# *The Quaternary Period in Manchuria*

Tokio SHIKAMA

## 1. Introduction

The study of Quaternary geology in Manchuria has not progressed as far as that of the pre-Tertiary, especially in stratigraphy. The stratigraphic order of the stages is unknown. It is noteworthy that the majority of Japanese geologists who worked in Manchuria were hired for surveys of ore deposits, and many geologic surveys were done. In these reports it is evident that "hard rock" geology was their major interest and the problems of the Quaternary system were treated very simply. The drift geology was mainly concerned with loess deposits, and it seems to the writer that even the drift of the upper half of the Tertiary formation was treated as lightly as the Quaternary system. Under such conditions, the following studies are particularly outstanding works: studies of the Quaternary volcanoes in northeastern Manchuria, studies of topographic planes in Jehol and Liao-tung, studies of the sand dunes and lake deposits in Mongolia, and studies of fossil beds especially in the areas near Ku-hsiang-tun, near Harbin and Djalainor[1]. Though special surveys of placer gold, diatom earth and peat, as well as surveys of ground water and dams, are, naturally, concerned with the Quaternary Period, they are not treated here in detail. At the present time, it is too early to give a general outline of the Manchurian Quaternary, owing to the lack of sufficient data on chronology. Study of the Quaternary Period has recently progressed remarkably in China proper (North and Central China) in contrast to the studies of Manchuria which are still in a preliminary stage.

LICENT and TEILHARD DE CHARDIN (1930) established the stratigraphy of the Quaternary system at Ou-tao-chuan, southwest of Chang-chun and at Djalainor in northwestern Manchuria. Since then no further studies have appeared. However, Ou-tao-chuan was treated in a chronological study of the vicinity of Chang-chun by Sōki YAMAMOTO in 1948, and Djalainor was treated in a report on the discovery and study of a human skeleton found at Djalainor by Riuji ENDO (1945, 1949). The Quaternary system in Jehol, which is adjacent to North China, has been studied more than in other districts of Manchuria. Following the geomorpho-

1) The name is spelled various ways, such as Dalainor, Dalai Nor, Dalay Nor, Darinor, and Da-la-i-no-erh, "nor" or "no-erh" meaning "lake".

logic studies by BARBOUR in 1935, Fumio TADA published studies in the same line in 1937 based on his work with the First Scientific Expedition to Manchuria and Mongolia. The geomorphologic and stratigraphic studies in the vicinity of Pei-piao by Shigeru KUSAMITSU in 1942 further advanced knowledge of the Quaternary geology of Jehol. Knowledge of the Quaternary system in Liao-tung was accumulated by Japanese geologists over a long time but resulted in comparatively few publications. The most important, concerned with the excavations at Ku-hsiang-tun, Harbin, which was done as a part of the First Scientific Expedition to Manchuria and Mongolia, are by Shigeyasu TOKUNAGA and Nobuo NAORA (1934, 1936, 1939).[2] They reported many fossils and human relics. However, their studies were based on pioneer work by Russian scholars such as LOUKASHKIN (1937) and PONOSOFF (1937). Stratigraphic knowledge was further clarified by the excavations of the Central National Museum of Manchoukuo in 1927–1928 (ENDO, 1942 and SHIKAMA, 1943). Paleontological and chronological study of the materials excavated by the Manchoukuo Museum was delayed or prevented as all the materials were scattered and lost due to the war.

## 2. Characteristic Features of the Quaternary System in Manchuria

Rinji SAITO (1940) divided the sedimentary facies in Manchuria into the south Manchurian type and the north Manchurian type and designated the boundary as a line which connects Wu-tan-cheng, Kai-yuan, Hui-nan, An-tu, Muson (Korea) and Ch'ongjin (Korea) (approximately the 43° parallel of north latitude); this is named the Hui-nan—Kai-yuan line. The Tertiary system located on the north side of this line represents the Siberian facies, while that on the south side is closely related to the north Chinese facies. However, the Hua-tien series, like the Feng-shan series, shows a transitional facies between the Siberian—north Japanese side and the north Chinese side. Therefore, it may not be possible to divide the system into two distinct areas. TEILHARD DE CHARDIN (1941) divided the Quaternary sedimentary facies into three large divisions: the north Chinese facies, the Manchurian facies, and the Mongolian facies. The north Chinese facies does not appear much beyond the Hui-nan—Kai-yuan line. Jehol belongs, on the whole, to the north Chinese facies, while the western slope of the Ta-hsing-an-ling range belongs clearly to the Mongolian facies. Although the Manchurian plain looks like a prolongation of the plains of North China, it is characterized by the Manchurian facies. The north Chinese facies and the Manchurian facies are bounded not by a line which runs east-west, but by a line which runs approximately NNE—SSW, a line which connects Cheng-chia-tun with Kai-yuan. The fluvio-lacustrine facies, which is most characteristic in the Manchurian facies, develops mainly along the Sung-hua-chiang (Sungari) River, upstream from Kiamusze (Chia-mu-ssu) and from

