dynasty, but not until the Han dynasty did it come into relatively common use.

When discussing the meaning of this conclusion, it is necessary to remember that the ooze was probably formed in a pond, and that it was originally probably of such loose consistency that heavy objects, like metal things, could sink through the bed down to its bottom. But even with this reservation, I think it fairly safe to consider that the ooze deposit which covers the peat was formed in historical time, probably not earlier than the Han dynasty. Regarding the age of the peat-bed itself we have no direct evidence, but very likely there is no great break in time between the peat and the overlying ooze.

Let us now return to the remarkable find of a water-buffalo skull. The water-buffalo is a characteristic of the limnic area of southern China, including the Yangtze provinces, and its remains seem utterly out of place in the dry and dusty Peking plain. When first the discovery was made known to me by my collector Chen, I presumed that the specimen was of considerable antiquity and referable to a wild race of the water-buffalo which had lived in the North China plain under a climate widely different from the present. But the fact, clearly established by our later visit at the spot, that iron objects occur in the same bed where the skull was found, seems to prove that the skull is also of rather modern age. Probably some of the other mammal remains (pig, dog, cattle?) belong to domesticated races, and then it is quite likely that the water-buffalo too was brought there by Man. Granted that the water-buffalo was domesticated, it is still hardly probable that it could have thriven in the Peking plain under present conditions. Its occurrence, connected with the deposits of peat and ooze which all point to watery conditions, might indicate some change of climate in historical time. These problems will be much more fully elucidated when the samples of the different sediments as well as the vertebrate remains have been fully examined and described.

The two other peat deposits, at Wu Pai Hu and Mo Chuang Tzu, have yielded no vertebrate remains. At the last named place have been found *four*

§ Memoir of the Geological Survey. Series B., No. 2.

polished stone axes and chisels, representing three different types which are well known from our collections of stone implements found in northern China. They are reported to have been found in the loess-like material which forms the overburden of the peat. Three of these tools were discovered in one place, 8 feet below the surface. The fourth find, a small stone chisel, was obtained in another part of the deposits, 13 feet beneath the surface.

I am at a loss to bring the occurrence of these implements in the loess-like top-layer at Mo Chuang Tzu into accord with the numerous finds of iron instruments and pottery of relatively modern type in the ooze at Pu Lao Ting. The persistence in the sequence of beds in the three peat areas and the uniform type of the peat in all these places make it probable that the peat is in all places of approximately the same age. It is then startling to find stone implements high above the peat in Mo Chuang Tzu and iron instruments close above the peat in Pu Lao Ting.

Further research is needed to clear up this conflict of evidence.

REVIEW OF THE CENOZOIC DEPOSITS OF NORTHERN CHINA.

INTRODUCTION.

The statements in existing literature about Cenozoic deposits in N. China, are exceedingly scarce. Apart from the plant-bearing beds of Fushun in Fengtien, the age of which has been determined by Russian and Japanese scientists to be early Tertiary, there is practically one deposit which entirely dominates the old geological descriptions, namely the loess.

This remarkable sediment which plays such an unparalleled role in the physiographic aspect of N. China, was well described, as to its distribution and physical properties in Richthofen's classical work "China". The ingenious explanation of the origin of the loess advanced by this grand old man, the nestor of geological research in China, is certainly one of his most masterly and memorable achievements. Apart from this, Richthofen did surprisingly little to clear up the age and stratigraphic relationship of the loess, and the research recently carried out by the present writer has made it perfectly clear that a very considerable part of what passes as loess in Richthofen's volumes is in fact the *Hipparion* beds belonging to the transition period between Miocene and Pliocene.

Regarding many other features referring to Cenozoic geology Richthofen was entirely in the dark, as for instance, in the case of the fatally misinterpreted Nanking "volcanoes" and the fantastic idea that the loess was a substratum of the basalt at the S. edge of the Mongolian plateau.

Loczy went somewhat further than Richthofen, in stratigraphic recognition of the Cenozoic sediments, especially with reference to the existence of a Tertiary series which he properly distinguished from the loess.

The work of Bailey Willis marks a tremendous forward step especially in physiography. But in other respects his treatment of the Cenozoic deposits is just as inadequate and lacking in stratigraphic and palæontological facts, as his description of the older geological systems is penetrating and illustrative.

In 1903 Schlosser published his masterly treatise on the fossil mammals of China. His material was of a very peculiar origin, it consisted of medicine bones

bought in druggists' shops in some of the treaty ports. Because of this strange source of supply, Schlosser's work, admirable as a profound analysis of a defective material, throws very imperfect light on the distribution and sequence of Tertiary and Pleistocene beds in China and is indeed in some parts quite misleading.

In the general introduction to this volume I have related the circumstances which, in 1916, carried me into the field of Cenozoic research. Since then I have been able to study a considerable number of illustrative sections in the Tertiary and Pleistocene deposits of N. China and Inner Mongolia. As explained more fully in the general introduction, I have thought it desirable to compile at the present time a comprehensive summary of my knowledge of the Cenozoic deposits of N. China. The references given to literature are by force of circumstances much less complete than I should desire. I hope to be able to overcome this deficiency in the much more complete treatment of the Cenozoic history of N. China which I intend to prepare after my return from the journey to NW China which I am now going to undertake.

EOCENE.

The single Eocene area as yet known in China, that of Yüan Chü Hsien in S. Shansi, has been fully described in a preceeding chapter of this paper and it will be sufficient to give here the following brief summary.

The Eocene area of Yüan Chü Hsien is a low-lying expanse of land surrounded by mountains on the N,W and S. The extent of the Eocene area is 14-16 km. in N-S and 10-14 km. in W-E direction. The Eocene area is limited by faults on the N. and S., partly so on the E. and possibly also on the W., but in one place along the W. boundary the Eocene beds have been observed unconformably overlying the Ordovician limestone.

Within the Eocene deposits there is a rather uniform dip SE with an average of 22°. In the NW., N., and E. portions of the Eocene area the beds dip in many varying directions. Very few faults, and these only of minor size, have been observed within the Eocene, and it seems probable that the aggregate thickness of the whole series exceeds 1,000 m.

In the lower part of the Eocene series there are numerous thick beds of coarse conglomerate alternating with red or variegated clays. This part of the series is practically unfossiliferous with the exception of a few bone fragments which have been observed in sandy beds of more or less conglomeratic type.

In the upper part of the series the conglomerates are less coarse and interbedded with white sand and red clay. Interstratified in this series are thin layers of marly limestone generally not more than a meter in thickness.

A few bones have been found in the sands and conglomerates, but the chief source of fossils are the thin marl beds which contain spore cases of *Chara*, numerous *Ostracoda*, and the following mollusks determined by Dr. N. Hj. Odhner:

Planorbis pseudammonius Schloth.
" " " *var. leymerici* Deshayes.
Pl. sparnacensis Deshayes.
Pl. chertieri Deshayes.
Physa cf. lamberti Deshayes.
Euchilus deschiensianum Deshayes.
Ceratodes sinensis Odhner n. sp.
Eupera sinensis Odhner n. sp.

With these mollusks there are numerous fragments of vertebrates, some of these have been identified as the remains of fishes, but the large majority represent turtles of the genus *Trionyx*. Besides these there are also some fragments of a small crocodile. Some few mammal remains have also been found, namely: An *Amynodontid*, an *Artiodactyl (Anoodon?)*, a *Lemuroid* or *Insectivore*, and a *Rodent*.

FUSHUN SERIES.

(*Oligocene*).

FENGTIEN PROVINCE, FUSHUN. In S Manchuria, Fengtien province, 60 li E from Mukden, lies the Fushun coal field containing a seam of exceptional thickness, forming a vast supply of good steam coal. Its age was determined as older Tertiary in 1906 by Palibin's identification of a number of typical early Tertiary plants§.

The geological features of the Fushun coal field are described by Inouye in the following words§§:

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§. *J. W. Palibin.* Fossile Pflanzen aus den Kohlenlagern von Fu-schun in der südlichen Mandschurei. Verh. Kais. Russ. Miner. Ges. Ser. 2. Bd. 44. St. Petersburg.

§§. The Coal Resources of the World, Vol. 1, p. 268-269, Toronto 1913.

"The coal-field is a hilly plateau, abruptly sinking by cliffs to the Hun-ho, which bounds the field on the north. To the south it is bordered by a somewhat steep mountain range, which is intersected by the tributaries of the Hun-ho. The coal-field is divided into an eastern and a western section by a central highland, where the strata have been much contorted and bent almost at right angles, so that it was formerly supposed that a great fault occurred there, with a horizontal displacement of 2,400 feet.

The basement complex is granite gneiss, on which the tuff, considered as lower Cambrian, has been deposited. In the eastern part of the coal field, red and green tuffs with porphyrite sheets cover the gneiss unconformably. Tufaceous sandstone and shale lie on it and run from north-west to south-east, forming a syncline. These, together with red and green tuffs, are considered to be Mesozoic of unknown age. The Tertiary formation, in which the coal-seams are interbedded, was deposited on the "graben" running from east to west, in the gneiss and older formations, and generally dips N. 30°. By fossils discovered in the shale, the formation has been proved to belong to the Miocene. It may be divided into the lower and the main coal-bearing series. The lower coal-bearing series consists of tufaceous sandstone, conglomerate and shale, in which two coalseams are interbedded. The series may be followed from the eastern corner of the coal-field westward to the east of Yang-pai-pao station. Farther westwards it is found in small areas to the south of Yang-pai-pao and Ch'ien-chin-chai stations. Generally the strike is west-north-west and the dip N. N. E. 30°–40°. The series reappears on the east of the Ku-ch'êng-tzu-ho, bending northward with the river, where it is covered by alluvium. The main coal-bearing series consists of shale with a thick coal-seam but no sandstone. The shale overlying the coal is very thick, being about 2,500 feet, measured by outcrops. The series attains full development at the middle of the field and no outcrop is found at the eastern corner. Basalt forms the southern part of the field, occurring as sheets, especially between the lower and the main coal-bearing series or in the lower coal-bearing series. The effects of contact metamorphism are seen in the shale and coal-seams in the lower coal-bearing series, which it often covers, but not in the main coal-bearing series. Thus it will be seen that the intrusion of the basalt was later than the deposition of the lower, and before the deposition of the main coal-bearing series. The strike of the formation is nearly east-west, dip N. 25°-45°. Faults are very frequently met with but there is none large enough to make mining difficult. A broad fold is found between Yang-pai-pao and Lao-hu-t'ai, by which the strata

seem to have been shifted about 2,400 feet, as above stated. The formation forms a monocline dipping northward, but to both sides it bends northwards, from which fact we can infer that lateral pressure acted from south to north. The dip angle is steep at the north or near the outcrops, but southwards it becomes gradually lower, being nearly 25°."

In the lower coal-bearing series there are two seams of less importance, whereas the main seam with a maximum thickness of 200 feet, lies in the upper coal-bearing series.

Judging from Inouye's description it seems evident that the basalt occurring in the lower coal series is intrusive for it is stated that the coal is often cut and metamorphosed by basalt.

As mentioned above, Palibin gave the first list of fossil plants from the locality, namely:

Osmunda torelli
Carpinus grandis
Aspidium conf. meyeri
Juglans acuminata
Sequoia langsdorfi
Planera ungeri
Glyptostrobus ungeri
Fagus feronie
Populus glandulifera

Dr. Florin§, of the Riksmuseum, Stockholm, who has recently undertaken a critical study of the Fushun flora considers that *Sequoia langsdorfi*, *Glyptostrobus ungeri*, *Fagus feronie*, and *Populus glandulifera*, are reliable determinations, but that the rest are too poorly preserved to be identified with certainty.

In the Chinese Mining Magazine, published in Dairen, No. 18, 1911, p. 1-30 is a description of the Fushun coal field, in which there are, in addition to Palibin's list, enumerated two other collections of fossil plants from Fushun.

One collection was identified by Yokoyama, and contains the following species:

§. Palaeontologia Sinica Ser. A. Vol. I, fascicle 1, 1922.

Osmunda sp.
Thuya cf. borealis Hr.
Parrotia cf. priestina Ett.
Quercus sp.
Salix sp.
Sequoia cf. disticha Hr.
Sequoia cf. langsdorfi Br.

The other list whose author is not mentioned comprises the following genera:

Aphananthe
Styrax
Ginkgo
Alnus (?)
Tilia (?)
Viburnum (?)

According to Florin's opinion these lists ought to be accepted with much reservation.

In 1919 Mr. T. O. Chu, of the Geological Survey of China, upon the request of the present writer made a collection in Fushun which has been carefully studied by Dr. Florin who gives the following list of the Fushun flora as far as it is known to him§.

Lygodium kaulfussi Heer.
? *Dryopterites sp.*
Osmunda lignitum (Giebel) Stur.
Sequoia langsdorfii (Brongn.) Heer.
Glyptostrobus europaeus (Brongn.) Ung.
Populus glandulifera Heer.
? *Juglans sp.*
cfr. Carpinus grandis Ung.
Alnus kefersteinii Ung.
? *Corylus macquarrii* (Forb.) Heer.
Dryophyllum dewalquei Sap. et Mar.
Fagus feronie Ung.
cfr. Zelkova ungeri Kovats.
cfr. Panax longissimum Ung.
cfr. Viburnum nordenskiöldi Heer.

These species are known to occur in the Upper Cretaceous to Pliocene of Europe, N. America and the Artic region. The Fushun flora is by Palibin and Florin considered as of Oligocene age.

CHAHAR ADMINISTRTIVE AREA. On the borderlands between Chih'i province and Inner Mongol'a, in Chang Pei Hsien of the Chahar administrative area I found in 1919 at the very edge of the Mongolian basalt plateau a plant-bearing deposit intercalated between the basalt flows.

Before I go to describe in detail this occurrence of old Tertiary plants it is desirable to give the broad outlines of the geology of that region.

As already described by Richthofen, the surroundings of Kalgan are hills of trachyte-porphyry. The geological features between Kalgan and the edge of the basalt-plateau 40 li further north at Han Jo P'a is shown in a schematic way by fig. 21. In the northernmost part of Kalgan city the trachyte is underlaid by agglomeratic gravels, and such beds, partly real tuffs, apparently overlying the trachyte, also occur in the low hills along the road northwards to Han Jo P'a.

Further north, near Han Jo P'a, we meet with horizontally bedded gravel with porphyry pebbles, and these gravel beds in their turn are overlaid by the basalt.

In NE direction from Han Jo P'a, there are below the basalt-cliffs two small coal deposits in the porphyry gravel at a place named T'an Yao Kou (炭窑溝).

Also in westerly direction from Han Jo P'a, in Wan Chuan Hsien, there is a coal deposit interbedded in the porphyry gravel. This

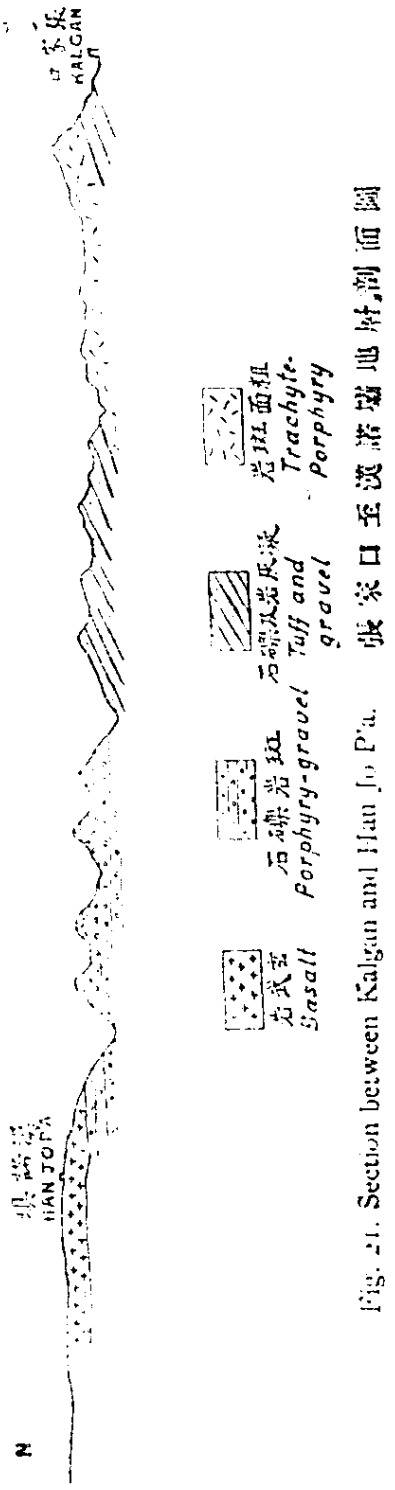
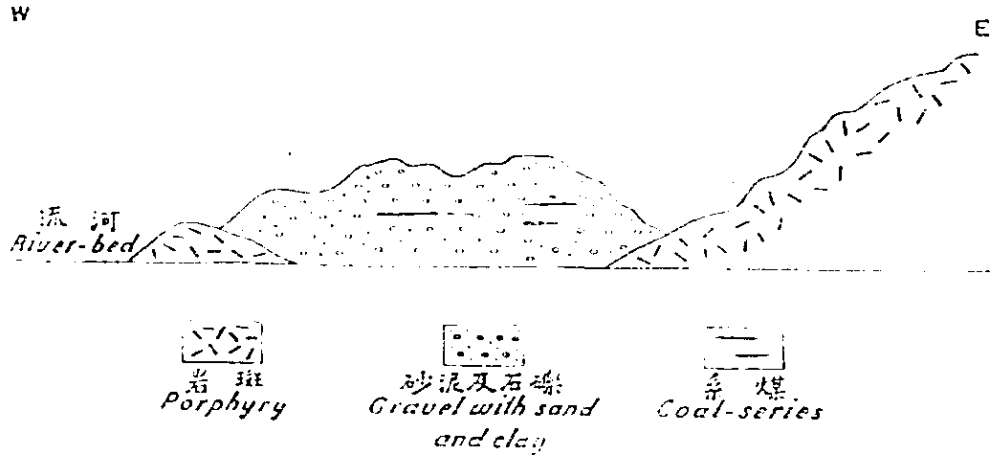


Fig. 21. Section between Kalgan and Han Jo P'a. 張家口至漢諾地點剖面圖

coalfield is situated 8-10 li N to W from Wan Chuan city. Its extent in N-S direction is about 4 li and in E-W 2 li. In fig. 22 is shown a section through the southern, relatively narrow part of the field. The gravel is evidently laid down upon a pre-existing topography of porphyry-hills.



萬全縣產煤之砂礫層剖面圖
Fig. 22. Coal-bearing gravels. Wan Chuan Hsien.

The prevalent sediment is gravel of varying coarseness, still there were hardly seen any pebbles bigger than fist-size. Mostly the gravel is loose but locally somewhat consolidated, so that it deserves the name conglomerate. In the gravel there are lenses of sand or loose sandstone, whitish yellow in color.

In the gravel there are numerous old shafts, and round these are found pieces of a nearly black, thinbedded shale containing very numerous but mostly undeterminable plant remains, as well as a grey, partly somewhat consolidated clay in which a few determinable plants were noticed. Amongst these I have with some doubt identified *Podozamites* and *Pterophyllum*, which indicate the Jurassic age of the deposit.

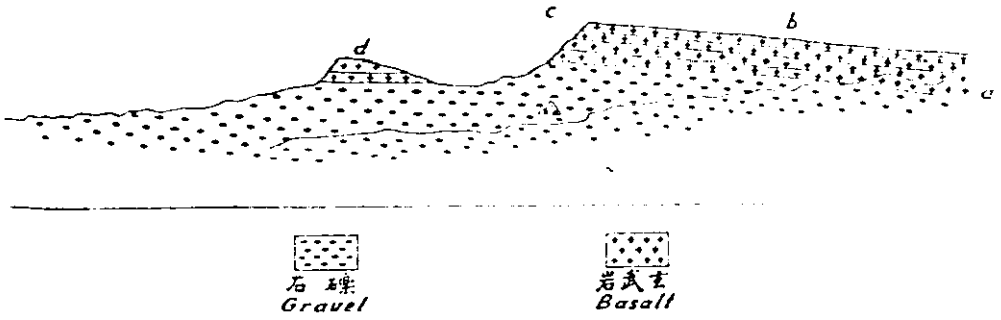
Because of the rapid change of different kinds of sediment it is difficult to ascertain the true position of the beds, but in most cases they are nearly horizontal. In a part of the field I noticed a NW dip of 15-20°.

The coal seems to occur in the lowest part of the gravel deposit, where the gravel is white or yellowish in color. In the upper part of the gravel-deposit a reddish color prevails.

In the western hills of Peking there occurs a formation of porphyry conglomerate (the Tiao Chi Shan formation) with plants of Jurassic age. This conglomerate is consolidated to a hard rock and its beds are strongly tilted. In

Hsuan Hua Hsien there also occurs a porphyry conglomerate, or rather gravel in part, which is also in some places slightly tilted§. Because of the Jurassic plants common to them both the Tiao Chi Shan conglomerate of Hsi Shan and the gravel beds N and NW of Kalgan must be considered as nearly contemporaneous in spite of the former being consolidated and tilted, in striking contrast to the loose structure of the mostly horizontal beds of the latter.

After having traced the geological affinities of the big porphyry-gravel formation, which forms the basement of the basalt, let us now return to this latter rock. Fig. 23 shows the basalt cliff as seen in westerly direction from the edge of the basalt plateau at Han Jo P'a. (a), (b) and (d) of the figure are different spurs of the basalt, (a) being the nearest and (d) the one most distant from Han Jo P'a, the whole situated N of Wan Chuan Hsien. (c) is a detached block of basalt which has slipped down as the erosion wore away the loose gravel which forms the basement of the basalt. In fact, the gravel slopes below the basalt cliff are all covered with basalt debris and also with fairly large masses of basalt which have slipped down as a consequence of the rapid erosion of the gravel.



自漢諾塢西望之玄武岩壁圖

Fig. 23. The basalt-cliff as seen in W. direction from Han Jo P'a.

On the occasion of an excursion to the area shown by figure 23 I noticed 3 li N of Hsin Kai K'ou (新開口) a rather singular feature, namely a dyke of basalt only a meter broad which could be followed for a considerable distance, extending through the unconsolidated gravel.

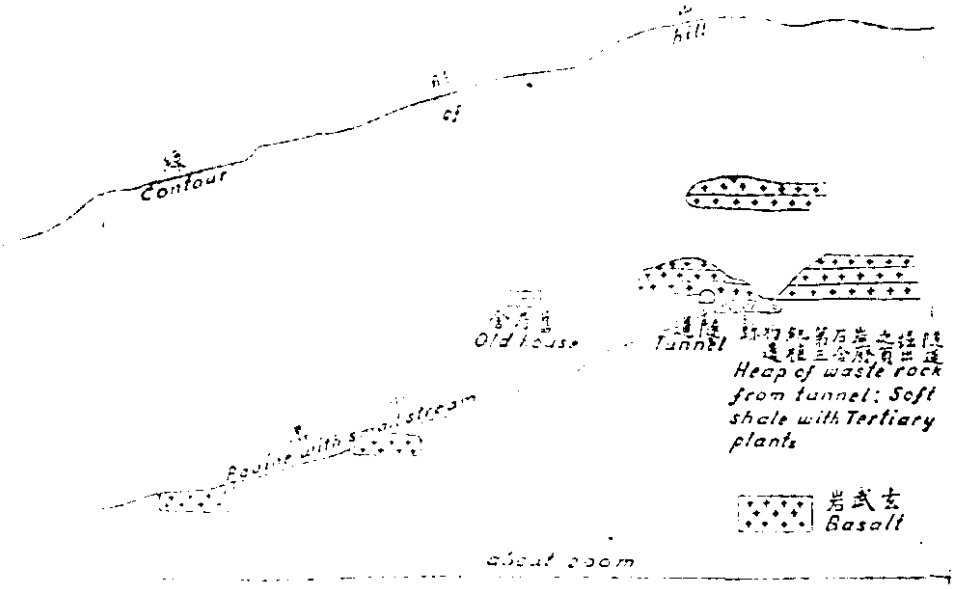
In all the places so far mentioned, the basalt rests upon the porphyry gravel but in a place NE from Han Jo P'a and about 4 li E from the coal locality

§. L. F. Yih. The Geology of Hsi Shan. Mem. Geol. Survey of China, Ser. A. No. 1. 1929. Page 27 and following.

T'an Yao Kou above mentioned the basalt was seen directly overlying some old steeply dipping folded rocks as shown by fig. 24.

漢諾塌東北之玄武岩與下覆之摺皺岩層剖面圖
Fig. 24. Basalt overlying ancient folded rocks, NE from Han Jo P'a.

When staying at Han Jo P'a I was told of the occurrence of a "coal mine" in the cliff of the basalt plateau itself. The coal locality is in a ravine called Ta Ching Kou (大井溝) near west from the village Han Jo P'a.



漢諾塌大井溝土法煤鑛圖
Fig. 25. The Ta Ching Kou "coal mine". Han Jo P'a.

The local conditions are shown by fig. 25. A tunnel had been driven in a fruitless effort to find the reported coal (probably some surface indication of the dark shale mentioned below had given cause to the whole mining enterprise). Near the mouth of that tunnel, which was no longer accessible, there was a small heap of waste rock, brought out from the tunnelling, which consisted of a dark-brown, very soft shale. In this rock I made quite a satisfactory collection

of plant fossils, evidently Tertiary, but unfortunately the soft shale had a fatal property that when drying up, it crumbled into paper-thin sheets which fell into small fragments before the slightest touch. Only a few plant specimens preserved in more resistant rock could be saved. These few plant remains have been examined by Dr. R. Florin of the Riksmuseum, Stockholm, who has published a small note on them§. He identifies the following types: *Pinus sp., Comptonia anderssonii n. sp., Carpinus sp., Phyllites sp.* The material is insufficient to settle the age of the deposit but Florin expresses the tentative opinion that the flora is probably Middle Tertiary.

As shown by fig. 25 there are outcrops of basalt both above and below the tunnel from which the plant bearing shale was derived. There seems then to be no doubt that the shale is an intercalation between two basalt flows. In fig. 26 I have tried to give my conception of the stratigraphic conditions of this locality.

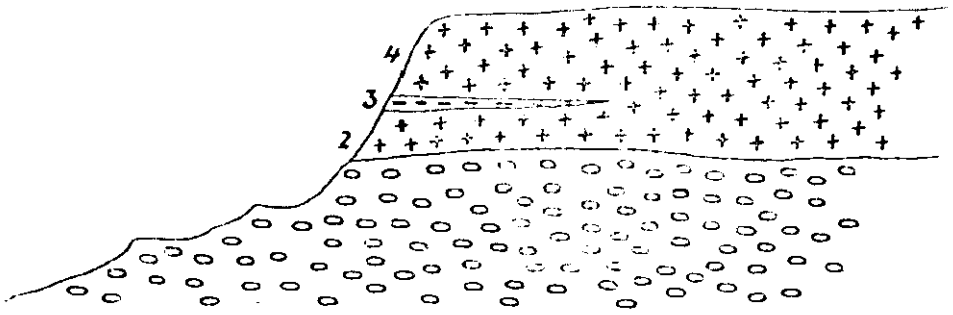


Fig. 26. Ideal section at Ta Ching Kou, Han Jo P'a. 漢諾塔大井溝剖面圖

1. Gravel. 砂礫岩
2. Lower basalt. 玄武岩下部
3. Plant-bearing shale. 帶牧植之頁岩
4. Upper basalt. 玄武岩上部

N. SHANSI, FAN CHI HSIEN (繁峙縣). A third locality for Tertiary plant bearing beds in association with basalt-flows was found in 1920 by Mr. T. C. Wang of the Geological Survey. The locality is situated 1 li N. of Shan Yang Kou (山羊溝), a village 60 li NE of Fan Chih city. The stratigraphic conditions are show in fig. 27, which was communicated by Mr. Wang who has also given the following additional notes.

The plant remains were found in a bed of light grey clay about 8 m. thick. In all directions this clay soon turns into fine white sand-stone in which the fossils are obscure. Under this horizon is basalt at Shan Yang Kou, or gneiss at

§. R. Florin. Einige chinesische Tertiärpflanzen. Svensk Botanisk Tidskrift. 1920. Bd. 14. H. 2-3. p. 239-243.

Chiang T'ai Pei (蔣台背) 10 li N of Shan Yang Kou. The fossiliferous clay is overlaid by black shale or coal, about one meter thick, above which there is another bed of basalt.

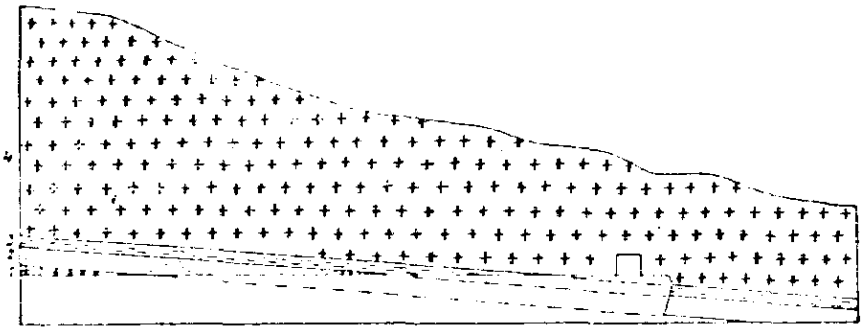


Fig. 27. Section at Shan Yang Kou coal mine. (Communicated by Mr. T.C. Wang).
山羊溝煤礦剖面圖 (據王竹泉君報告)

1. Basalt. 玄武岩
2. White to grey fine sandstone, locally passing into clay, in which the fossils were found. 砂岩及黏土化石層
3. Black shale and coal. 黑頁岩及煤層
4. Basalt. 玄武岩

The fossils found in the clay are cones of a conifer as well as numerous leaves of dicotyledonous plants which have not so far been closely examined.

In October 1922 I paid a flying visit to Shan Yang Kou and was then able to add some observations to those communicated by Mr. Wang. Fig. 28 gives my interpretation of the conditions round the village Shan Yang Kou. Wang's locality is at the spot marked "coal mine" in my section.

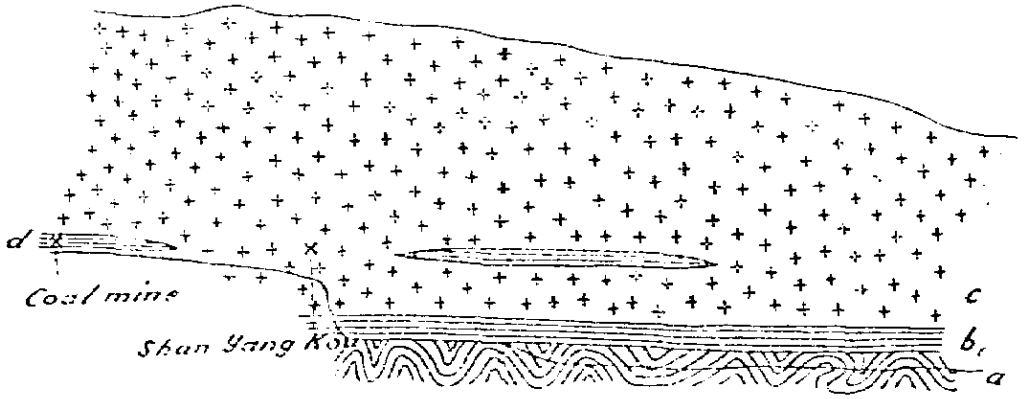


Fig. 28. Section at Shan Yang Kou village. 山羊溝剖面圖

a. Archæan rocks. 太古界岩石
b. and d. Sand and clay. 黏土及砂岩
c. Basalt. 玄武岩

From this place the small brook flows down to the village Shan Yang Kou where it tumbles down, by a vertical fall of about twenty meters, into a narrow ravine in which the substratum of the basalt series is beautifully exposed. In the bottom of this gulley there are outcrops of steeply dipping Archæan rocks, gneiss and amphibolite. Between this Archean substratum and the basalt there is a series, 10-12 meters thick of stratified plant-bearing beds. The lowest of these beds is conglomeratic. Above the conglomerate follows sand with several thin layers of lignitic wood fragments. Such thin lignitic wood splinters also occur in great number all through the sand.

Above the sand are thinbedded clayey layers rich in scales of mica. The uppermost member of the sedimentary series, immediately underneath the basalt, is a hard, slightly violet claystone which is probably somewhat metamorphosed by the basalt. Except the named splinters of lignite, no fossils were found in these beds.

Three dykes of basalt, each about a meter in thickness, traverse the Archean as well as the sedimentary beds. A horizontal dyke, less than a meter thick, was seen, forming for some distance a regular intrusive sheet in the sand.

Above the basal sedimentary series is a flow of basalt about 15-20 meters thick. It is covered by a second sedimentary bed, to which the plant bearing beds described by Mr. Wang seem to belong. These sediments are well developed in some places, but apparently not continuous, there being barren areas were the lowest and the second basalt flow are in immediate contact.

The basalt with associated sedimentaries has a slight but distinct dip to the south.

The few plant remains so far found in the plant bearing beds of Han Jo P'a and Shan Yang Kou are not sufficient to prove those deposits to be contemporaneous with the richly fossiliferous beds of Fushun. But the connection of all these sedimentaries with basalt may serve as a reason for grouping them together provisionally as the Fushun series.

THE LU TZŬ KOU BEDS.

During the survey of the Pao Te Hsien area in NW Shansi with special reference to the rich *Hipparion* deposits, which was undertaken by Dr. O. Zdansky in the early part of 1922, this scientist made the interesting discovery of a series underlying the *Hipparion* clay, but still apparently belonging to the Younger Tertiary.

The series has been named the Lu Tzŭ Kou (盧子溝) series from the valley in which it is best developed. This locality is situated in the NW corner of the area surveyed by Dr. Zdansky, and the reader is referred for details to the map and text of Dr. Zdansky's paper.§

The beds in question rest upon the Carboniferous series which forms the basement rock of the region. In one place the Lu Tzŭ Kou beds are overlaid by typical *Hipparion* clay with the characteristic fossils of this deposit.

The bedding of the Lu Tzŭ Kou series is horizontal. The maximum thickness is 25-30 meters.

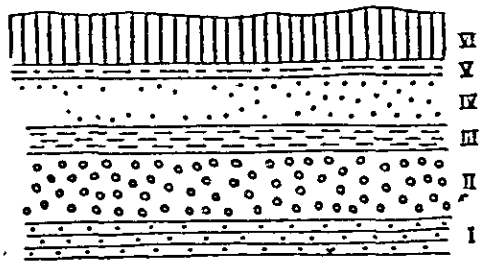


Fig. 29. Section of the Lu Tzŭ Kou beds at San T'a Kou.
(Communicated by Dr. O. Zdansky)
三道溝之中新統地層剖面圖 (據師丹司基博士報告)

The variety of sediments represented in this series is shown in fig. 29. while the following note will explain the details (in ascending order):

I: Carboniferous beds.

II: 6.5 m. Quartz gravel with some bone fragments and teeth of mammals.

III: 2.3 m. Greenish yellow marl and marly limestone with fishbones and mollusks.

IV: 4.5 m. Yellow sand with cross-bedding. Contained the lower jaw of a *Rhinocerid.*

V: 1.3 m. Greenish white stratified marl with mammal bones and mollusks.

VI: More than 4 meters. Reddish loess-like material with bone fragments, parts of a *Rhinocerid* tooth.

Beds II-V form the Lu Tzŭ Kou series. Whether VI belongs to the *Hipparion* series or to the loess is not clear. As already stated, typical fossiliferous *Hipparion* clay has been found in another place overlying the Lu Tzŭ Kou series.

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§. O. Zdansky. Fundorte der Hipparion Fauna um Pao Te Hsien in NW Shansi. Bulletin of the Geological Survey of China. No. 5.

The age of these beds will be better known when the mollusks, fishbones, mammals remains and plant fragments have been examined.

The occurrence of an *Equid* molar proves according to Dr. Zdansky that the series belongs to the younger Tertiary. As the *Hipparion* beds represent the transition from Miocene to Pliocene, the Lu Tzŭ Kou beds could eventually be supposed to represent the Miocene, but there are some facts at hand which indicate that they are in age nearly related to the *Hipparion* beds.

THE HIPPARION BEDS.

In order to make the reader acquainted with these beds which contain the richest and best preserved fossil mammal fauna of Northern China it is advisable to begin with a summary of the report furnished by Dr. O. Zdansky on the famous bone deposits of Pao Te Hsien in NW Shansi at the Yellow River. These deposits are by far the richest of the *Hipparion* localities, the beds are beautifully exposed in numerous ravines, and Dr. Zdansky has surveyed this region with an accuracy which has not its equal in our exploration of the other *Hipparion* areas.

Hipparion clays are widely distributed in this part of NW Shansi and the adjacent part of Shensi. But only in three areas, Chi Chia Kou (鸡家沟) in Pao Te Hsien, Nan Shah Wa (南沙窪) in Ho Ch'ü Hsien (河曲縣) of Shansi province and Wu Lan Kou (五蘭溝) in Fu Ku Hsien (府谷縣) of Shensi are there bone accumulations in these clays which are otherwise entirely barren.

Chi Chia Kou is the most extensive and richest of these localities. The bone carrying area has here an extension of 4,800 m. from N. to S. and 4,000 m. from W. to E.

The Chi Chia Kou region is a plateau land dissected by an intricate system of ravines, in the bottom of which the substratum of the *Hipparion* clay is almost everywhere visible. The basement rock is formed by the Carboniferous coal series in nearly horizontal beds. The basal layer of the *Hipparion* series is a conglomerate bed, at most 4 meters thick with gray matrix. Above this basal conglomerate rests the red *Hipparion* clay with a maximum thickness of 65 meters. In the clay there are interbedded gravel beds of little persistence and occasionally also lenses of sand. In certain horizons there are also irregular lime concretions in the clay. Round the fossil mammal bones are seen infiltrations of lime.

In the 65 meters of red, mostly entirely barren clay there is a well defined bone-carrying horizon 25 meters above the bottom and 35 meters underneath the top of the deposit. The bone layer is mostly less than a meter thick and so nearly horizontal that there is not more than 5 meters variarion of altitude of the bone bed throughout the whole Chi Chia Kou area. In the bone horizon there are not bones everywhere, but rather pockets or nests rich in bones separated by some meters of barren clay.

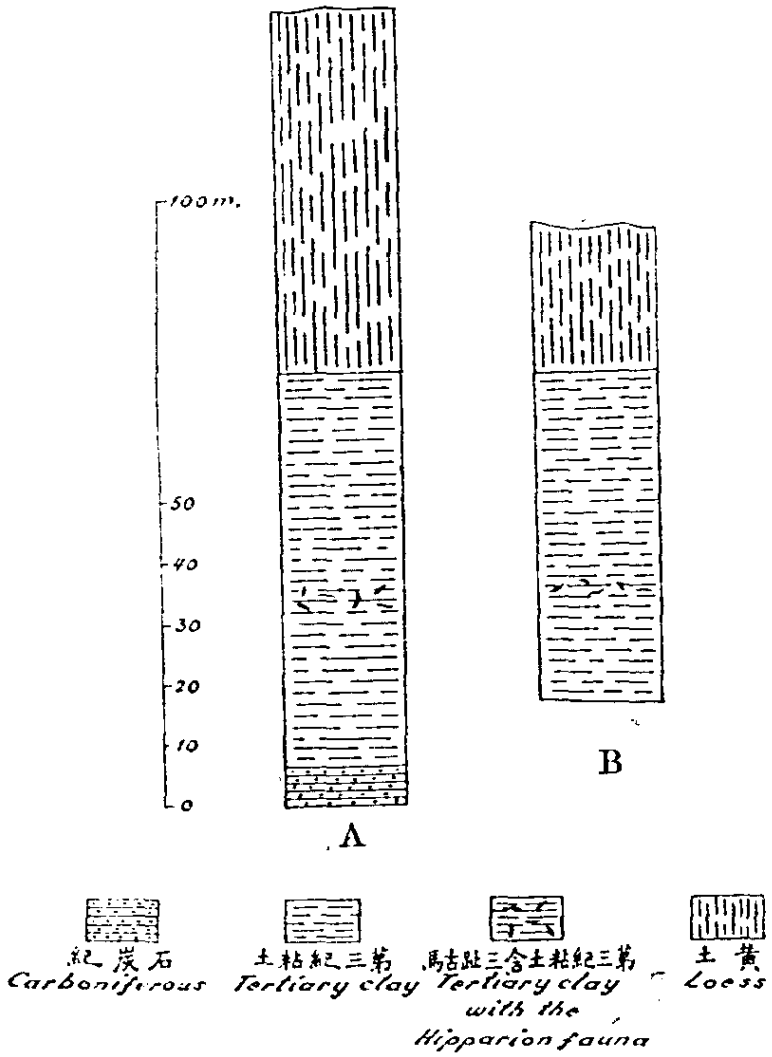

Fig. 30. Section of the Hipparion beds.

含三趾古馬粘土層柱狀剖面圖

A. at Chi Chia Kou and Nan Sha Wa. 窯家溝及南沙窪

B. at Wu Lan Kou. 五蘭溝

(Communicated by Dr. O. Zdansky 據師丹斯基博士報告).