[2] See also OKADA, Naoe, 1939, Prehistorical researches in Ku-hsiang-tun, in: *Mem. Inst. Sci. Res. Manchoukuo*, v. 3, no. 1. Inst. Science Research Manchoukuo, Hsin-ching, Manchuria. (J).

Pei-an in the north to the eastern foot of the Ta-hsing-an-ling range and south to the area including Chang-chun and Ssu-ping-kai. Its eastern limit is distinctly bounded by a line which connects Chi-lin with I-tung. In the area east of this line, piedmont facies such as terrace deposits, talus, and fans developed along each river, though on a small scale. These piedmont facies gradually pass into the above-mentioned fluvio-lacustrine facies. Roughly speaking, the loess-like deposits in the area between Lung-ching and Yen-chi (Chien-tao Province) and Sangsambong (Korea) along the Tu-men-chiang River are a prolongation of the Manchurian facies. The type of the Manchurian facies is the Ku-hsiang-tun formation which consists of loess, sand, and loam. The formation contains abundant fossils; in this respect the Manchurian facies is different from the north Chinese facies.

Should the type of the north Chinese facies in Manchuria be represented by the Liao-ho plain group, it may be preferable to set the type on the drifts, which are developed along the Lao-ha-ho River, particularly in the vicinity of Chih-feng, by slightly modifying the original view of the author. The coastal district of Liao-hsi, west of the lower Liao-ho River, clearly belongs to the north Chinese facies. The facies of the Liao-tung Peninsula are questionable, but in a broad sense they probably belong to the north Chinese facies.

Basaltic plateau occupy a vast area in northeastern Manchuria. The detailed eruptive stages of the basalts and their relation with the Ku-hsiang-tun formation have not yet been determined. The relation between the rock detritus formation of the Ta-hsing-an-ling mountain range and the Djalainor formation or Ku-hsiang-tun formation is also unknown. However, the relation between the Pai-tou-shan glacial stage and the volcanic activity, reported by Goro ASANO (1947), may give some assistance to the present problem.

## 3. Chronology

The formations ranging from the Pontian in the lower Pliocene to the Alluvium (H-K) were divided into six regions, namely, Jehol-Liao-hsi, Ta-shih-chiao, Liao-tung Peninsula, the coast of the Yellow Sea, Shen-yang, the Sung-hua-chaing districts, and they were correlated as shown in Table 1 (SHIKAMA, 1950A). Inner Mongolia, the mountain district of eastern Manchuria, and the marginal part of Korea are omitted as the Diluvium in these districts has not yet been studied, although they offer the data for chronological determinations. In Table 1, the general horizons recognized in north China are shown, and the horizons of Manchuria were correlated with those of north China. Erosion stages A-G are based on TEILHARD DE CHARDIN's classification, and 1–4 are noticeable deposition stages.

Among the four deposition stages in north China, namely, the Pao-te, San-men, Chou-kou-tien and Ma-lan, the Ma-lan and Chou-kou-tien belong to the Diluvium. In Manchuria, the Ma-lan stage is most extensively developed, while the Chou-kou-tien series is distributed sporadically. The occurrence of the San-men