Dr. Zdansky has given the following provisional list of the vertebrates found in the Chi Chia Kou area:

PERISSODACTYLA:

Hipparion richthofeni, Schl.
Teleoceras 4 species
Aceratherium
Sinotherium lagrelii, Ringström§
Anchitherium

ARTIODADTYLA:

Some *deer* of different size
Many *antelopes*
Chilinotherium tingii Wiman§§
Sus 2 species

CARNIVORA:

Hyæna
Some *Viverridæ*
Felidæ
Machairodus
?Arctocyon or *Hyaenarctos*
Mustelidæ 2 species

PROBOSCIDEA:

Mastodon
Stegodon
Elephas

RODENTIA:

Castorid
Rodent of squirrel-size

AVES:

Struthionid

REPTILIA:

Emydid
Testudinid

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§. A new type of *Rhinocerotidæ*, related to *Aceratherium*, as well as to *Elasmotherium*. T. J. Ringström, Sinotherium lagrelii, a new fossil Rhinocerotid from Shansi, China. Bull. Geol. Survey. No. 5.

§§. A new member of the Giraffidæ.

The Hipparion deposits of Nan Sha Wa and Wu Lan Kuo are smaller in extent but otherwise very similar to that of Chi Chia Kou as shown by the columnar sections fig. 30.

According to Dr. Wiman and Dr. Zdansky the *Hipparion* fauna indicates steppe conditions, but the occurrence of Giraffinæ and Suidæ points to the existence of groups of trees and of water pools spread over this steppe. As the clays are mostly barren over wide areas and rich in mammals only in the three areas mentioned, it might be inferred that in the otherwise very dry steppe there were locally oases with trees, water pools and occasionally also sheet floods after the rains. It seems as if these genial conditions prevailed only during a short, well defined period. This explanation suggested by Dr. Zdansky seems to conform well with all the facts above reported.

The other area, where we have found the *Hipparion* fauna well represented, in fact the first place where, in the autumn of 1918, we had an opportunity to study this fauna is Hsin An Hsien in Honan about 100 li west of Loyang. The *Hipparion* beds are best developed within some twenty li N. and E. of the district city. This region consists of rounded hills built up of *Hipparion* beds as shown by fig. 37. In the valleys between these hills there is a considerable deposit of loess. The post-*Hipparion* geology of the area is more fully explained in the description to the figure referred to.

No detailed survey, like that of Chi Chia Kou has been undertaken in Hsin An Hsien, and consequently I am not able to give exact figures, but from rapid estimates it seems likely that the thickness of the *Hipparion* beds is here somewhat more than the 65 meters found by Dr. Zdansky in Chi Chia Kou.

A remarkable feature of the Honan beds which distinguishes them from those of Chi Chia Kou, is the great variety of sediments. Figures 31 and 32 explain this feature better than any description.

The clay is sometimes uniformly red but in many other cases variegated; and one common type with whitish irregular spots is appropriately named by the Chinese "chicken manure earth".

In the section shown in fig. 31 there are extensive deposits of whitish chalky limestone.

Layers of sand and gravel are common. Another characteristic feature is the frequence of lime concretions of the irregular type which has originally been described as a characteristic of the loess and named "Loess-Püppchen". These concretions often form definite levels in the clay, each concretion standing with the long axis of the irregular body *in* vertical position. They are sometimes small and scattered in the clay; in other instances they have grown into fair sized, irregularly branching bodies which form a more of less complete network; the last stage of development being the more massive growth of this network, thereby forming a solid limestone bed. Such intercalations of fairly hard limestone, sometimes inclosing numerous pebbles, is quite a common feature. Lime-concretions are common round the mammal bones occurring in the same manner as in the case of the deposits of Chi Chia Kou in Shansi.

The fossil bones seem to occur more irregularly than is the case in the Chi Chia Kou area. At any rate we have not been able to trace a regular bone level, but the bones seem to form accumulations scattered very sparingly through the deposit. One of the most important localities of the Hsin An area is Shang Yin Kou (上印溝) Loc. 12 of our field-record, where a bone bed, a few meters in length gave a very fine harvest. The bones were less well preserved than is the case in Chi Chia Kou, and their surface was somewhat blackish, probably from weathering of a comparatively recent date.

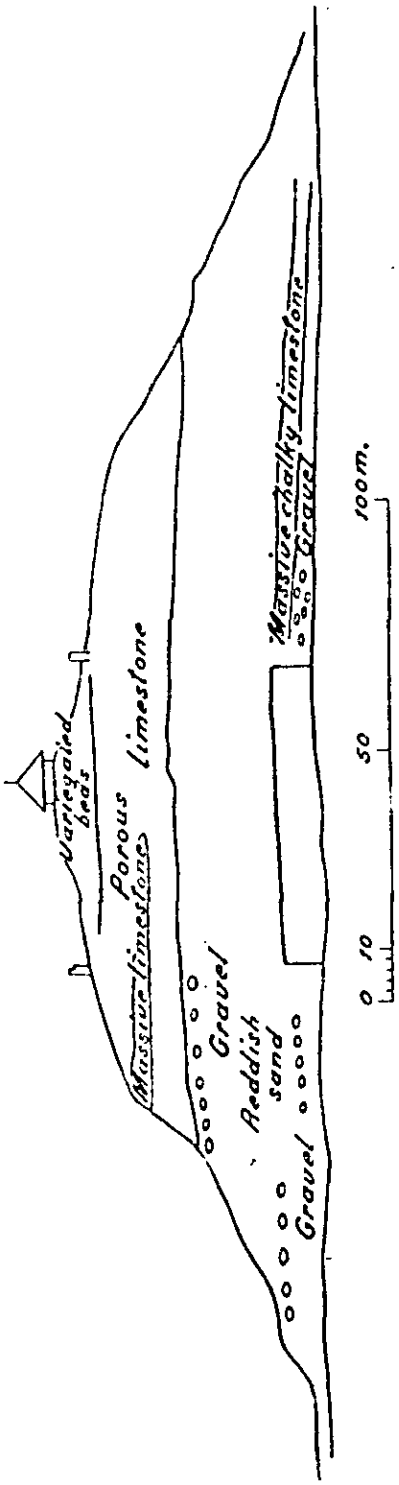

Fig. 31. Railway-section at Hsin An Hsien, Honan. 河南新安縣車站附近地層剖面圖

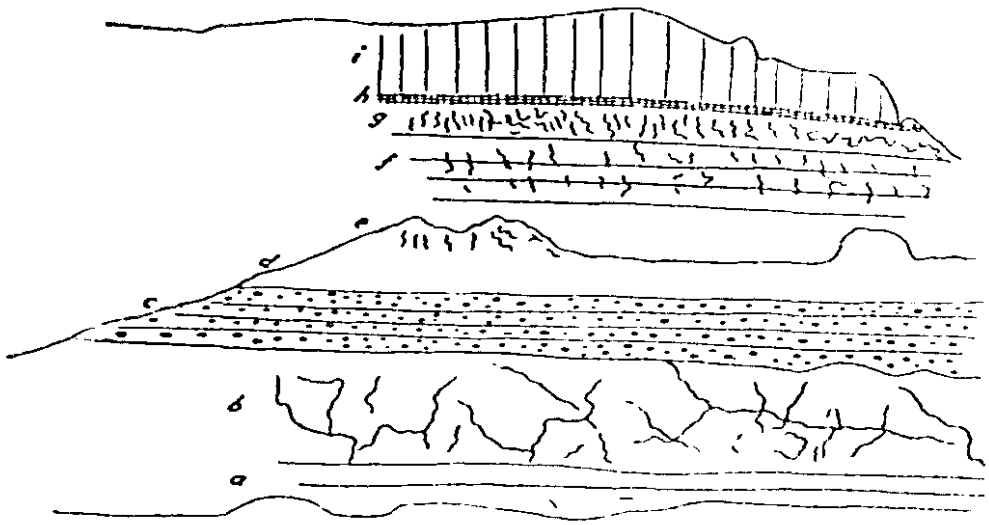

Fig. 32. Section of the Hipparion beds at Tung Yang Chen close by the railway 15 li E of Hsin An city. Thickness of the figured series 25-30 m.

新安縣東十五里東陽鎮含三趾古馬之地層剖面圖

a. Distinctly stratified beds of clay, fine sand and marl?

b. Variegated red and grey-green clay with irregular veins of gypsum (?)

c. Coarse gravel.

d. Loess-like clay.

e. Loess-like clay with irregular lime concretions ("Loess-Püppchen").

f. Reddish clay with fairly regularly reoccurring (every 0.3 m.) beds of small "Loess-Püppchen" and small pebbles.

g. Clay much like (f) but with bigger and more numerous Loess-Püppchen.

h. Strongly redcolored clay.

i. Loess.

The whole series except (i) is supposed to belong to the Hipparion series. Poorly preserved bones of the type of the *Hipparion* fauna were found close by this section in the same beds.

The locality (No. 12) which yielded a rich variety of species is in clay. Only about two li from this spot there is another important locality (No. 35) where the dominant species was *Cervavus*, the best skulls of which have come from this place. This *Cervavus* accumulation was found in a lense of red sand interbedded in the ordinary red clay.

In Mien Chih Hsien, 100 li W. of Hsin An Hsien we have studied another area of *Hipparion clay*. Here the beds are very regular with parallel limestone bands as shown by fig. 33. In this place the bones are perfectly white and hard, in preservation favourably competing with Pao Te Hsien, but the material obtained is not large.

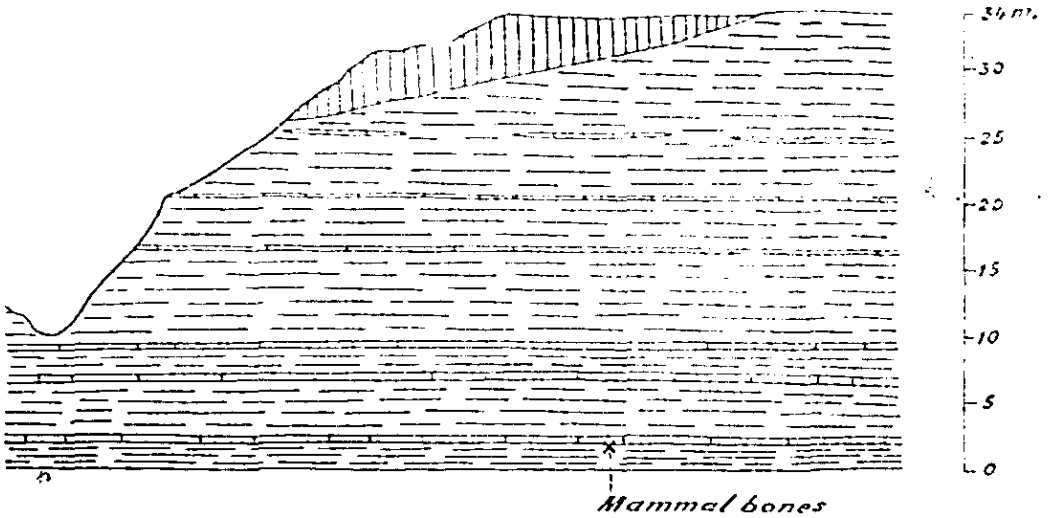

Fig. 33. Section through the Hipparion beds at Lan Kou, Mien Chih Hsien (Loc. 20 of our register). Red clay with limestone bands (overlaid by loess).

澠池縣蘭溝含三趾古馬土層剖面圖

The vertebrates found in the Honan localities are mostly of the same types as those already enumerated from Chi Chia Kou. The *Rhinoceroses* seem to be less numerous in Honan than in the Pao Te Hsien region. A feature of the Honan *Hipparion* fauna to which there is no parallel in Pao Te Hsien is the presence of one or probably two species of *Primates* belonging to or nearly related to the genus *Cynocephalus*. Of these Primates we have found in all three specimens, a nearly complete skull, a lower, and an upper jaw. The two first mentioned specimens represent a smaller form. The last named specimen, representing a fairly large-sized species, was found in Hsin An Hsien together with *Hipparion, Ruminantia, Hyaenictis* and a small molar of an *Elephas,* all according to determinations made by Dr. Zdansky.

Two very rich deposits of a young Tertiary fauna have been discovered and excavated by Père E. Licent in Ching Yang Fu of E. Kansu. The Rev. Père had the kindness to invite me to see his beautiful collection in Tientsin in

June 1921 and during this rapid examination I recognized *Hipparion* in the material and obtained the impression that the *Rhinocerida*æ and some other species are of the types found in the *Hipparion* fauna of Shansi and Honan. Fuller notes together with Père Licent's sections, are given above (page 72-76) in the chapter on the remains of Struthionidæ.

In addition to the areas here mentioned we have made collections from red clay similar to the undoubted *Hipparion* clay in many other places, in Shantung, Chihli, Shansi and Honan. With respect to those places where *Hipparion* has not been identified, there remains a certain doubt as to the age of the deposits. As I have more fully explained in the final paragraphs on the Chou Kou Tien deposit, there are some indications pointing to the wide distribution of red loess-like or partly more *Hipparion*-clay like sediments with a fauna containing a true horse, *Equus*, probably of Upper Pliocene age. But with the exception of the rich Chou Kou Tien cave deposit, these beds are very little known. Not until Dr. Wiman has prepared definite lists of the mammals contained in each of our numerous localities will it be possible to form a definite opinion on this point.

THE CHOU KOU TIEN CAVE DEPOSIT.

In the summer of 1921 we discovered at Chou Kou Tien, the terminus of the Liu Li Ho-Chou Kou Tien branch line of the Kin-Han railway, 70 li SW from Peking a richly fossiliferous deposit filling a cave-like cavity in the Ordovician limestone. This deposit was surveyed and excavated by Dr. O. Zdansky who has furnished me with the following summary of his detailed report.

The bone deposit is in a valley named Lao Niu Kou (老牛溝), 300 m. NNW from the railway station house. Here, in a nearly vertical limestone wall about 6 meters above the bottom of the quarry, the limestone is replaced by loamy and sandy deposits which form the filling of a former cave which was exposed by the working of the quarry. Higher up there follows again limestone forming the roof of the former cave. From the eastern lower corner of the visible mass of cave-sediment a narrow pipe extends downwards as far as can be seen, filled with a very hard yellowish sandstone containing the same kind of mammal bones as those occurring in the main deposit nearby.

Certain observations indicate that the main room of the former cave is about as deep as the pipe, being only hidden by a thin wall of limestone.

In two sections A and B the thickness of the strata has been measured (counted from the top to the bottom). Their dip is very gentle, being on an average N 18° E 7°.

Section A.

8. Breccia of angular pieces of limestone without stratification. Contains landshells and bone-remains.
7. 80 cm. lightred, loamy sand with intercalations of sandstone. Landshells.
6. 33 cm. brown loam, with brown bands. Boundary towards 7 not quite distinct.
5. 21 cm. dark-brown laminated loam.
4. 6.5 cm. light yellow loam.
3. 4.5 cm. dark-brown loam.
2. 15 cm. light yellow, sandy loam with plenty of bones.
1. Yellowish sandstone. Thickness unknown. Contains many fossils, fragments of limestone and stalactites.

Section B.

9. The same as 8 in section A.
8. 80 cm. red sand, stratified.
7. 16 cm. loam, top brown, bottom yellow.
6. 15 cm. red sandstone.
5. 30 cm. red, stratified sand, partly hardened.
4. 6 cm. light-yellow loam.
3. Like A No. 3.
2. 17 cm. light yellow, sandy loam with many bones.
1. Like A No. 1.

The fossils occur in the whole series, the larger species being confined to strata 1, 2 and 3; only the micro-fauna is distributed through the entire series. Of the larger animals mostly lower jaws and isolated teeth are found but no skulls; large limb-bones, vertebræ, fragments of deer antlers and countless splinters of bones are also found. The microfauna is mostly represented by an immense number of limb bones of *two small rodents*, of which also lower jaws are found. Remains of *Talpa* are scarce, as well as those of *another Insectivore* and of small *Birds*.

Of large animals there are a species of *Equus*, a *Rhinocerid*, numerous *Artiodactyla*, including a *pig*, a *deer* with a remarkably thickened lower jaw and a number of smaller *Ruminants* which have so far not been closely examined. A large *Bovine* is easily distinguished. Of *Carnivores* there are a *Machairodus*, similar to the *M. horribilis* Schlosser, a rather small *Bear* and an animal of the size of a fox.

The red sand and the breccia at the top of the deposit contain two kinds of *land shells*, one of them very common and probably identical with a species still living in the same region.

The cave might have been inhabited by some large Carnivore which brought its prey into it. The scarcity of intact limb-bones may be due to the circumstance that the brute crushed them to get the marrow. The rodents may have lived in the cave.

To judge from the presence of a true horse and the absence of *Hipparion* is seems likely that this fauna is younger than the *Hipparion* fauna and possibly of Upper Pliocene age.

At the present stage of our explorations, the Chou Kou Tien fauna stands alone as a richly fossiliferous, probably young Pliocene deposit. But it may be justified to question whether there are not deposits, less rich in fossils, which for general geological considerations may be supposed to be approximately of the same age.

In this connection I recall a deposit in Huai Lai Hsien (懷來縣) of Northern Chihli, where I found in 1918 an Artiodactyl, probably a deer with conspicuously thickened jaw like that described by Dr. Zdansky as characteristic of a deer in the Chou Kou Tien fauna.

The locality, a village named Hu Lu Tao (葫蘆套) is situated 18 km. WNW from Huai Lai city. 2.5 li E from this village in a very narrow ravine, numerous bones had been found, among them the characteristically thickened jaw of an Artiodactyl already mentioned. The ravine is about 20 meters deep and its walls consist all through of typical loess without any intermixture of gravel. The find was made in this typically loess-like material at the very bottom of the ravine.

It is of course premature to say that this find is contemporaneous with the Chou Kou Tien cave deposit. The mode of occurrence and the lithological

character are just as different as they possibly could be. The only similarities between the two finds is that they contain two Artiodactyla which certainly are nearly allied and possibly may be identical.

A general consideration of the problem unavoidably leads to the assumption that at the time when the Chou Kou Tien cave deposit was formed, deposits must have been forming in the open plain which are lithologically very different from the cave deposit. In a succeeding chapter on the loess I will show how the early explorers, such as Richthofen and Willis, included all kinds of sediments in the term loess, and that our mammal collections have proved that a very large part of what earlier authors named loess, can now be definitely assigned to the *Hipparion* clay with a well defined fauna of the loess. Petrologically it is often very difficult to distinguish between these two sediments as there exist in fact widely distributed deposits which form a kind of petrological transition between the genuine deep red *Hipparion* clays and the typical greyish-yellow loess. It is quite possible that deposits which chronologically link the Early Pliocene *Hipparion* clay with the Pleistocene loess, are to be found amongst these more or less loess-like clays. In fact, we have found in Northern Chihli, Shantung, Honan and Shansi small faunas in such loess-like clays. These faunas mostly consist of Artiodactyla and their relationship to the genuine Hipparion beds has not yet been properly elucidated. It is to be hoped that Dr. Wiman's researches on these collections will fully reveal to what extent we have amongst them time-equivalents to the Chou Kou Tien cave deposit and to the Hu Lu Tao loess-like deposit described above.

THE SAN MEN SERIES.

In many places where the basement of the loess is exposed, it is found to consist of gravel deposits which occasionally attain the thickness of 10 meters or more. Gravel is also found intercalated in the loess in its lower part and in higher levels, specially near hill slopes from where the coarse detritus was washed down. Bailey Willis has graphically depicted the interaction between eolian and fluviatile forces in the formation of the loess or huang t'u, the former depositing the typical loess, the latter the intercalations of gravel. It seems that in the beginning of the loess period the fluviatile forces were still preponderant and resulted in vast gravel-accumulations, whereas later on the eolian forces became dominant with the result that the loess deposition became nearly continuous.

In the Yellow river valley these sub-loess gravels are widely distributed and of unusual thickness. Here they also have in two localities been found to contain abundantly freshwater mollusks, that is a fauna fundamentally different from that of the loess. Consequently I have considered it necessary to distinguish these sub-loess gravels and sands of the Yellow river valley as a special series which has been named *the San Men series* from the type locality which was discovered by Dr. V. K. Ting.

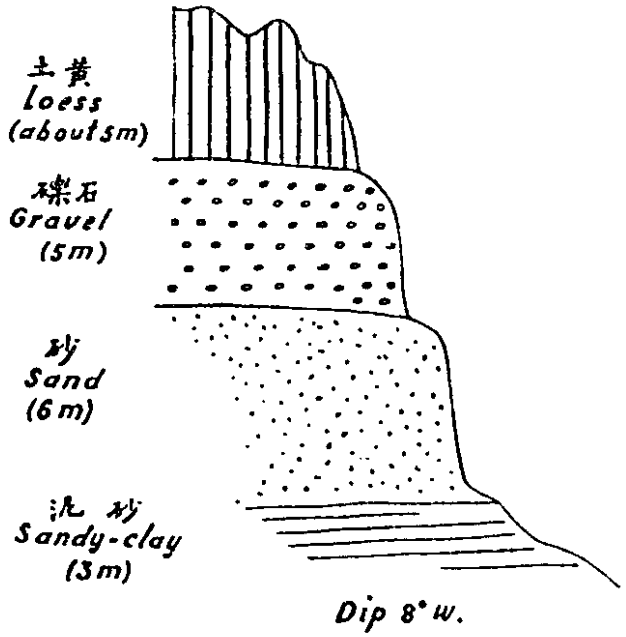

Fig. 34. Section at the San Men rapids. 三門土層剖面圖
(Communicated by Dr V. K. Ting). (據丁文江先生報告)

In 1917 I undertook a survey of the Yellow River from Tung Kuan (at the Honan-Shensi border) to Shen Hsien and noticed in many places these deposits of gravel, sand and even clay underneath the loess. At Shen Hsien some few fragments of big mussels were seen in these beds but they were much too imperfect to be determined.

In August 1918 Dr. V. K. Ting studied the surroundings of the San Men rapids in the Yellow River on the Shansi-Honan border. At a place about 9 li above San Men he discovered the interesting section reproduced in fig. 34. In the lowest series there are numerous big bivalves, a collection of which was made by Dr. Ting. These bivalves were later forwarded for determination to Dr. Wm H. Dall of the Smithsonian Institution, Washington, who has kindly communicated the following note on these specimens:

"There are three species, all near to but not exactly like species now living in China. We have not specimens of the living species enough to determine the limit of variation but the differences are such as to suggest that the fossil forms are the ancestors of the living ones and probably of early Pleistocene age.

The species are as follows:

Quadrula near *Q. spurius* Heude,

Quadrula near *Q. affinis* Heude,

Cuneopsis near *C. capitatus* Heude."

In May 1921, when surveying the Eocene area of Yuan Chü Hsien I was shown some very big mussels which were said to have been found near Ho Ti (see map 1) in the bank of the Yellow river. The locality is shown in text-figure 35 as well as in Plate VII. The details of the section can be described as follows:

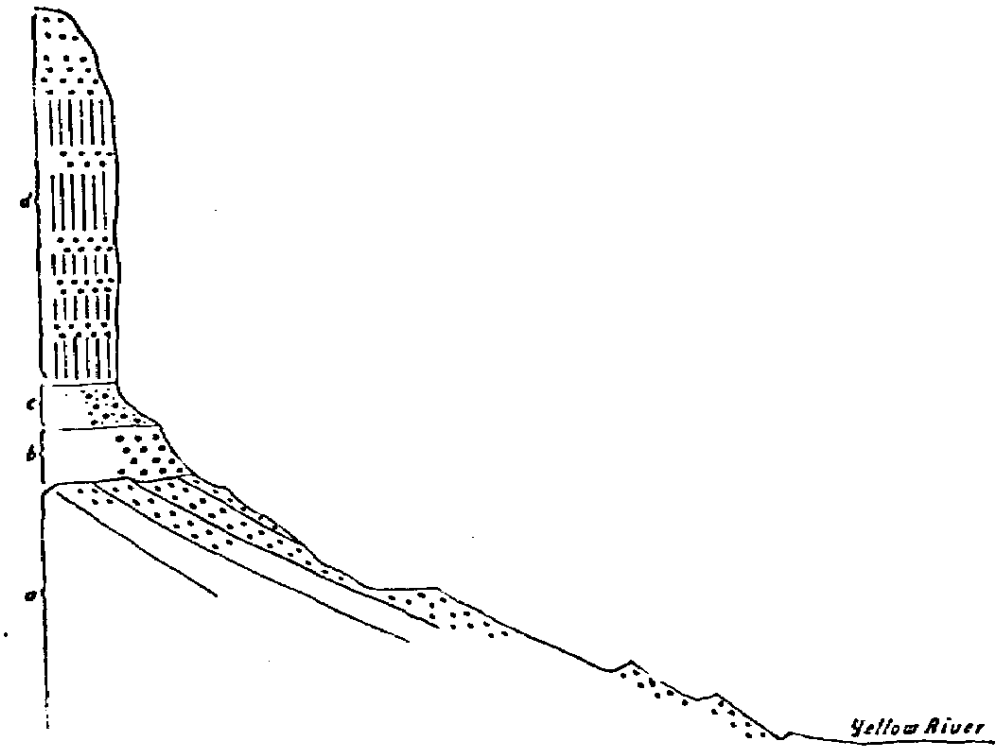

Fig. 35. Section in the bank of the Yellow River. Near Ho Ti Tsun, Yüan Chü Hsien, S. Shansi.

山西垣曲縣河堤村近黃河岸之剖面圖

(a)	Coarse Eocene conglomerate with pebbles of limestone, the beds dip SE 30°.	17 meters
(b)	Coarse gravel	2.5 ,,
(c)	Gravel and sand mixed with gravel. In this hard packed mass there are numerous *freshwater mussels*, some of them of unusual size. Many of the big shells were seen standing edgewise in nearly vertical position.	2 ,,
(d)	Interstratified beds of loess and gravel, about	20 ,,

The mussels have not yet been specifically determifined, but from memory I would think that one or two of the species are identical with those determined by Dr. Dall form the San Men collection. There is also a much smaller type, and an elongate shell (Unionid) of more than 26 cm. length. In the mussel bed there was also found a small fragment of a mammal bone. Some tens of meters from the mussel locality I saw in the sandy gravel a very big bone fragment, 60.5 cm. in length and 20 cm. in diam. To judge from the size it most likely belonged to a *Proboscidean*.

After I had studied this section at Ho Ti, I surveyed the course of the Yellow River from Yuan Chü to the Kin-Han railway bridge, a distance of 300 li. In several places I found considerable gravel beds underneath the loess, but in none of these localities there were shells in the gravel. Some mammal bones were found, but they are very scarce and fragmentary and little can be said at present about the vertebrates contained in those beds.

In SW Shansi there flows a considerable tributary to the Yellow River, the Fen Ho. From some information at my disposal it seems that also in this river valley there are thick deposits of sand underneath the loess. Rev. Bertram Lewis of the Ho Ching mission station has kindly collected some fossil bones from this area. These specimens are now in the museum of the Geological Survey and consist of the scapula, fragment of a jaw and fragment of a molar, all belonging to an *Elephas*. In August 1918 Dr. Ting visited this area and examined the locality where the said mammal remains had been found. They come from a village Pei Li, some 25 li NE from Ho Ching city. There is a section showing 30 meters thickness of indistinctly stratified sand underneath 10 meters of loess. The fossils were found in the uppermost part of the sand, close underneath the contact to the loess (fig. 36).

Mussel-bed belonging to the San Men Series. Near Ho Ti, Yuan Chü Hsien.
(Compare fig. 35, page 119.)
層系門三之殼介物動體軟夾村堤河曲垣西山

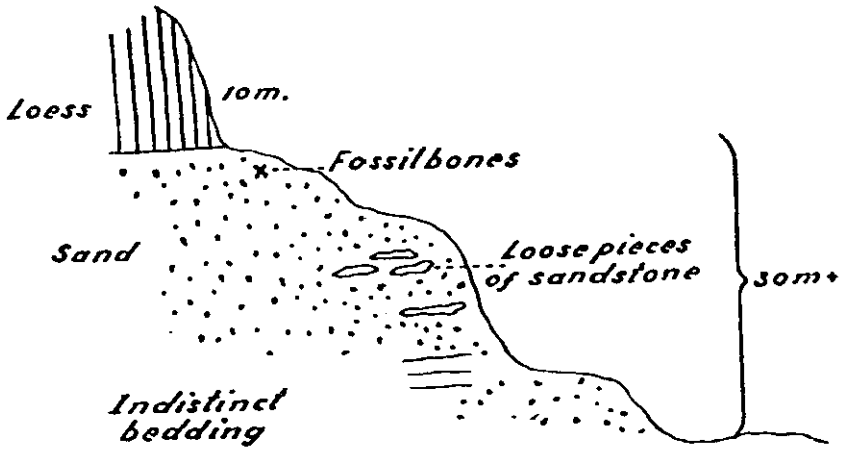

Fig. 36. Section at Pei Li, Ho Ching Hsien, Shansi.
(Communicated by Dr. V. K. Ting).

山西河津縣北里剖面圖 (據丁文江先生報告)

It appears from the notes given above that so far the fauna of the sands and gravel underneath the loess is very imperfectly known and little can at present be said about the age of the San Men series.

As stated above, Dr. Dall considered the mollusks from the San Men section to be of early Pleistocene age and this well conforms with the age which I would from general geological considerations ascribe to these beds.

THE LOESS.

The physical properties, as well as the geographical range and topographical distribution of the loess have been graphically depicted by Richthofen, and Bailey Willis has added some important observations, especially on the interstratification of gravel with the loess.

In many respects the loess still remains an enigma of Cenozoic geology in northern China, and it is my intention at a later occasion to deal more fully with the problems connected with this deposit. At present it will suffice to add some remarks on the following topics:

The mode of occurrence of the loess.
The relationship of the loess to underlying sediments.
The origin of the material constituting the loess.
The vertebrates contained in the loess.
The age of the loess, and
The climatic conditions under which the loess was formed.

In order to make the mode of occurrence of the loess better understood it will be appropriate to describe some typical areas where this deposit has been closely studied by us.

Every passenger, coming south on the Kin-Han line from Peking must have noticed a high loess cliff bordering the Huang Ho on the south side, at the place where the river is crossed on the long railway bridge. From this point the loess cliff runs almost uninterruptedly up the river for a distance of 200 li until the hilly land is reached. In N-S direction the loess plateau is not very broad, forming in fact a mantle on the northern slope of a low rock range running W-E not far south from the Yellow River and named Mon Shan. Towards the river the loess plateau everywhere forms a steep cliff indented be numberless ravines. The height of the cliff can be estimated at 40' perhaps in some places as much as 60 meters, these figures at the same time serving to indicate the thickness of the loess.

In several places I have noticed stratified gravel and sand underneath the loess, these deposits very likely belonging to the San Men series. If this interpretation is correct, it

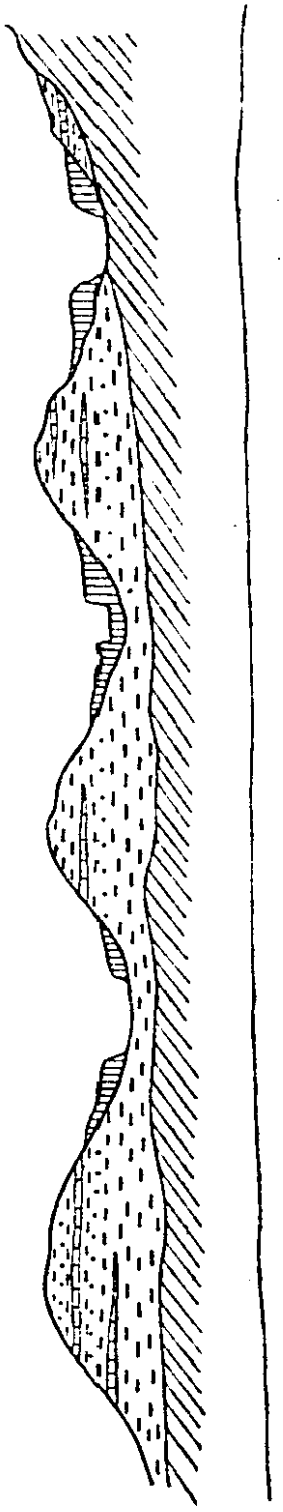

Fig. 37. Ideal section showing the relationship between Hipparion-clay and loess. N. of Hsin An city, Honan.
河南新安縣北土層剖面圖(表明合三紐古馬之粘土與上覆黃土之關係)

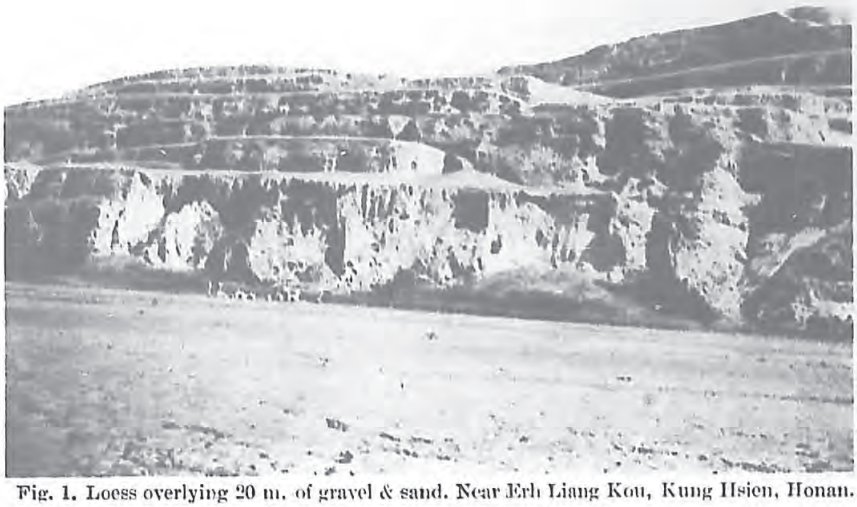

Fig. 1. Loess overlying 20 m. of gravel & sand. Near Erh Liang Kou, Kung Hsien, Honan.
土黃之上層礫砂溝兩貳縣鞏南河

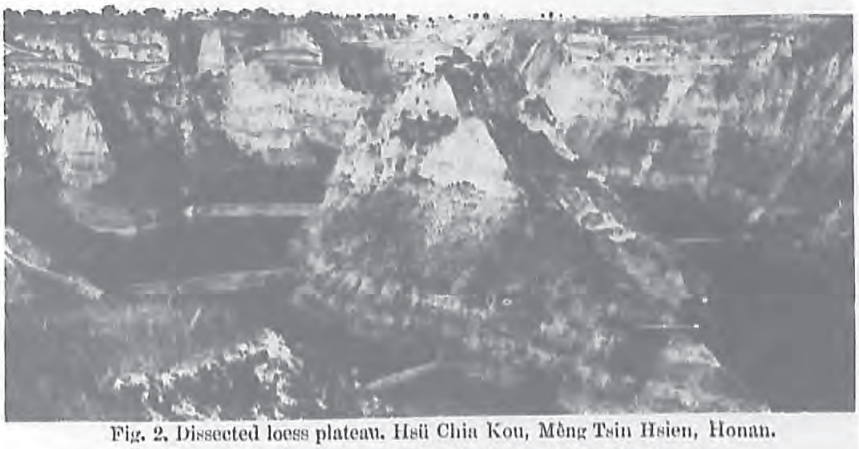

Fig. 2. Dissected loess plateau. Hsü Chia Kou, Mêng Tsin Hsien, Honan.
原高土黃之破冲經溝家徐縣津孟南河

follows that the whole series above the gravel is loess in spite of the fact that the lower part is reddish in color with indications of stratification in the shape of a distinct horizontal color-banding. Only the upper part of the deposit has the yellowish grey color of the typical loess and shows no sign of stratification, Plate VIII shows sceneries from this loess region.

Further west in Honan, in Hsin An Hsien, I have studied another instructive loess area, the main features of which are shown by fig. 37. Here the loess occurs as a valley deposit, filling the valleys which were cut in *pre-loess* time into the plateau of *Hipparion* beds. These valley fillings are now much eroded by streams which have in most instances followed the pre-loess valleys and often cut down through the total thickness of the loess until the *Hipparion* beds have become exposed in the bottoms of the valleys. Here the loess is everywhere of the typical yellowish grey color.

In Mien Chih Hsien, about 100 li further west, much the same conditions prevail. Here too the loess is a valley deposit filling pre-loess ravines cut down into the Pliocene clays. The modern cycle of vertical erosion which has largely removed the once continuous loess fillings in the valleys has in most cases reopened the pre-loess ravines. The loess is typically yellowish grey in color. It sometimes occurs also on the top of the plateau, but there only with a thickness of a few meters, whereas in the ravines the rapidly changing thickness of the loess may locally attain 30-40 meters.

In the Pao Te Hsien area of NW Shansi, which has been studied in much detail by Dr. O. Zdansky, the loess, with a thickness of 40 meters, forms a cover over the *Hipparion* clay. As shown by Dr. Zdansky's section (fig. 38) the loess here forms a plateau deposit, but it has been noticed by Zdansky that here too the loess was deposited upon a pre-loess topography cut down into the *Hipparion* clays, and in this case also the old valley topography has been reopened by the post-loess erosion. Dr. Zdansky remarks that in this area the contact between the *Hipparion* clay and the overlying loess is perfectly sharp and that there is no difficulty in distinguishing one deposit from the other.

Early writers, specially Richthofen, described the loess as a deposit of locally very great thickness, 1.500 feet and more. As far as our observations in the eastern provinces of northern China, Shantung, Chihli, Shansi and Honan go, this enormous thickness has not been confirmed, 50-60 meters being in fact the greatest thickness observed for the undoubted genuine loess.

This difference in opinion as to the thickness of the loess of northern China is partly due to the fact that we now know that much of what was designed by Richthofen as loess, are in reality much *older deposits belonging to different* Tertiary epochs, above all the period of the *Hipparion* fauna.

The loess was practically the only Cenozoic deposit known to Richthofen and Bailey Willis, and in several cases when passing by sections described by those authors I have been able to determine thta the lower part of the series exposed is not the genuine loess but much older, Tertiary deposits, mostly the *Hipparion* clays. In order to illustrate the fundamental change of opinion brought about by the identification of the Tertiary clays as entirely distinct from the loess, it is serviceable to recall that Richthofen described the limestone concretions (Loess-Püppchen) as a specially characteristic feature of the loess. Loess-Püppchen, originally known from the loess deposits of Germany, certainly are of common occurrence in the Chinese loess, but as a matter of fact there are few places where I can *prove beyond doubt* that the sediment containing these calcareous concretions is undoubted loess, whereas there are numerous places known with typical Loess-Püppchen in reddish clay containing the *Hipparion* fauna.

In many sections there is a well marked boundary line between the overlying grey loess and the underlying red *Hipparion* clay, and in such cases it is easy to distinguish

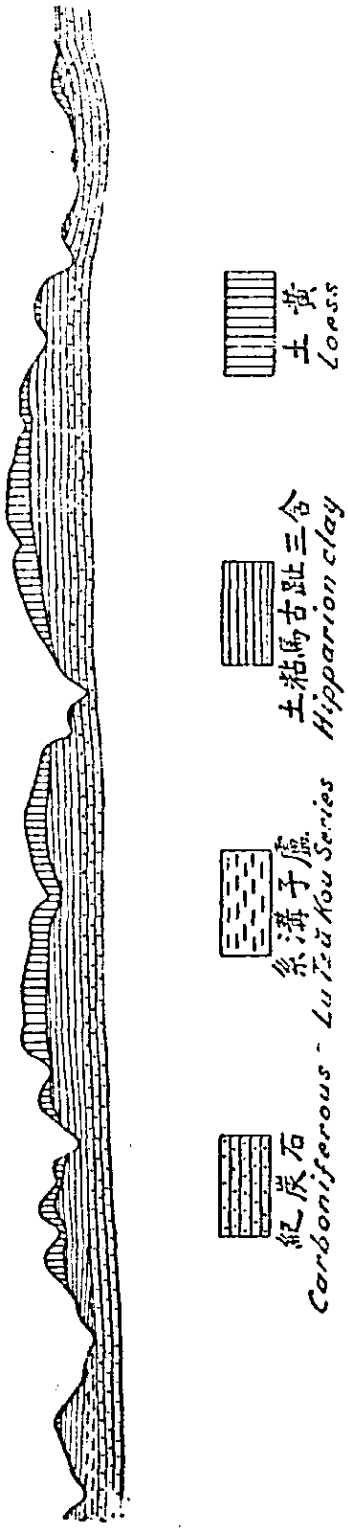

Fig. 38. Section through the Chi Chia Kou area, Pao Te Hsien, (Communicated by Dr. O. Zdansky).
山西保德縣岔溝剖面圖 (據師丹斯基博士報告)

between the two sediments especially when mammal fossils are present to confirm the conclusions drawn from petrological and geological considerations. But in many other localities the sediment is more indifferent so that it can be called a loess-like clay or reddish, somewhat clayey loess. As fossils are very rare, it is often impossible in such instances to decide the age and nature of the deposit. Under these circumstances it is hardly possible at present to tell how much of Richthofen's loess is the genuine thing and how much belongs to older, mostly Tertiary sediments. Illustrative in this respect is Dr. Zdansky's careful survey of the Chi Chia Kou region in Pao Te Hsien, NW Shansi, where 65 meters of *Hipparion* clay is overlain by 40 meters of loess (see fig. 38).

It has already been pointed out that sediments are abundant which seem to be of intermediary types between the typical *Hipparion* clay and the typical loess.

In the final passage of the chapter on the Chou Kou Tien deposit it was indicated that probably many of these intermediary sediments are of transitionary nature, not only in petrological character but also in age. Otherwise expressed, I presume, that continued palaeontological research on our collections of fossil mammals will prove the existence, between the early Pliocene *Hipparion* clay and the Pleistocene loess, of loess-like clays with a late Pliocene fauna.

These considerations have lead me to depart, at least to some extent, from the explanation given by Richthofen for the origin of the loess. According to that author, the material which formed the loess was brought by aerial forces from the desert and steppe areas of Central Asia. I admit that this might be the case, at least to a considerable extent. In the small area of Inner Mongolia which I visited in 1920, I hardly saw any true loess, and in these borderlands the loess seems to be just as common in the dissected area of China proper close up to the edge of the Mongolian plateau as it appears to be rare or entirely absent upon the plateau itself. It is evident that the absence of the loess on the plateau can be accounted for in accordance with Richthofen's views by assuming that the winds swept the vast plateau clean from the loess material and deposited it in the dissected and consequently more sheltered terrains of China proper.

But the fact, established in an overwhelming series of cases that there exist almost everywhere in the loess-areas transitionary stages between the *Hipparion* clays and the loess, points to some relationship between these two sediments which are of such widely different age.

To judge from the composition of the rich mammal fauna of the *Hipparion* clay it becomes increasingly apparent that it was laid down under steppe conditions, much as was the case with the loess according to Richthofen's explanation. If I am right in my assumption that there are also late Pliocene sediments of steppe origin, it seems likely that in Late Tertiary and most of Pleistocene times steppe conditions prevailed in northern China, probably interrupted by a period of much more abundant rainfall, as shown by the vertical erosion of the Fen Ho stage and the stratified sands and gravels (San Men series) underneath the loess.

The *Hipparion* "clays" are not a real clay in the strict sence of word but probably the somewhat resorted residuum from the long continued weathering of a rock-surface consisting largely of limestones. It can hardly be considered merely an accident that the *Hipparion* areas are within or immediately bordering upon regions of extensive limestone deposits.

It seems as if these residual clays were resorted and deposited repeatedly, and this selective resorting process resulted in washing away the finest clayey material which the rivers mostly carried out to the sea. The residuum gradually assumed the character of a sandy loam. In Middle Pleistocene time, the region became more decidedly arid with the consequence that aerial forces became dominant and assorted and redeposited the loam according to the laws of winddrift deposition. This may be regarded as a tentative explanation of the transition from the *Hipparion* clay to the typical loess: a series of redepositions of largely local material continued during a long space of time which extended from early Pliocene to Middle Pleistocene. By this interpretation I do not deny the correctness of Richthofen's idea that the loess was largely derived from the interior of this continent. It has merely been my desire to call attention to the fact that such transitionary stages exist and that consequently the loess might be partly of local origin.

Fossils of the loess. The commonest animal remains in the loess are land shells, mostly *Helicidæ*. These shells must be collected with special care in order to insure immunity from intermixture of recent shells which are by the rains washed down upon the loess cliffs and left there under conditions which would easily deceive the less wary observer. My series of carefully collected loess-shells are in the hands of my malacologist collaborator, Dr. N. Hj. Odhner, who will in due time report on them.

Of mammals from the loess so far very little is known and the few notes existing are partly misleading. The mammal fauna of the loess is very poor, both in individuals and species. Nearly in all cases only single individuals are found very sparingly scattered in the immense volume of the loess deposits. There exist no localities where mammal bones can be regularly excavated, as is the case with the *Hipparion* clay, but the student is limited to occasional finds made by the local population.

The most common mammal remains in the loess are tusks and molars of an *Elephas*, which according to Dr. Zdansky may possibly be *Elephas namadicus*, which was originally found in the Pleistocene alluvium of the Narbada valley of India, where is occurs together with two species of *Hippopotamus*, and several other mammals. The reappearance of this Indian species in the North China loess would be very surprising, especially in view of Richthofen's eolian theory. However, Dr. Zdansky's provisional determination has to be tested by a much closer study of the specimens. At any rate, it is beyond doubt that the common loess elephant is not the Mammoth as has formerly been suggested.

Among the numerous isolated finds which have been made in loess-like material the following species can with fair safety be assigned to the loess: *Rhinoceros affinis simus, Ovis? sp., Hyena sp., Ursus sp.*, A skull of a *Castorid* also was obtained form undoubted loess, and this is another find which tends to weaken Richthofen's eolian theory. The same applies to a recently found *Sus sp.*

Only in a single case, have we ever come across what deserves the name of a small bone accumulation in the loess. This was in SE Shansi, in Yuan Chü Hsien, and the locality has been studied by Dr. Zdansky who has communicated the section fig. 39. In this place were found: *Hyena, Equus, Cervus* and *a turtle.* The deer, a forest animal, and the turtle, a water animal, are further finds which hardly agree with Richthofen's eolian theory.

Lastly we have to mention a fossil which seems to conform better with the said theory, namely the egg shells of an *Ostrich*, a bird described under the name *Struthiolithus* (for details see my article on *Struthionidæ* remains, in this series of essays). The modern ostrich is a steppe bird, and the mere mode of occurrence of these unbroken shells, often two or more together, seems to indicate that the nests were occasionally covered by a wind-drift deposit which prevented the eggs from maturing and preserved the shells in an unbroken state.

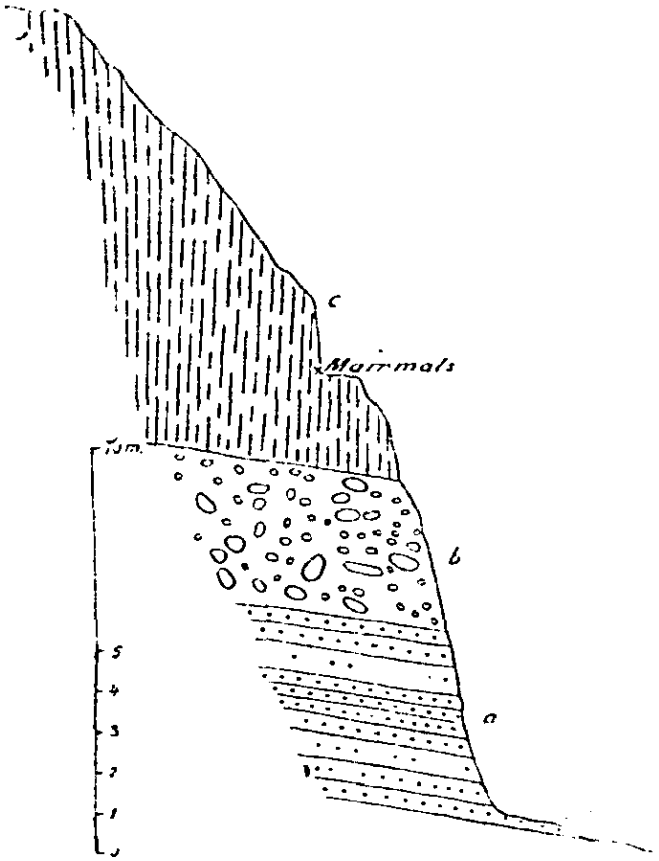

Fig. 39. Section at Yuan Chü Hsien, Shansi. (Communicated by Dr. O. Zdansky)
山西垣曲縣地層剖面圖 (據師丹斯基博士報告)

a. Eocene beds, 始新統地層
b. Gravel. 砂礫層
c. Loess. 黃土

With our present, very imperfect knowledge it is impossible to give a definite opinion on the climatic conditions of the loess formation. The geological and topographic evidence is strongly in favour of Richthofen's eolian theory but the fossil discoveries are of conflicting nature.

Furthermore, the age of the loess is not well settled. The fauna is decidedly of a Pleistocene type, and, assuming that Dall is right in dating the mussels of the sub-loess San Men beds as early Pleistocene, it will follow that the loess is of Middle Pleistocene age. It would then indicate an arid equivalent of the Pleistocene Ice Age.

Recently we have made a find which might eventually prove to be a cave facies of the loess. It is a cave deposit in the Western hills of Peking. The sediment is a loess-like loam in which there have been found the following species: *Rhinoceros, Ursus, Sus, Artiodactyla* and some few *bird* remains. The correlation of this deposit with the loess is apparently so far based upon only very slender evidence.

POST-LOESS DEPOSITS.

Redeposited loess. In many valleys within the loess areas there are deposits of loess interstratified with gravel and occurring under such conditions that they must evidently be regarded as representing later redepositions derived from the genuine loess. They are valley deposits of very limited extent with rapid and irregular changes of the stratification. Thick beds of gravel suddenly appear, and the gravel component of these deposits is far more abundant than is the case in the genuine loess. Everything goes to show that in the formation of these secondary loess-gravel beds water action has been the dominant factor and that the wind has played only a very subordinate role. I call these deposits Redeposited Loess in order to distinguish them from the genuine Primary Loess.

Only in Northern Chihli and in Joho have fossils been found in these beds. Most common among these are the antlers of a big *deer* and skulls of a bighorn *sheep*, with horn cores thicker than those of any living species. Horns and also part of the skull of a *Bos sp.* have also been found. A beautiful skull of *Rhinoceros antiquitatis* bought from a medicine shop in Chao Yang Hsien, Joho, might have come from the redeposited loess, or else from the old primary loess.

The Chi Ku Shan deposit. A peculiar small bone deposit occurring at Chou Kou Tien, 70 li SW from Peking, was described by me in Geografiska Annaler, Stockholm 1919, page 265-268.

It is a pillar of red clay, 5.5 meters high, the base of which is surrounded by the Ordovician limestone. The pillar stands in the midst of a limestone quarry, and there is no doubt that the clay mass originally formed the filling of a small cavity in the limestone which has been largely removed, leaving the clay mass in the shape of an isolated pillar.

In this clay-pillar numerous bones have been found, namely *birds, Rodentia,* probably two species; *Carnivora,* a smaller and a bigger form.

Another deposit of the same type was found by us in 1922 at Hui Yü (炭 峪) in Wan P'ing Hsien near Peking. Here were found the same small animals that occur in the Chi Ku Shan deposit but in addition to them there were also some rather beautifully preserved remains of small *Artiodactyla*.

Until the fossil bones obtained from these two deposits have been scientifically examined, there is no means of settling their age. The slight mineralization seems to indicate, that they are comparatively young and they have consequently been classified here amongst the post-loess deposits.

Cave-finds. In some caves of the Western Hills of Peking we have obtained small mammal faunas which probably are of post-loess age. Little is to be said about these collections until they have been closely examined. However, I want to mention a remarkable type which has been met with in two or three of these caves, namely a *Hystricid* of unusual size§. Mostly only isolated incisors have been found, but on one occasion one of my collectors brought home part of a lower jaw with the incisor and the first molar. A comparison with two skulls which I had collected in Anhui of the modern *Hystrix subcristata*, proved that the subfossil jaw is considerably bigger. I am also under the impression that the Peking sub-fossil *Hystricid* was a much larger species than the *Hystrix*, remains of which are not seldom found in the Aeneolithic site of Yang Shao in Honan.

In modern times *Hystricidæ* are not known with certainty north of the Yangtze valley (the reported occurrence of a porcupine in the C'hin Ling Shan range, S. of Sianfu in S. Shensi, has not yet been confirmed by specimens)§§. In Honan, where *Hystrix* seems to have been common in Aeneolithic time, we failed to locate the living animals.

The finds of a *Hystricid* in the vicinity of Peking means a tremendous former extension of this mammal group towards the north. In modern times *Hystricidæ* occur only in the humid area of southern China, and it is quite likely that the examination of our finds of sub-fossil *Hystricidæ* in Honan and near Peiking will throw interesting light upon the question of changes of climate in the most recent geological past.

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§. A. de Carle Sowerby who heard of this find during a visit to my home in Peking has made a communication on the matter in Journal of the North China Branch of the Royal Asiatic Society Vol. LIII, 1922. p. 3.

§§. Filchner mentions (Wissenschaftliche Ergebnisse der Expedition Filchner nach China und Tibet, 1903-1905, Band II, p. 47) the occurrence of "Stachelschweine" in Kansu, 60 li W. of Lanchoufu, but in the volume describing the mammals collected by him there is no mentioning of a *Hystrix*, so the statement may not have been corroborated by the acquirement of specimens.

Peat-bogs. The youngest mammal bearing deposits known to me are the peat-bogs in San Ho Hsien and Yih Hsien E. of Peking (see p. 84-92). To judge from the archæological finds occurring together with the mammal bones it seems most probable that these peat-bogs were formed in historical times.

EARLY MAN.

Very little is known about the occurrence of anthropomorphic Apes or of Pleistocene Man in Northern China.

In his classical monograph on the medicine bones, Schlosser describes under the denomination *?Anthropoide g. n. et sp. ind.* a posterior molar - M3 - of considerable interest§.

The tooth is strongly fossilized, and some reddish clay was seen adhering to it. The last named fact is considered by Schlosser as indicating that the specimen came from the Tertiary clay, not from the loess.

"Die Zusammensetzung, der Umriss, und die Beschaffenheit der Wurzeln sind entschieden Mensch-ähnlich, bei Anthropomorphenzähnen divergiren schon die Wurzeln viel stärker, allein der Erhaltungszustand scheint doch für ein relativ hohes Alter, Tertiär, zu sprechen und es ist demnach doch gewagt, diesen Zahn der Gattung *Homo* zuzurechnen, so lange die an sich ja sehr wahrscheinliche Existenz des Tertiärmenschen noch nicht sicher gestellt ist. Wir müssen daher doch auch die Möglichkeit in Betracht ziehen, dass dieser Zahn einem neuen Anthropoiden-Genus angehört, welches allerdings im Zahnbau dem Menschen viel näher käme, als alle bisher bekannten Anthropomorphen.

"Eine weitere Möglichkeit wäre allenfalls auch die, dass der vorliegende Zahn wirklich von einem Menschen stammt und etwa auf secundärer Lagerstätte in oberflächlich aufgelockerten Tertiärschichten begraben wurde. Allein es ist sehr die Frage, ob ein Zahn von etwa pleistocänem Alter unter solchen Umständen so stark fossilisirt werden und einen solchen Erhaltungszustand annehmen könnte, dass man ihn von Zähnen von wirklich tertiärem Alter nicht mehr unterscheiden könnte, wie das hier der Fall ist. Aber selbst, wenn diese Möglichkeit wirklich eintreten könnte, so müssten wir doch diesem Zahn ein sehr hohes Alter,

§. Schlosser. Die fossilen Säugethiere Chinas. 1903. Page 20-21.

mindestens Altpleistocän zuerkennen, denn es ist absolut ausgeschlossen, dass ein recenter oder selbst prähistorischer Zahn sich unter diesen Umständen so gewaltig verändern würde.

"Ein sehr hohes Alter ist demnach für diesen Zahn auf jeden Fall sicher gestellt, nur lässt sich nicht entscheiden, ob es sich um Altpleistocän oder bereits um Tertiär handelt, ja selbst die Möglichkeit, dass wir es nicht mit einem Menschen-, sondern mit einem Anthropoidenzahn zu thun haben, erscheint keineswegs vollständig ausgeschlossen. Allein eine definitive Lösung dieser Räthsel ist wenigstens vorläufig nicht zu erzielen.

"Der Zweck dieser Mitheilung ist es, spätere Forscher, denen es vielleicht vergönnt ist, in China Ausgrabungen vorzunehmen, darauf aufmerksam zu machen, dass dort entweder ein neuer fossiler Anthropoide oder der Tertiärmensch oder doch ein altpleistocäner Mensch zu finden sein dürfte."

H. Matsumoto described in 1915 some fossil mammals obtained from Honan province, among which was a human sacrum considered to exhibit certain primitive features. The specimen is described by him as follows*:

"As compared with the majority of human sacra, the remarkable featuret of the present specimen are that the diminution in size from the first towards the last sacral vertebra is very gradual and the curvature is very feeble. A recens human sacrum is mostly much more curved, the second sacral vertebra being much more retired backwards than the first. The center of the first sacral vertebra of the present specimen is shorter and narrower than that of the majority of recent human sacra, while the same of the fifth sacral vertebra of the former is longer and wider than that of the latter. In these characteristics, the specimen reminds us of *Homo neanderthalensis*, more or less approaching a Simian sacrum."

"As human corpses are buried in earth, one may be anxious whether the present specimen might have originated in such a way. But, the present specimen is almost similar to the vertebra of *Elephas* aff. *primigenius* above referred to, in the state of preservation and in the degree of fossilisation, being, like the latter, attached by a quantity of loess. I am inclined to think that the present specimen represents a Pleistocene man, who was contemporaneous with the extinct elephant. The appearance of the weathered surfaces of the present specimen resembles that of the vertebrae of the La Chapelle man, as judged from Boule's photographs".

*. H. Matsumoto. On some fossil Mammals from Ho-nan, China. Science Reports of the Tohoku Imperial University. Second Series. Vol. III, No: I. 1915.

There is nothing to prove that the different mammal bones described by Matsumoto from Honan actually came from one and the same locality. But they are said all to have come from the loess and are considered as forming together a fauna, as shown by the following quotation:

"All the specimens included in the present paper are very feebly or scarcely fossilised, being obtained from loess. Among the eight species, five are extinct and three living. It is therefore very probable, that the fauna of Honan represented by these species belongs to Younger Pleistocene.

"During Tertiary and early Pleistocene, China, as well as Japan, was almost entirely occupied by a fauna of the southern, i. e. Oriental, type; but afterwards by that of the northern, i. e. Palæarctic, type. The fauna of Honan evidently belongs to the Palæarctic type, being closely allied with the Pleistocene fauna of Europe. A comparison of the particular species of the fauna of Honan with those similar or closely allied with, from Europe is made as fo'lows:

Honan	Pleistocene of Europe
Elephas aff. *primigenius.*	*F. primigenius*
Equus leptostylus.	"*E.* cfr. *stenonis*" of Boule
Sus aff. *scrofa.*	*S. scrofa,* foss.
Cervus hortulorum.	*(C. perrieri;* Pliocene*)*
Elaphurus davidianus.	———
Bos primigenius.	*B. primigenius*
Bison exiguus.	*B. priscus*
Homo sp.	*Homo neanderthalensis*

"Almost all species of the Fauna of Honan have European representatives, except *Elaphurus,* which is characteristic of North China and Japan. The fauna of Honan appears to be by no means related to that of India."

"As to particular species, the following results may be more or less noticeable."

"A large horse form the Pleistocene of China, *Equus leptostylus,* is characterised by the combination of the very slender anterior inner pillar, as in Pliocene horses, and a certain type of the folding of enamel, as in typical Pleistocene and Holocene large horses, of an upper premolar."

"*Cervus hortulorum* and *Elaphurus davidianus,* which are living in North China, occur in the Pleistocene of the same land; especially, the latter species is recorded also from Pleistocene of Japan."

"*Bison exiguus* from the Pleistocene of China is distinguished from European *B. priscus* chiefly by the smaller size."

"A race of man, who reminds us of *Homo neanderthalensis* in the feebly curved sacrum, probably dwelt in the Pleistocene of China."

As Dr. Davidson Black has at his disposal more material of recent and prehistoric human skeletons from China than any other scientist ever had, I asked him kindly to give his opinion concerning the sacrum described by Matsumoto. In reply Dr. Black had the kindness to put at my disposal the following interesting communication:

"During the last two years a considerable amount of human material of Æneolithic age has been collected by the Geological Survey from the Sha Kuo T'un cave in Fengtien and from the great Yang Shao Tsun deposit in Honan. Of the dozen or more sacra excavated in Sha Kuo T'un five are sufficiently well preserved to be compared in detail with the sacrum described by Matsumoto and from the Yang Shao deposit nine well preserved sacra are similarly available. This material has been studied in comparison with modern European and modern North China sacra and will be described in detail subsequently. It is of interest, however, at this time to note that specimens have been found as well in the Æneolithic material as in the modern North China series that closely resemble the sacrum described by Matsumoto in all the features noted by him. So close is this correspondence that no doubt can remain as to the identity of the specimen described by Matsumoto with a type of sacrum frequently found among the inhabitants of North China since Æneolithic times."

From Dr. Black's note it seems as if the evidence brought forward by Matsumoto to show the similarity of the Honan sacrum to that of *Homo neanderthalensis* is hardly convincing. If it could be proved that the Honan sacrum had actually been found together with *Elephas* aff. *primigenius* etc, then the occurrence of Palæolithic Man in China had been proved by means of *geological* facts. Now there seems hardly to be any *anatomical* evidence to prove the assumed relation to an extinct human race.

During our researches in N. China we have never come across any human skeletal remains carrying the mark of geological antiquity. One of the few indications, and a very uncertain and isolated one, of the occurrence in these regions of Palæolithic Man is the find in Northern Chihli (Hsuan Hua Hsien) of

a laurel-leaf point of the type which is considered characteristic of the Solutrean culture stage of the Old Stone Age of Western Europe.[1])

This implement which is shown in Pl. IX, fig. 1. is broken at in both ends. The length in its present state is 243 mm. (when complete it must have been about 320 mm. long), greatest width 78 mm. The material is a reddish grey felsite-like rock. It is coarsely chipped with some smaller retouches along the edges, much in the manner typical of the Solutrean *pointe en feuille de laurier*. Most of the French Solutrean flints of this type seem to have been considerably smaller, 161-180 mm. long, and even less than that. But if I am not mistaken, one of eleven very large Solutrean laurel-leaf points found at Volgu attained the length of 340 mm.[2]), and an implement of the same type and assigned by Montelius to the same period, found on the west coast of Sweden is 300 mm. in length.[3]) These European implements of Solutrean age are mostly made of flint, but is seems quite possible that a dense felsite-like rock could have been used by Solutrean Man here in China where flint is not at hand.

These comparisons go to prove that the felsite blade from Northern China may very well be of Solutrean age. But it is very far from being proved that this is the case. From the flint and obsidian quarries of Northern America W. H. Holmes has described numerous blades of types similar to the Solutrean pointes en feuille de laurier.[4]) According to such high authorities as Holmes, Hrdlicka and Wissler, America was peopled by Mongolian offshoots which crossed Bering Strait in a time so late that those tribes already had acquired a Neolithic culture. If this conclusion is correct, it goes without saying that the American laurel-leaf like implements are of comparatively recent date. Holmes seems to think that the quarries from which these blades were obtained continued to be worked also in post-Columbian time "until the encroachments of Europeans drove the natives from the general region or substituted other materials for the anciently indispensable flint."

It ought also to be mentioned that Peet has described from Italy a number of "Palæolithic survivals" into Neolithic time including almond shaped and willow-leaf shaped lance-heads (?) reminding one of Chellean types of the Palæolithic.[5])

1.) Déchelette. Manuel d'Archéologie. I. P. 138-139.
2.) Osborn. Men of the old Stone Age. P. 339., fig. 169 (No. 130).
3.) Montelius. De mandelformiga flintverktygens ålder. Antikvarisk Tidskrift. Del. 20. fig. 24. 1913.
4.) Holmes. Handbook of Aboriginal American Antiquities. Part. I. Fig. 61 and 92. 1919.
5.) T. E. Peet. The Stone and Bronze Ages in Italy and Sicily. P. 177-184. 1909.

The specimen here in question was bought from a village man. Later on one of my Chinese assistants visited the place and was shown the exact spot where the implement was said to have been found. However he failed to find at that spot any further evidence of ancient human habitation, so the finding is so far an isolated one.

In a region adjacent to the one where this big laurel-leaf point had been found, in Wan Chuan Hsien (萬全縣) W. of Kalgan I personally collected in 1920 a small beautifully worked implement of a yellowish-brown flintlike stone. The specimen is shown in Pl. IX, fig. 2. Its length is 27 mm. It is elaborately worked by chipping off long narrow flakes and shows a rounded cutting edge. In shape it comes most closely to the "grattoir caréné" of the Aurignacian Period (compare Osborn, Men of The Old Stone Age, p. 309), but the size is smaller than what seems to be the average with flints of this type.

The circumstances of the find hardly indicate a prehistoric age for this object. One of my Chinese collectors had found in 1919 at the spot in question a complete human skeleton buried in sitting contracted position. The skeleton was handed to Dr Black for examination and is, according to his statement, of an entirely modern type.

In 1920 I visited the place in order to examine the local conditions. In a meters distance from the finding place of the skeleton and in about the same same depth below the present earth surface, I found in redeposited loess with occasional pebbles this beautifully chipped little flint. In the same bed were found also some pieces of modern glazed pottery and even a small fragment (tea-cup ?) of simple white and blue porcelain. It goes without saying that the deposit is of quite recent date, but a flint, like the one here in question, is nearly undestructible and might have been secondarily washed into this modern loess-like deposit from some older site.

A persistent search undertaken in 1922 on the slopes round this place gave only some few raw flakes of the same yellowish brown flint-like stone but no chipped instruments or other signs of an ancient site.

The only possible use for such a flint-like stone in modern time would, as far as my experience goes, be in a tinder-box such as are still in use in out-of-the-way places in many parts of China. However, the flints for firemaking are simply raw flakes but not chipped stones of the perfect workmanship exhibited by the

Fig. 1. Fig. 2.

Fig. 1. Laurel-leaf point. Hsuan Hua Hsien, Chihli. Red. 2/3. (See page 134-136).
Fig. 2. Chipped flintlike stone, Wan Ch'üan Hsien Chihli, Nat. size. (See p. 136).

第一圖 葉桂得所化宣隸直 刻石式
第二圖 萬隸直 全得所擊撃作成之石器

specimen here in question. To judge from the shape, our specimen is more likely a real implement of some antiquity.

The big laurel leaf point from Hsuan Hua Hsien and this small chipped flint from Wan Chuan Hsien are the only indications and very uncertain ones of the *possible* occurrence of late Palæolithic Man in these regions. Not only are there no unquestionable traces of Palæolithic Man so far known in N. China, but the true Neolithic seems also to be missing, as far as our researches have gone. Large numbers of stone implements have been made known through the investigations of Torii and myself, but my detailed examination of the Sha Kuo T'un cave deposit in Fengtien and the large Yang Shao site in Honan has proved that these deposits are not really Neolithic, but belong to a considerably more advanced *Æneolithic* culture, to which I have assigned the local term *The Yang Shao culture.*

A preliminary review of the Yang Shao culture has been given by me in a paper "An Early Chinese Culture", Bulletin of the Geological Survey No. 5, and for the present purpose it will suffise to sum up the main features as follows:

The type locality, Yang Shao Tsun, is located in the open plain in Mien Chih Hsien of Honan province. The deposit is of unusual dimensions, 960 meters in N-S and 480 meters in E-W direction. In the northern part the culture stratum is not fully continuous, but in the southern half, or more, nearly every square meter is occupied by a culture deposit 1-5 meters thick.

The furniture occurring in this deposit is rich in polished stone implements, greenstone axes, rectangular knives, slate arrow points, sling stones, spinning whorls and flat stone rings (armlets or pendants). There are also artifacts made of bone, such as beautiful sewing needles and awls, and others made of deer horns and mussel shells.

The vast majority of the human products are ceramic fragments. The coarse pottery, represented by a large and very varied number of types, exhibits striking affinities to bronzes of early Chinese dynasties, and in several other respects there are also such similarities to things Chinese that I have not hesitated to name this site a monument of an early Chinese culture.

Intermixed with these stone implements of a Neolithic type and with coarse pottery clearly allied to the "Ting" and "Li", two well known Chinese bronze tripods, there occurs sparcely and mostly in small fragments a very fine

pottery ware with polished surface and paintings in black, white and red upon the mostly red, but sometimes dark-grey surface of the ware. This polychrome pottery shows remarkable similarity to polychrome wares of Æneolithic age which have been found in numerous places in the Near East and Europe (Russian Turkestan, SW Russia, W. Persia, Babylonia, Greece and Italy). The affinities between these two, geographically widely separated groups of polychrome pottery are so striking that we must accept as a working hypothesis for continued research the possibility that a migration of art designs (and probably also other cultural and racial features) might have taken place from the Near to the Far East.

No metal object has ever been found during our excavations in the Yang Shao sites, but, because of the rich variety and in part beautiful finish of the ceramics, coupled with the striking affinity to early bronzes and other Chinese things, I consider it inadvisable to name this culture Neolithic but prefer to include it in the Æneolithic period, the transition from the late Noelithic to the early metal ages.

Besides the type locality, Yang Shao, several other sites of the same culture have been studied by us in Honan. To this stage I have also tentatively referred the Sha Kuo T'un cave deposit in Chin Hsi Hsien of Fengtien province. Recently my palæontological collaborator Dr. O. Zdansky from his survey of the Pao Te Hsien area of NW Shansi has brought home a small collection which conclusively proves the existence of the Yang Shao people in that region also. When all these facts are taken into consideration, we may be justified in assuming that the Yang Shao culture extended all over the eastern part of northern China from central Honan to the Mongolian border-lands and from the Yellow Sea to the Shensi-Shansi border.

Besides the sites above mentioned, which have been studied by us in the field and where a more or less complete Æneolithic furniture has been gathered, I have in my collections thousands of stone implements bought from the country population in various parts of the area mentioned. These polished stone artifacts could very well be of Neolithic age, but they so perfectly agree with the stone implements actually found in the Yang Shao sites, that I feel inclined to consider them or at any rate the greater bulk of them to belong to the Yang Shao cuiture.

In addition to this evidence obtained through my researches, we have the vast material from S. Manchuria and E. Mongolia made known by Torii's investigations. This comprises stone and bone implements identical with those

found by us and also pottery, partly of types familiar to me. It is possible that some of Torii's material refers to another racial group, but our find of the Sha Kuo T'un cave, actually within the region studied by Torii, makes it more probable that his material also belongs to the Yang Shao culture. He sometimes names his finds Neolithic, but in other cases he mentions facts intended to prove that some stone implements were contemporaneous with early Chinese dynasties. The real affinities of Torii's finds are not very clear, but is seems to me most likely that the larger part of his material is approximately contemporaneous with the Yang Shao culture.

I have above brought together a large number of facts which tend to show that there is all over northeastern China abundant evidence of a culture of Æneolithic age showing apparent affinity, not only to early historical Chinese times, but also to the Western World.

In striking contrast to this abundance of Æneolithic material stands the absence of finds from earlier periods. My laurel-leaf point and "grattoir caréné" are both too uncertain and isolated facts to be interpreted as proof of Palæolithic Man. From the earlier part of the Neolithic I know at present not a single undisputable specimen.

Negative evidence is always exceedingly uncertain. But as things stand for the moment, the absence of Palæolithic and early Neolithic finds is remarkable, specially as our research has been systematically conducted in that direction. We have explored several tens of caves in Chihli, Shansi, Honan, Shantung and Fengtien. One (Sha Kuo T'un) yielded an interesting Æneolithic furniture together with numerous remains of Man of that time; several others contained Pleistocene mammal faunas of noticeable interest (compare p. 129-130). But in none have there been found traces of Early Man.

In a masterly lecture on "The Anthropology of Asiatic Peoples" delivered before the Joint Conference of the China Medical Missionary Association and the National Medical Association of China in Peking, February 1920, the eminent anthropologist Dr. A. Hrdlicka, made a statement which practically predicted the condition of things which has become evident through our researches in 1921 and 1922. Dr. Hrdlicka spoke as follows:

"The reasons for the apparent paradox of the presence of pre-human and possibly very early human forms over doubtless large regions of southern Asia, and the absence or scarcity of early man over the vast area of the central

and northern portions of eastern Asia, can mean only one thing, and that is, that the earlier spread of the stock into these territories was hindered by something very potential."

Some few days after Dr. Hrdlicka had delivered his lecture, I had the pleasure of receiving him in my home together with Dr. Davidson Black. At this occasion I called the attention of the two anthropologists to the great importance, from a geologist's point of view, of Dr. Hrdlicka's statement and the possible way of explaining the striking anthropological fact brought forward by him in the light of geological data accumulated during our researches. I pointed out that, according to our finds of fossil mammals in the loess, this deposit is probably of Middle Pleistocene age, and, according to Richthofen, an arid steppe deposit. Consequently these arid conditions of northern China were approximately contemporaneous with the development of Palæolithic Man in Europe, and it seemed worthy of consideration that the steppe-desert conditions of N. China during a large part of the Pleistocene time might have retarded the immigration of Man into that area.

Dr. Hrdlicka remarked that this way of explaining the absence of Palæolithic Man from N. China was entirely new to him and worth thoughtful consideration.

It was with some surprise, that I later read in the reprint of his lecture in the Anatomical Supplement to the "China Medical Journal", July 1920, the following passage which did not occur in his spoken lecture and which dealt with the obstacle preventing the distribution of Man into the central and northern portions of eastern Asia:

"Whether this was climate, or other cause, it is as yet too early to say; but climatic conditions, such as a possible semi-desert area over what are now the loess regions of China, should, it would seem, receive the first consideration."

That Dr. Hrdlicka after our conversation inserted my suggestion in his manuscript without mentioning its origin, might be due simply to the fact that he did not want to burden his paper with footnotes. In a private letter of Nov. I, 1921 he has duly acknowledged my contribution to his written treatise.

The question once brought up by me in the conversation with Mssrs Hrdlicka and Black, whether the arid loess climate delayed the appearence of Man in N. China has become more and more acute for me as our researches progressed

during the last two years, the outstanding achievement of which is the manifestation of the wide-spread and far advanced Yang Shao culture.

A feature of the Yang Shao site, not yet mentioned in this paper is the remarkable fact, that the ravines which dissect the area to a depth of 40 meters were cut down *after* the culture deposit was formed. The matter is somewhat more fully treated in my paper "An Early Chinese Culture".

Consequently, the Yang Shao people lived upon the unbroken loess plain, which has here been dissected only during the last four or five thousand years. How far these conclusions can be extended to embrace in a general way the characteristic ravine topography of N. China, will become the object of future research. Premature conclusions of a too far reaching nature are certainly undesirable.

As mentioned in the chapter on remains of *Struthionidæ*, fragments of a *Struthiolithus* egg have been found in the Yang Shao site. It would be tempting to explain this fact as the proof that the loess steppe climate still prevailed at that time. But I have mentioned that very likely the *Struthiolithus* shell was fossil already when it was found and broken by the Yang Shao Man.

In some details the fauna of the Yang Shao period seems to have been different from the present one in those tracts. Especially noticable are the repeated finds of jaws and teeth of a *Hystrix*, a mammal which, as far as we could discover, has now disappeared from the Yang Shao region. But *Hystrix* would rather indicate a more moist climate than the modern one, to judge from the fact that at present *Hystricidæ* do occur only in the watery region of the Yangtze valley and further south.

The abundance of charcoal fragments in the ashy earth of the Yang Shao culture bed indicates that the old village was surrounded by forest or at any rate a bush vegetation, and the repeated finds of antlers (partly worked to tools) and even complete skeletons of *deer*, a forest animal trend in the same direction.

To watery conditions also point the occasional finds of fragments of *turtles* and of *fish bones* in the culture stratum.

To sum up these facts, it is most likely that many changes had taken place after the loess steppe climate gave way and before Æneolithic Man with his polished greenstone axe cut his firewood in the forests of the Honan plain.

All we can say at present is that we know of no undisputed proof of Palæolithic or early Neolithic Man in N. China, and that the extent and wide distribution of the Yang Shao culture forms a remarkable contrast to the lack of evidence from earlier times.

However, it is my hope that some day a fortunate find will nullify Dr. Hrdlicka's and my own speculations, and in this spirit I close this volume and start out for continued field research.

ADDENDUM.

RECENT RESEARCH IN KANSU AND SHANTUNG.

Different parts of the previous paper have been written at widely different times. The chapter on the "Nanking volcanoes" was prepared in January 1920. Those on the Yuan Chü Eocene, the Mongolian vertebrate deposits and Struthiolithus date from the summer of 1921. The rest was written in the course of 1922.

Because of the unintermittent pursuit of our fieldwork some of the chapters have already become somewhat antiquated before they have appeared in print. Our recent reconnaissance in Shantung has proved that there are much wider areas of the older Tertiary than we formerly dared to believe. The new facts from Kansu brought home by the earthquake-expedition are also of great promise. In the following pages I give a very brief summary of these new facts. For details the reader is referred to Mr. Hsieh's paper on the geology of Kansu and to the paper by the present author and Mr. T'an on the geology of the Meng Yin and Lai Wu valleys in Shantung. Both these papers will be published in the Bulletin of the Geological Survey.

In addition to the description of the new Eocene areas in the provinces named, it has been found necessary to mention also the younger Mesozoic beds which in those two provinces are closely related geologically to the older Tertiary. Furthermore, these recent researches have thrown so much light upon tectonic problems that it was advisable to delineate some general features of the younger Mesozoic and Tertiary history of Northern China.

On the 16 of December 1920 an earthquake of unusual intensity swept through N. China. In the epicentral area, in Kansu, the destruction was formidable. In certain districts the landscape was radically changed. Numerous landslides occurred in the loess-masses and whole willages were annihilated. The number of people killed was estimated at 150,000 individuals.

In the spring of the following year a government commission including three geologists, Dr. Wong Wen-Hao, Mr. Wang Lieh and Mr. L. Y. Hsieh, was sent to examine the conditions in the devastated areas. The geological work of Dr. Wong and Mr Hsieh has enormously increased our general knowledge of the geology of Kansu, especially with regard to the Mesozoic and Older Tertiary. From Mr. Hsieh's paper on the Red Beds of Kansu we learn the following:

In different regions of Kansu, in the eastern part of the province, as well as in the valleys of the Siningho and Tatungho and finally also in the distant NW between Nanshan and Peishan there occurs a series consisting largely of red shales and sandstone; these beds are for the most part tilted but locally are distinctly folded. This is the Kweite formation of Lozcy, who, upon very slender evidence, interpreted it as of Pliocene age.

In SE Kansu, the Pingliang-Kingyangfu area (and also in adjacent darts of Shensi) fishes of the genus *Lycoptera* and other types have been found in these beds. This part of the series is evidently of Jurassic age.

In Ku Yuan Hsien a limestone bed was found in these "Red Beds" containing abundant shells and opercula of a small gastropod which I recognized as probably identical with a species of the Yuan Chü Eocene (S. Shansi), described in an earlier chapter of this paper. This identification has been fully confirmed by my recent observations in Shantung where "the Ku Yuan gastropod" is the index fossil of the richly fossiliferous Eocene beds. Evidently, in the Ku Yuan section at least, there is also an Eocene series included in the Red beds. These Eocene sediments are distinctly folded as shown by the section fig. 40 which Mr. Hsieh has kindly put at my disposal.

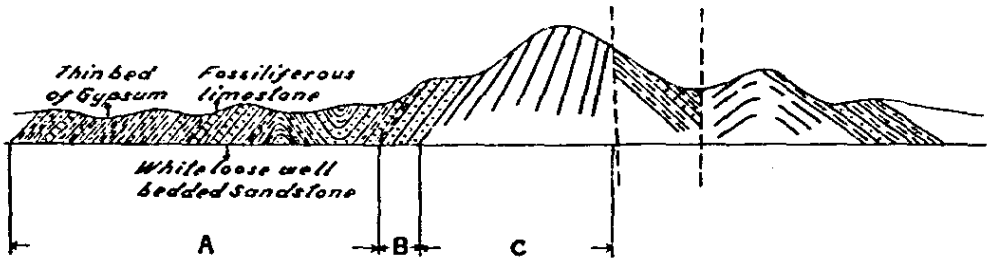

Fig 40. Section at Szekoutze, NE. of Kuoyüan Kansu. 甘肅固原石溝子剖面圖
A. Red Beds consisting of shale and sandstone alternately bedded. Dip to NEE. 40°—50°. 互相夾間之紅色頁岩及砂岩
B. Red sandstone, massive and coarse grained. 紅色粗粒砂岩
C. Paleozoic sediments. 上古期地層

The details of the recent reconnaissance in Shantung by Mr. T'an and myself are told in our joint paper "The Geology of the Meng Yin and Lai Wu valleys in Shantung". The main features of our results are as follows:

1: The Lai Wu valley furthest NE., the Meng Yin valley in the middle and the Fei Hsien valley (not visited by us but known from Mr. T'an's earlier survey)

are three asymmetrically built grabens occupied by a series of regularly northeastwards tilted sedimentary systems of the following sequence:

Eocene, approximate thickness	900 meters
The Meng Yin series (Cretaceous–Jurassic)	800 „
Red Sandstone (Trias?)	700 „
The Permo-Carboniferous coal-series	250 „
Ordovician limestone	850 „
Cambrian beds	780 „
Proterozoic limestone	50 „
Archæan	--
Total of post-Archæan sediments	4.330 meters.

2: The age of the two youngest of these systems, the Meng Yin Series and the Eocene was unknown before our visit.

In the Meng Yin series which consists of sandy, greenish grey shales, were found remains of a *Dinosaur,* fairly complete specimens of *turtles* and *fishes, freshwater mollusks, fossil wood* and impressions of *ferns.* This system is evidently of young Mesozoic age, either Jurassic or Cretaceous.

Above the Meng Yin series follows without visible unconformity a series of very variable petrological character, red sand and clay with interbedded gravel and conglomerate, variegated marls, limestones of many varieties including "Platten-Kalk" and calcareous paper shale. In this series were found several species of *freshwater*-and probably also of *land-mollusks,* remains of *Trionyx,* teeth of *lizards* and teeth, jaws and isolated bones of at least six species of *mammals,* including according to determinations made by Dr. O. Zdansky, a *Phenacodontid* or primitive *Hyracotheriine,* an *Anchitheriine,* possibly *Mesohippus, Anchilophus,* a *Creodont* or primitive *Canid.*

The age of this system is evidently Eocene. The very common occurrence of the "Ku Yuan gastropod" links it with the above mentioned beds of Ku Yuan in Kansu and also with the Eocene of Yuan Chü Hsien in Shansi. Spore cases of *Chara* are found both in Shantung and in Yuan Chü Hsien.

3: The faults bordering these grabens, represent dislocations with a downthrow of more than 4.000 meters. They are of post-Eocene age.

These observations permit far-reaching conclusions, for the full understanding of which it will be necessary to review briefly the Mesozoic history of

Hsi Shan of Peking as described in Mr. L. F. Yih's monograph on that region*. According to this author there is in Hsi Shan the following Mesozoic record (in descending order):

The Tiao Chi Shan Series: Shales, conglomerates (mostly with porphyry pebbles) and porphyritic lava sheets. The series contains the following plant fossils, *Podozamites, Elatides, Nilsonia.* 1500 m.

Unconformity: Earth movements and erosion.

The Chiu Lung Shan series. Green and violet shales, sandstone and conglomerate. No fossils. 500-850 m.

The Men T'ou Kou Coal Series. Grey sandstones and shales, often of dark colour with *Podozamites lanceolatus, Ctenozamites Browniana, Pterophyllum, Elatides cylindrica, Araucaria, Baiera angustiloba, Czekanowskia rigida, Asplenium whitbyensis, Cladophlebis remota, Thyrsopteris.*

To judge from the plant fossils, the whole of this series is of Jurassic age, still it ought to be kept in mind that the number of plants so far known from the uppermost system, the Tiao Chi Shan series, is small and that consequently the question of the age of this series remains open to some extent.

Below the Tiao Chi Shan formation there is in Hsi Shan a marked unconformity. In some places this series rests upon the Chiu Lung Shan series, in others upon the oolitic limestones of Cambrian age and in still other localities upon the pre-Cambrian siliceous limestone. It is apparent that considerable earth-movements and subsequent erosion took place after the formation of the Chiu Lung Shan series and before the deposition of the Tiao Chi Shan beds. In fact it seems that the last named series is only slightly tilted and that it has, so to speak, sealed up the principal tectonic movements of Hsi Shan.

As described above (p. 99-101) in greater detail there occur in Hsuan Huan Hsien and near Kalgan conglomerates and unconsolidated gravels which are only slightly tilted or practically horizontal. In these gravels I have with some doubt identified *Podozamites* and *Pterophyllum.* These conglomerate and gravel beds, which contain mostly porphyry pebbles, overlie unconformably the strongly dislocated older rocks in which also the Jurassic coal series (Men T'ou Kou series) is included.

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* Mem. Geol. Survey of China. Ser. A. No. 1. 1920.

From these facts it appears, that in N. Chihli earth-movements on a large scale took place in middle Jurassic time. This period is also marked by intensive volcanic activity. In the Jurassic coal series and the Chiu Lung Shan series of the Chai T'ang basin there are porphyry laccoliths intruded, and extrusive porphyries are known from several areas. Thereagain, the pebbles of the Tiao Chi Shan conglomerates consist mostly of porphyry.

Speaking of the igneous activity of the Mesozoic time, it may be pertinent to mention the diorites which occur in Honan, Shantung and the Yangtze valley and which have won much fame as carriers of the important iron ore deposits of the so called Yangtze type (Tayeh and Feng Huang Shan in the Yangtze valley, Chin Ling Chen in Shantung, Hung Shan in Honan). These *diorites form laccoliths, mostly in the Ordovician limestone (Shantung, Honan)* while the Palæozoic coal series and the red sandstone (Trias ?) are probably also affected by them. During our journey in Shantung, Mr. T'an and I made an interesting observation concerning these intrusives near Hsin T'ai city, where we found pebbles of the diorite in the Eocene beds, proving the pre-Eocene age of the intrusive. This makes it probable that these diorites, which are such a conspicuous feature of the geological structure of Central and Northern China also fall within the Mesozoic period of earth-movements and igneous activity.

Through the observations in Hsi Shan of Peking, noted above, as well as those in Hsuan Hua Hsien and near Kalgan, it had become the settled opinion of the Geological Survey including myself that in northern Chihli the principal earth-movements had taken place during Jurassic time. The only younger movement we knew of is a slight warping of very late Pliocene or early Pleistocene age which caused the cutting of the canyons of the Hun Ho and its tributaries. This warping is so gentle that it became expressed only in the physiographic aspect of the area but not, as far as we have observed, in its tectonic structure.

During the spring of 1921, when mapping the Eocene of S. Shansi, I observed features (See map 1 and p. 27-31) which proved that in this region there had been a much later period of tectonic movements. The Eocene beds, with a thickness of at least one thousand meters rest in a deep graben bounded by rocks of Proterozoic and Palæozoic age. The faults are post-Eocene and their throw may be roughly estimated at something like ten thousand feet.

This post-Eocene graben of S. Shansi could possibly be a local phenomenon without far-reaching consequences, but in my discussions with Dr. Wong in

connection with his earthquake-researches, I have expressed the opinion that the big graben-faults bounding the course of the Yellow river on the Shansi-Honan border and extending to the south of Sianfu in Shensi are all post-Eocene. This is not yet settled, but I consider it only a matter of time to prove that it is the case.

It is needless to say that the recent observations in Shantung have added tremendously to the weight of the results obtained in S. Shansi. In Shantung a whole system of grabens with a throw estimated by Mr T'an at something like 14.000 feet is proved to be post-Eocene, and these fault-lines are so closely related tectonically to the whole system of block-faulting in Shantung that there is good reason for believing that all this faulting is later than the Eocene.

At this point it may be well to extend the discussion by asking: how much of the faulting in N. China in general is of post-Eocene age. Some of the faults in N. Chihli are clearly much older, as for instance the big strike-faults in the Hsuan Lung iron ore field where the dislocated series, including probably also the Jurassic coal series, is unconformably overlaid by the Tiao Chi Shan conglomerate which is only slightly tilted. I think it very probable that most of the faulting in Hsi Shan also belongs to the Jurassic period of tectonic movements.

But on the other hand it is quite possible that we have Eocene faults quite close to the capital, and is not impossible that there may be sunken Eocene beds within one or two hundred meters beneath Peking.

All geologists travelling on the Kin-Han railway probably have noticed the remarkable sections exhibited in the yard of the Chang Sin Tien station about 30 li from Peking. These distinct and extensive sections exhibit a series of slightly tilted sediments: gravel interbedded with red and variegated clays. The series has considerable similarity to the Pliocene beds of Honan and I have formerly tentatively included them in the Pliocene deposits.

However, there was one fact which I could not harmonize with this determination, namely that these beds at Chang Sin Tien are distinctly tilted, whereas the Pliocene beds elsewhere are always undisturbed. After having seen the Eocene of Shantung, I have come to think that these beds at Chang Sin Tien are mostly likely not Pliocene but Eocene in age. In fact, as shown by our sections, all the features of these beds near Peking and those of the Shantung Eocene, agree closely even to the detail that they are both gently tilted. (Fig. 41 & 42).

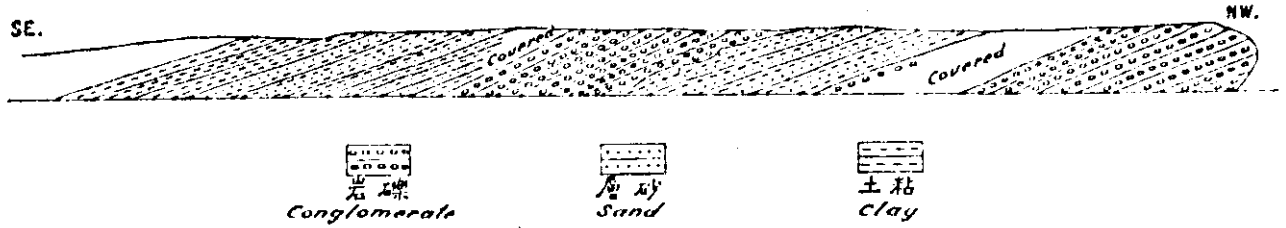

Fig. 41. Eocene beds, Yai T'ou, Hsin T'ai Hsien, Shantung. 山東新泰縣崖頭初新統地層

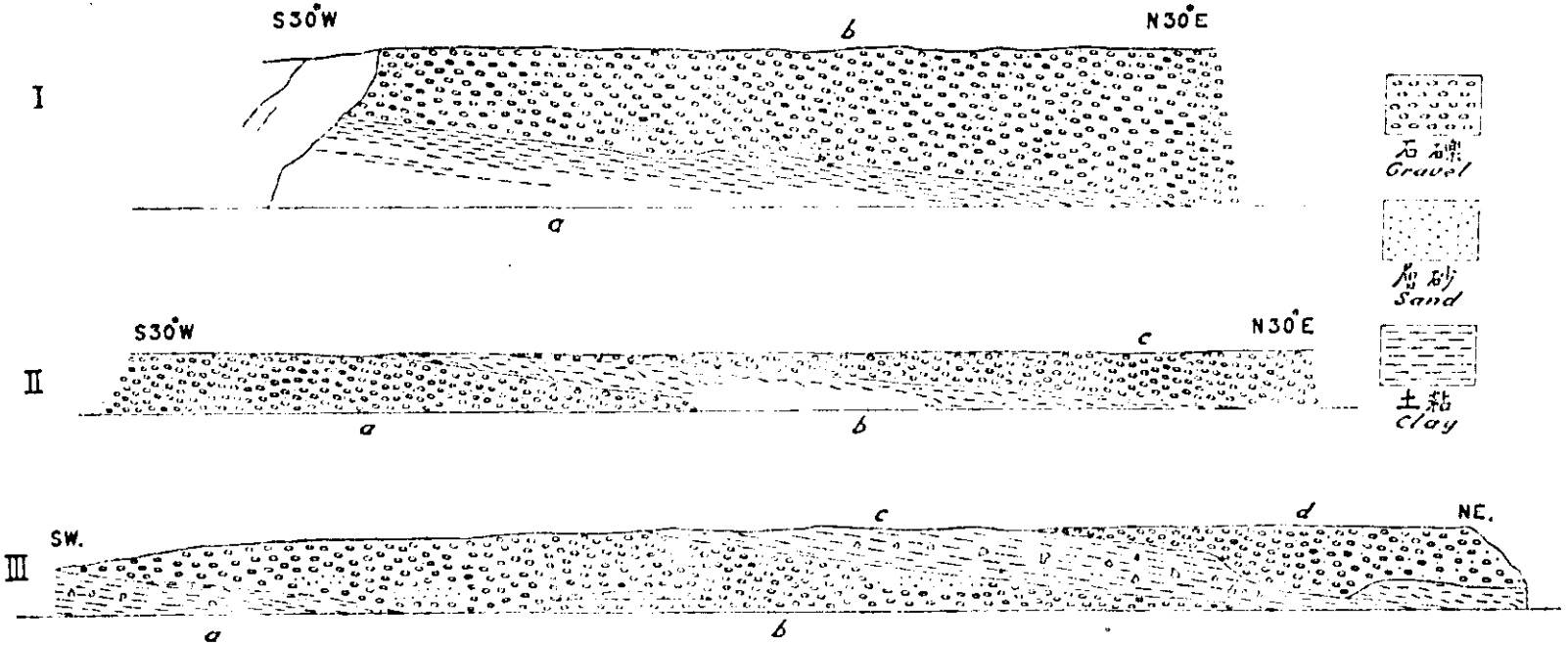

Fig. 42. Beds, supposed to be of Eocene age. Chang Sin Tien Station yard near Peking. Scale 1 : 400.
京西長辛店初新統地層

If the Chang Sin Tien beds are Eocene, then it is possible that it was Eocene red clay which was struck in hundred meters depth in the deep-boring in the Peking Union Medical College compound (Yü Wang Fu).

If these conjectures regarding the beds at Chang Sin Tien are correct, then the Peking plain must be a sunken area which in post-Eocene time was cut off by big faults running along the base of the present mountains. This interpretation of the major faults as being of comparatively modern age, would make it easier to understand the apparent location of thermal springs, such as the Tangshan hot springs, along these fault lines.

These are speculations which we must leave to the future to prove or refute. However, from the observations in S. Shansi and Shantung we may consider it well established that considerable areas of N. China underwent block-faulting of enormous throw in post-Eocene time.

The observations made by Dr. Wong and Mr Hsieh in Kansu during the earthquake expedition of 1921 are of the greatest significance in this connection. They proved the existence over very large areas of the so called red beds which represent the Younger Mesozoic and the Eocene. Fishes of young Mesozoic age are known from a number of localities, while in at least one section, that of Ku Yuan, we have been able to prove the Eocene age of a part of the series. The section established by the two explorers at Ku Yuan shows that considerable tectonic movements including folding have taken place within this Mesozoic-Eocene series. (Fig. 40).

It is a significant fact that central Kansu, the principal earthquake area of China, is also a region where especially strong tectonic movements of geologically recent date have been recorded.

According to Mr T'an there is in Shantung a large area, which we have not yet fully explored where a series of geological formations, including beds which he now considers as Eocene, form a gentle syncline of very wide extent. It may further be added that, according to Inouye, the Oligocene coal and plant-bearing beds at Fushun in Fengtien are folded. (Comp. p. 96-97).

These observations in Kansu, Shantung and Fengtien lead us to infer that the post-Eocene earth-movements were characterized not only by faulting on a very large scale scale but locally also by folding.

So far we have only been able to prove that the tectonic movements here described are post-Eocene. There are however excellent means for determining

their age in a much more definite way. These are furnished by the early Pliocene Hipparion fauna which is known from Shansi, Honan, Shensi and eastern Kansu.

This fauna occurs in beds of red clay or occasionally red sands aggregating only some tens of meters in thickness. These deposits are everywhere entirely undisturbed or have a hardly perceptible inclination which is probably the initial dip of deposition.

In Honan the horizontal Hipparion-beds overlie strongly tilted pre-Cambrian or Palæozoic systems (Fig. 37).

From the undisturbed position of the Hipparion-beds, it is evident that the earth-movements here described though post-Eocene, are nevertheless pre-Pliocene.

The study of the Hipparion-deposits has further revealed a fundamental fact, namely that that these early Pliocene beds were laid down upon an earth-surface which in its essential features is identical with the present topography. The only great physiographic development which has taken place since the deposition of the Hipparion-beds is the cutting of the canyons of the Fen Ho-Hun Ho type.

These features of the Hipparion beds give us a much fuller understanding of the radical tectonic and physiographic changes which have taken place in Northern China during Oligocene and Miocene times.

It becomes evident:

1. That the earth-movements, which possibly had their inception in Eocene time (the "Wen-Ho conclomerate") and locally continued into the Miocene (the Fushun coal series), had their maximum development in the Oligocene.
2. That following the Oligocene block-faulting and locally folding, a radical readjustment of the topography took place under the influence of degrading forces, and this to such extent that, at the end of Miocene, the broad features of the modern topography were already in existence. Evidently this period of erosion falls mainly in the Miocene.

We have now become cognizant of two periods of geodynamic activity, one during the Jurassic, the other during Oligocene time. We have also seen that the former period of earth-movements coincided with a time of intense and varied igneous activity (diorite-laccoliths, intrusions and extrusions of porphyries).

It is interesting to note that there exists a similar volcanic counterpart to the Oligocene period of geotectonic activity.

In Fengtien, Chahar and N. Shansi there are extensive basalt-sheets connected with plantbearing beds which have been identified as Oligocene (Fushun) or in a more general way middle Tertiary (Han Jo P'a). It is not proved, but most probable that the very large areas of basalt in Kiangsu, Anhui, Shantung and Kirin are of approximately the same age.

Basalt-eruptions and tectonic movements seem to be characteristic of the Oligocene period just as porphyry intrusions and extrusions accompanied by geodynamic processes were characteristic of Jurassic time.

Preceding, between and after these two periods of endogenetic activity the earth-crust in this part of the world seems to have been comparatively stationary and exogenetic processes prevailed.

Table I: Younger Mesozoic and Tertiary History of Northern China.

	Sedimentary record	Volcanic activity	Tectonic movements
PLIOCENE	*Upper*: Choukoutien cave deposit. Lower: Hipparion beds.	.....	.....
MIOCENE	.....	.....	Block-faulting in many regions. Folding in Kansu, Shantung and Fengtien.
OLIGOCENE	Plant bearing beds of Fengtien, Chahar and N. Shansi.	Basalt eruptions in Kirin, Chahar, Shansi, Shantung, Anhui, Kiangsu.	
EOCENE	Conglomerate, red shale, red clay and sand, marl and limestone with freshwater *mollusks, reptiles and* mammals. Shantung, S. Shansi, Kansu.	.....	.....
CRETACEOUS-JURASSIC.	*Meng Yin Series*, Shantung: Sandy shale, w. plants, freshwater mollusks, dinosaur, turtles and fishes. *Fish Series*, Joho, Shantung, Shensi, Kansu: Sandstone and shale with *Lycoptera* etc. *Mentoukou coal Series* with Jurassic flora. Shansi, Chihli, Shantung etc.	Porphyries with associated volcanic agglomerates and tuffs. Diorite laccoliths.	Folding and faulting in Hsishan (of Peking) and probably many other regions.

Table II: The Cenozoic Deposits of Northern China.

PLEISTOCENE	*Upper*	*Redeposited Loess* and gravel in N. Chihli with *Ovis*, *Cervus*, *Bos*.	
	Middle	*Primary* (largely eolian) *Loess* with *Struthiolithus chersonensis* and *Elephas cfr namadicus*, *Ovis?*, *Cervus*, *Sus*, *Equus*, *Hyena*, *Ursus*, *Castorid*, *turtle*.	
	Lower	*San-Men series:* Fluviatile gravel, sand and clay in the Yellow River valley, with fragmentary mammal remains and freshwater bivalves: *Quadrula cfr. spurius*, *Qu. cfr. affinis*, *Cuneopsis cfr. capitatus*.	
PLIOCENE	*Upper*	*Cave-deposit of Chou-K'ou-Tien, Chihli: Ursus, Hyena, Machairodus, Rhinocerid, Equus, Sus, Cervid, Bovine* and other *Artiodactyla, Talpa, Rodents (2 sp), bird.*	
MIOCENE	*Lower Pliocene or Upper Miocene*	*Hipparion Clays* of Shansi, Honan, Shensi and Kansu; red and variegated clays with lime carbonate concretions and gravel beds: *Cynocephalus?*, *Machairodus*, *Felide*, *Arctocyon* or *Hyenarctos*, *Mustelide*, *Viverride*, *Hyena*, *Mastodon*, *Stegodon Elephas*, *Teleoceras*, *Sinotherium Lagrelii*, *Aceratherium*, *Anchitherium*, *Hipparion richthofeni*, *Sus 2 sp.* *Antelopes*, *Cervavus*, *Deer; Giraffide (Chilinotherium Tingii)*, *Castorid*, *Struthio*, *Emydid*, *Testudinid*.	
OLIGOCENE	*Fushun Series*	*Coal bearing series of Fu-Shun* and Shih-Men-Chai in Fengtien province: tuffaceous sandstone, conglomerate and shale (740 m.) with thick coal seams: *Osmunda lignitum*, *Sequoia langsdorfi*, *Glyptostrobus europeus*, *Populus glandulifera*, *Alnus kefersteini*, *Dryophyllum daradqui*, *Fagus feronia*, *Zelkova ungeri* etc. *Soft shale of Han Jo P'a* in southernmost Chahar with *Pinus*, *Comptonia andersoni*, *Carpinus?*, *Phyllites*. *Sandstone, shale, clay and coal at Shan Yang Kou*, Fan-Chih-Hsien, Shansi, with undetermined plant-fossils.	The plantbearing deposits of Fengtien, Chahar and Shansi, here described, all occur in connection with basaltbeds and may be approximately contemporaneous.
EOCENE	*Yuan-Chü Series*	*Conglomerates, red and variegated clays, red and white sand, marly limestone* with *Chara*, *Ostracoda*, *Planorbis pseudammonius*, *Pl. sparnacensis*, *Pl. chertieri*, *Pl. sinensis*, *Physa cfr. lamberti*, *Euchilus deschensianum*, *Eupera sinensis* Also numerous but fragmentary *vertebrate remains: Teleostei*, *Testudinata (Trionyx)*, *Lacertilia*, *Crocodilia* and some *Mammals (Phenacodontid* or primitive *Hyracotheriine*, *Anchitheriine*, possibly *Mesohippus*, *Anchilophus*, *Amynodontid*, *Ancodon?*, *Rodent*, *Creodont* or primitive *Canid*, *Lemuroid or Insectivore)*.	

洪積統	上新統	中新統	浙新統始新統
上部 次生黃土 砂礫 直隸北部 化石 羊 鹿 牛	中部 風積黃土 化石 駝鳥蛋 巨齒象 羊 鹿 豕 馬 猰貐 熊 獾屬 龜	下部 三門系 河積砂礫 砂土 黏土 見於黃河一帶 化石有哺乳類碎骨淡水軟體動物	
	上部 直隸周口店洞 穴居 化石 熊 猰貐 劍齒虎 犀屬 馬 豕 鹿 牛屬 他種偶蹄類 鼠 齧齒類 鳥類	上新統或上部中新統 三趾馬層 山西河南陝西甘肅 紅色或雜色黏土 內含石灰質結核 化石 巨猴 劍齒虎 貓屬 狗熊 貛 鼠類 狸獾類 猰貐 柱齒象 掩齒象 象 單角犀 全角犀 無角犀 中新馬 祖馬 三趾馬 (李希氏) 豕 羚羊 鹿 吉拉夫屬 (麒麟) 獼 鴕鳥 龜	撫順系 奉天撫順煤田 直隸隰檢石門寨 灰砂岩、礫岩、頁岩、煤層、古生植物有 微紅木 刻松 白楊 赤楊 杉 山毛櫸等 察哈爾漠諸嶺 疑頁岩 植物化石 如松樺羊齒類等 山西繁峙縣山陽溝 砂岩頁岩黏土煤層 植物化石 (奉天察哈爾山西之植物化石層均與玄武岩共生故玄武岩或係同時)
			垣曲系 紅色及雜色黏土 紅色及白色砂土 灰質石灰岩 化石 輪藻 介形虫 淡水軟體動物 扁卷螺四種 麥螺 脊椎動物 硬骨 魚鰾 蜥蜴 鯉魚 哺乳類 鼠狸 古馬屬 齧齒類 肉齒犬 狐或虫食屬

時。此等玄武岩與前述中侏羅紀之斑岩、皆表示與地殼變動有密切之關係。此二時代之間、則變動殊少、而侵蝕作用反之而盛行焉。

中國北部省之中生界上部及第三期

	地層次第			火山作用	地殼變動
上新統	上部	周口店三趾馬洞穴黏土層			
	下部				
中新統					
漸新統		奉天察哈爾及山西北部之岩石	含植物化石	吉林察哈爾山西山東安徽江蘇之玄武岩	斷層作用及甘肅山東奉天之褶曲
始新統		山東山西南部、甘肅蒙陰系、山東砂礫岩、紅頁岩、紅黏土及砂土、泥灰岩、石灰岩、淡水軟體動物、恐龍、龜、魚、哺乳類	含淡水軟體動物、爬蟲類、		
白堊紀或侏羅紀		山東砂礫岩、紅頁岩、紅黏土頁岩含水中植物、山東陝西甘肅含魚岩系 熱河門頭溝煤系	石、	斑岩與火山礫石灰岩閃長岩	北京西山之斷層及褶曲他處當亦有之
		山西直隸山東等含侏羅紀植物化石			

數年前吾人研究北京西山地質時、葉君良輔分該處中生紀地層爲髫髻山系、九龍山系、門頭溝煤系。髫髻山系居上、屬上侏羅紀、其下二系屬下侏羅紀。二紀岩層不整合、蓋中侏羅紀爲地殼變動時期、斑岩類侵入下侏羅紀中、經侵蝕作用後、始有髫髻山系。該系砂礫中有中侏羅紀之火成岩、故吾人素以此期地殼變動爲最關重要者。

然據近今研究結果、新生界中亦有劇烈之變動。山東始新統層、斷層下墜至四千尺、山西且達一萬尺、變動劇烈如此、當非限於一隅者。如京西長辛店車站之砂礫層、其傾斜情形與山東始新統汶河礫岩相同。砂礫積於山麓、漸遠則變爲黏土。如長辛店之砂礫屬始新統、則協和醫學校打鑽所得之紅黏土（見西山地質誌）亦當爲始新統、而北京之盆狀平原、又當爲始新統後所造成者矣。

沿山西河南間之黃河、西越潼關至西安、皆似陷落地帶所成者。甘肅地震所以屢見者、亦以斷層較新、震動易起故耳。據翁謝二君觀察甘肅固原地質、始新統曾已褶曲。譚君謂山東他部始新統亦有成內斜層者。井上禧之助氏亦於奉天撫順煤系見之。故地殼作用除斷層外、又常見褶曲層也。

三趾馬層屬上新統、皆成水平層、未受變動。山西河南陝西甘肅東部皆然。故地殼變動當在上新統前及始新統後、即當漸新統及中新統之時也。

變動之力於始新統已潛伏、至漸新統而大作、間亦有延至中新統者。其結果爲斷層及褶曲。旋侵蝕作用隨之而起、時當在中新統矣。漸新統中隨地殼變動而興者爲火山作用、不啻與前述之中侏羅紀相伯仲。奉天撫順察哈爾及山西北部之玄武熔岩、皆屬漸新統。他如江蘇安徽山東吉林各處之玄武岩雖無確證、要當屬於同

片。似屬舊石器時代之物。然新石器時代中尙沿用之、故不足爲證也。即正式新石器時代之遺物、亦殊少見。日人鳥居龍藏氏在東蒙所得石器及余在奉天河南等處所得各物皆證明爲石器時代及銅器時代之過渡期、以河南仰韶村之古址較爲宏大、故名之爲『仰韶文化期』(見地質調查所彙報五號余著之『中華遠古文化』考一篇)

仰韶村在河南澠池縣之北、古址在村南。面積南北九百六十公尺、東西四百八十公尺。南部遺址似較連續、厚一公尺至五公尺不等。器物中有石斧、石刀、石鏃、石彈、織線墜錠、石環等。皆磋磨平滑。骨製者有骨針、骨鏃。又有角器貝器少許。以陶器爲最夥、率皆破碎。其中形式有與三代銅鼎銅鬲相似者、故余以爲華族遠古之文化。又因紅底黑花之陶器花樣、與近東諸地古代器物相似、故余暫時假定古來美術觀念曾由近東次第東行以輸入於遠東者。

余曾按序調查、於中國北數省各處皆有同類之發見。雖皆零星斷片、亦足見新石器末期民族散佈之普遍也。至於舊石器時代及正式新石器時代之遺跡悉未之見者、余以爲當洪積統中期歐西有人類時、而東亞一部尙爲乾旱草原、不適人民之轉移、故遺跡稀少。所有哺乳類化石、亦均有此徵象。

邇後於仰韶文化期內、天氣又溫暖。以有箭猪、故天氣當較近今尤暖。有鹿故知有森林、有魚鼈故知多水澤。今之溝渠皆刻劃仰韶文化期之土層、故當時人民居住之鄉、實爲連亙之平原。今所見深達四十公尺之溝渠、乃古址湮沒以後所造成者也。

地質構造

黃土堆積於洞穴者曾於京西西山見之。洞中土質爲細沙土與黃土、化石爲犀牛、熊、豕、及鳥等。

黃土後之地層

冲積黃土層　黃土區域河底澗中黃土每與砂礫層相間。砂礫顯由河流冲刷搬運而成、則其間之黃土層亦自當由河流冲積爲多、而不盡由風力轉運者也。直隸北部及熱河區域於此等冲積黃土層內、曾發見古物化石。常見者爲大鹿之角、巨角綿羊之角、牛之頭骨、間有犀之頭骨。

穴中積層　周口店鷄骨山石灰窰中曾有孤立紅土圓柱、高五公尺有半、立於奧陶紀石灰岩之上。未有石灰窰之前、此地石灰岩當較高、紅土只洞中之堆積物而已。紅土內所含化石、有鳥骨、齧齒類骨、食肉類骨等。宛平縣崁峪發見小獸骨、率與雞骨山同、尙有偶蹄類之小獸骨。西山石穴中及河南仰韶古址內、有箭猪齒。箭猪乃南部較熱帶之獸、彼時於北部見之、即知當時之天氣與今不同也。

初人

研究中國遠古人類者、昔有德人施羅瑟氏及日人松本氏。施氏曾得一臼齒與人類臼齒頗相似。化石出於第三紀紅土中、至晚當屬第四紀下層。施氏意以爲人類之起源或能於中國發見之。

松本氏研究河南黃土中之哺乳類化石、得人類尾閭骨。各節漸次縮小、不似今人之尾閭骨至第三節即驟變小者。亦較今人之尾閭骨爲直。從化石證之。當屬第四紀上層。蓋第四紀下層之化石屬熱帶、而上層屬寒帶云。數年來、吾人所得石銅時代之骨骸爲數頗夥。經步賴克博士研究、以爲此種人之特徵與松本氏所述者完全相同。按松本氏所得、似屬舊石器時代、然吾人所得該時代之遺物極希。雖宣化縣萬全縣所出零星柱葉式石

基博士報告、山西保德縣黃土皆位於高原之上。厚四十六尺。河流均沿黃土以前之地勢、不時冲刷、故顯露三趾馬紅黏土層。此層厚六十五公尺。二層接觸處、極清晰、易辨識。

李希霍芬氏以爲黃土生成時天氣乾燥、風力猛疾。黃土自中亞細亞沙漠及草原間隨風轉運而至云。按李氏歸之風力、理由固當。惟黃土在蒙古高原積聚頗少、而在中國內地經河流冲刷之低原反多。如風力能盡將高原上之黃土吹散。而移之中國內地、固亦可解。然事實有與此論適相反者、故吾人立論亦須與李氏之說稍異。欲知黃土之由來、當回溯前述之三趾馬層。此層既屬第三紀上新統初期、其與第四紀黃土層中間之過渡層復頗不易決定、自當繼續研究。然三趾馬層中之化石、皆屬草原動物、足證此期爲乾旱時代。其土質乃石灰岩風化所致、每與石灰岩同出一地者、亦以此也。爾後過渡期中、雖爲乾旱、然似有一潮濕時代。如汾河系之冲刷、及三門系之砂礫、即其明證。灰岩風化之土、經冲刷卽溶解、黏土質隨水洗去、所餘者只細砂土耳。在第四紀之中期、天氣復乾旱、砂土隨風分佈、乃成今日吾人所見之黃土。故非盡如李希霍芬所言、悉由亞洲中部移來、其於原本地址作成者當亦不少也。

黃土中之化石、蝸牛類最多。哺乳類只零星散佈而已。常見者爲野象之牙、犀牛、獐羊、熊、鼠狗、馬、鹿、獵、及爬虫類之龜、或示熱帶天氣、或似富有水濕者、惟鳥類有古駝鳥之卵散黃土間、似又爲乾旱帶之徵。故地質地形均呈乾旱之象、而化石則互相衝突不能定論矣。

黃土之時代以化石爲準。皆當屬第四紀。據達魯氏所定三門系、當屬第四紀之初期、則其上之黃土當屬第四紀中期、爲氷期時代乾旱之現象。

黃土經河流沖刷、其底部顯露砂礫層、厚有至十公尺者。蓋黃土堆積之初、風力與水力互相爲用。近山處水力較盛、故砂礫隨之而下。水風之力互有消長、故砂礫與黃土參互相間。嗣乃水力漸減而風力益強、上層遂完全爲黃土矣。余於民國六年在潼關陝縣一帶即見此層、惟所見化石皆破碎不易檢定。民國七年丁文江先生在山西河南間之三門峽見砂礫層、得軟體動物數種。復於山西河津縣北里見砂土層與黃土相間。其最上之砂土層、卽路易牧師得象骨之處。民國十年余自山西垣曲河堤村沿大河東下、至京漢鐵路黃河橋、行程約三百里。所見黃土下有砂礫層者數處、得古代獸骨數塊。惟除垣曲河堤見大介殼少許外、他處均未得之。據美京博物院達魯氏之檢定、以軟體動物屬第四紀初期。適與余於地質方面之觀測相合。

黃土

李希霍芬及維理士二氏曾詳述黃土之性質及地形。今應研究者、爲(一)黃土之位置及與其下之地層之關係、(二)黃土原質之來源、(三)黃土中之化石、(四)黃土之年代、(五)黃土造成時之天氣。

京漢鐵路黃河橋南站黃土絕壁、帶河之南岸、西延約二百里。其南孟山東西行、山之北坡盡屬黃土。處處刻劃成深溝、厚四十至六十公尺、率多絕壁。其底部有數處爲成層砂礫層頗似三門系。自此以上盡爲黃土。色灰黃、無層序。雖其下部有帶紅色爲層狀者、但當與其上之純黃土無別。又西於新安澠池二縣內黃土皆積於山麓溝渠中。經河流沖刷乃發見其下之紅色黏土層、蓋黃土初僅塡積溝渠中、以土質易沖刷、故今河流似仍沿黃土堆積以前之故道而行。其下之三趾馬層遂被刻劃而顯露也。前此考察黃土者、每包括第三紀土層而總計之、故厚度大增。實乃黃土下之紅色土層屬於第三紀上新統初期。其中化石如三趾馬等皆可爲證。據師丹斯

北京西南周口店左近之老牛溝石灰窰中、發見砂土層。高出周圍石灰岩六公尺。再上復爲石灰岩。此砂土既經開掘、始行顯露、則疑當時係填積於洞穴中者。又砂土層之東尙有圓洞、洞頗深、爲黃色硬砂岩所充塞。所有砂土層及硬砂岩土質皆不一致。細分之可得八九層。每層皆有化石、化石又復相類。化石巨大者皆限於底部三層。此外各層僅見小動物遺骨。頭骨不多、所常見者爲下額骨、齒骨、肢骨、脊骨等。最多爲齧齒類之肢。餘如田鼠類、食虫類、鳥類、亦間有之。

巨大動物中有

奇蹄類　馬　犀

偶蹄類　豕　鹿屬（鹿之額骨較尋常見者爲厚）

反芻類　小動物　巨牛屬

肉食類　劍齒虎　熊屬　鬣狗

頂部之紅砂層及角礫層含陸產軟體動物介殼二種、其一與現生種類相似。此洞昔時或曾爲食肉類及齧齒類之獸穴、骨肢多被嚙斷、故不完全。化石中無古馬而有今馬、故其時代較三趾馬期爲新、或屬上新統上層。約與周口店同時者、爲直隸懷來縣西北之葫蘆套村。其地溝深約二十公尺、盡屬黃土層。於溝底部得化石一與周口店所得之鹿屬近似。雖其土質完全與周口店不同、蓋一在曠野、一係洞穴、各有由來、不得相提並論也。

洪積統

三門系

嚙齒類　獼屬　松鼠屬

鳥類　駝鳥

爬虫類　鼈屬　龜類

南沙窪及五蘭溝二處面積較小、而地層情形略同。據韋滿及師丹師基二博士之意、以爲所有古生物皆表示草原情形。而吉拉夫屬(麒麟)及豕屬又証明其地有樹與水池者。除此三處外、率無化石。故知其時氣候乾旱、遍地皆成草原。偶或一時一處雨水豐足。池沼樹林得以發展、動物亦因之萃集其中。

余首發見此層於河南新安縣北二十里之處。其地土山纍纍、皆三趾馬黏土層。惟溝渠中多黃土、如三十七圖所示。三趾馬層土色皆紅。然土質屢變、不如冀家溝等處之一致。石灰質結核頗多、有成石灰岩者。化石零星散佈、亦不如冀家溝之一律成層也。重要區域爲上印溝、採集獸骨頗多。距上印溝二里許、於紅土層中發見紅砂土層。其中鹿骨頗多、鹿類頭骨最佳者即得於此。新安縣西一百里澠池縣境內、亦有三趾馬層。保存獸骨、既堅且白。雖爲數較少、然與保德縣屬所得互相參證。所異者河南少犀屬、而發見猴骨三具。頭骨一、上額骨下額骨各一。該下額骨屬大猴類、與三趾馬、鹿、羊、鼠狗等同出一地。

此外在甘肅慶陽縣亦有所發見。餘如山東直隸山西河南均有相似地層、惟化石中無三趾馬、或當有屬上新統上層者。似宜待確定化石種類後、方能論定也。

上新統上層

周口店洞穴層

中新統及上新統過渡層

盧子溝系

師丹斯基博士於山西保德縣三趾馬層下、發見砂土及泥灰岩之累層。厚二十五至三十公尺。砂土中有獸骨。泥灰岩層有魚骨、及軟體動物之介殼。於山西中部南端此等岩土又夾於黃土中、或覆於黃土上。故此數處之時代、雖未確定、要與三趾馬層同時而異象而已。

三趾馬層

中國北部盛產哺乳動物化石者似皆屬三趾馬層。師丹斯基博士於山西保德縣之冀家溝、河曲縣之南沙窪及陝西省谷縣之五蘭溝、調查極詳。

冀家溝面積南北長四千八百公尺、東西長四千公尺。三趾馬層之底部爲砂礫層、厚四公尺、下爲石炭紀煤系。其上三趾馬層最厚達六十五公尺。粘土中含粗鬆砂礫層、及石灰質結核。自底部上溯約至二十五公尺處、遇化石層、厚僅五公尺。所得化石經師丹斯基博士暫爲檢定如左。

哺乳類

奇蹄類　三趾馬　全角犀　無角犀　巨角犀　中新馬

偶蹄類　鹿　羚羊　『麒麟』　豕

肉食類　鼬狗　狸獾屬　貓屬　劍齒虎　狗熊　鼬鼠屬

長鼻類　杜齒象　掩齒象　象

漸新統

撫順系

奉天撫順煤田以植物化石証之、定爲漸新統、又名之爲撫順系。井上禧之助氏研究極詳。其地爲一高原。北部以絕壁下臨渾河。南帶岡巒、而渾河支河縱橫刻劃其間。煤田分東西二部。中隔高原。地層率經變動、傾斜壁立。底部爲元古界之花崗岩、片麻岩、及下寒武紀岩石。東部又有紅綠色凝灰岩、及玢岩。覆於片麻岩上更有中生界之凝灰質砂岩、頁岩、自西北走東南成一內向層。第三期煤層位於斷層下投側、可分爲二部。下部爲凝灰砂岩、砂礫岩、及頁岩、中夾二煤層。傾向東北三十餘度。上部盡爲頁岩及厚煤層、而無砂岩。傾斜向北二十五至四十五度。玄武岩侵入下部煤層。斷層雖多、然無大者、不致妨礙鑛業。此處側壓力自南趨北、故傾斜方向亦如之。主要煤層悉在上部、最厚達二百尺。植物化石曾經巴李氷及橫山氏研究。民國八年地質調查所技師朱君庭祐復爲採集、經傅蘭林博士檢定。其中植物在歐美及北極圈各地生於白堊紀以至上新統。據巴李氷及傅蘭林二氏則以撫順系爲漸新統。

察哈爾張北縣直隸萬全縣宣化縣皆有玄武流岩。其下夾煤之砂礫層似屬侏羅紀。亦有直接覆於太古或元古之摺皺層者。惟余在大井溝見頁岩、色深褐而鬆軟、其上下皆爲玄武岩。頁岩中之古生植物頗夥。惜頁岩鬆軟、不易保存。傅蘭林博士謂其當屬第三紀中部。山西繁峙縣東北六十里山羊溝地方、王君竹泉見上下玄武岩中、夾有砂岩黏土。中含植物化石、以松柏類及雙子葉植物爲夥。

察哈爾及繁峙二區古生植物尙未確定。然其與玄武岩之關係略同撫順、故亦歸之於撫順系。

中國北部之新生界

安特生原著
袁復禮節譯

始新統

自來考察中國地質者、對於新生界地層、除黃土外、殆少研究。始新統地層乃吾人首於山西垣曲縣發見者。其地爲廣濶平原。西南北三面環山、南臨黃河。隔岸尙有始新統層一小部。面積南北長十四至十六公里、東西長十至十四公里。南北各有明顯斷層、與古生界岩石相接。地層傾向東南二十二度。他處斷層及傾斜亦間有之。地層厚約一千公尺。底部礫岩及紅色泥石參互爲層、中少動物化石。漸上則砂礫漸細、間有白色泥灰層。砂礫層中含化石骨少許。泥灰層有甲殼類之介形虫及淡水軟體動物八種。此外尙有魚、龜、鱷魚、水犀、偶蹄類屬、猴屬或虫食屬、及一齧齒類。

考查甘肅地震時、翁文灝博士及謝君家榮曾見紅色岩石散佈頗廣。除魚層屬中生界外、謝君復於周原紅色砂岩及頁岩中、發現一薄層石灰岩、中含腹足動物。亦斷爲始新統。

最近余與譚君在山東蒙陰及萊蕪谷道中、發見中生界及新生界之地層二。中生界者爲灰綠砂頁岩、屬侏羅或白堊紀。含恐龍、龜、魚、硅木、羊齒類葉痕。覆此層之上者有紅色砂土及黏土、介於砂礫岩、雜色泥灰岩、石灰岩、及石灰質頁岩之間。其中含淡水軟體動物、龜、蜥蜴、及哺乳類六種。又腹足類與在周原者同。輪藻之胞子與在垣曲者同。皆証此層屬始新統。又山東之新生界在蒙陰及萊蕪皆處於斷層之下投側。地層陷落不下四千尺。此又始新統以後之變動也。

插圖

附圖目錄

地圖

珂羅版圖

地學報甲種第三號

中國北部之新生界

袁復禮著
特生原譯

中華民國十二年三月　農商部地質調查所印行