**Table 1.** Correlation of the Younger Cenozoic System in Manchuria

| | General succession of N. China | Lan-ho (TADA) | Ta-ling-ho (TADA) | Jehol (TADA) | Jehol--Liao-hsi | Vicinity of Ta-shih-chiao | Liao-tung Peninsula | Coast of the Yellow Sea | Chang-chun—Shen-yang | Sung-hua-chiang, Harbin |
|---|---|---|---|---|---|---|---|---|---|---|
| K2 | Pan-chiao stage (G) | | 30-40 m terrace (ENDO, MORITA) | | Present erosion | Forming of present small valleys | Forming of present small valleys<br>Slight upheaval | Forming of up-heaved coast<br>Muddy coast | Erosion of the present time | Erosion of Sung-hua-chiang stage |
| K1 | Black earth stage | | | | Black earth stage | | Submergence of Ta-lien Bay<br>Black earth<br>Pu-lan-tien stage | Ta-ku-shan peat bed<br>Redeposited clay bed | Black earth stage | Wen-chuan-ho bed (Wen-chuan-ho stage) |
| J3 | Ma-lan stage ④: Djalaos sogor sand bed | | First denuded plane 60-120 m | First denuded plane<br>Chang-tu plane 60-120 m | Erosion of Lao-ha stage | | Pi-tzu-wo stage (period) 20-50 m | Upheaval<br>Erosion | Upheaval<br>Erosion | Erosion of Wa-pen-yao stage |
| J2 | Ma-lan stage ④: (F) Ma-lan loess | Loess | Loess | Loess | Chih-feng stage: Redeposited loess (partially gravel bed)<br>Eroded Liao-ho stage<br>Jehol loess | Kai-ping clay group (Elephant of Pei-piao) | Pu-lan-tien clay group<br>Base of Pi-tzu-wo plane<br>(Ta-lien mammoth) | Ta-yang-ho yellow clay bed | Liao-ho plain group (mammoth)<br>Hun-ho clay bed<br>Ying-cheng-tzu gravel-clay<br>Chang-chun clay bed | Ku-hsiang-tun formation: Upper / Lower |
| J1 | Ching-shui stage (E) | 200 m a Denuded plane | Second denuded plane 180-200 m | Second denuded plane<br>Tung-liao plane 180-200 m | Erosion | Erosion and up-heaval<br>More than 30 m was dissected | Kuang-ning-ssu plane 120-200 m<br>Liao-tung peneplain | Erosion of Liao-tung stage | Erosion of bed rock<br>Effusion of basalt | |
| | Chou-kou-tien stage ③ | | | | Loam<br>Reddish clay group | Hsiao-sheng-shui-ssu group<br>Niu-hsin-shan group | Reddish clay | | Chang-tu fissure bed (Red formation) | |
| I2 | Huang-shui stage (D) | 280 m b Denuded plane | Third denuded plane<br>Chahtara plain 280-300 m | Third denuded plane 280 m | Erosion of Taling-ho stage | Forming of caves and fissures | | | Forming of caves and fissures | |
| I1 | San-men stage ② | | | | | | | | | |
| H | Fen-ho stage (C) | 400 m c Denuded plane | Fourth denuded plane 400-420 m | Fourth denuded plane<br>Chahatam plane 400-420 m | | | | | Sand | |
| | Pao-te stage (B) ① | 480 m d Denuded | 460-490 m | 460 m | Pei-piao red earth bed / Ling-yuan red earth bed | | Chin-chou clay group | Chuang-ho red clay bed | Red sand and clay | |
| G | Tang-hsien stage (A) | 560 m e Denuded plane | Fifth denuded plane<br>Kien-ping plane 540 m | Fifth denuded plane 560 m | | | | | Gravel and sand | |

series in Manchuria is not confirmed, while the Pao-te series is found only in Jehol Province and in the Liao-tung Peninsula.

Based on observation of deposits of the later Cenozoic era distributed between Chang-chun and Pai-cheng-tzu and between Ssu-ping-kai and Cheng-chia-tun, Sōki YAMAMOTO (1948) divided it into seven sedimentary stages, in ascending order, as follows:

| | |
|---|---|
| Gravel | (Tang-hsien stage) |
| Red sand and clay | (Pao-te stage) |
| Sand | (Fen-ho stage) |
| Bluish gray clay | (San-men stage) |
| Gravel | (Ching-sui stage) |
| Brown clay | (Ma-lan stage) |
| Sandy clay | (Pan-chiao stage) |

He also pointed out three remarkable features as follows: (1) the clay in the Pao-te and San-men stages is not reddish in general, (2) the development of sand in the Fen-ho stage is poor, and (3) a downwarping occurred prior to the Malan stage. YAMAMOTO's division has not been confirmed from the paleontological point of view. His division is unique in that he applied a deposition stage to each erosion stage of Tang-hsien, Fen-ho, Ching-shui, and Pan-chiao.

At any rate, it is certain that level planes, such as erosion or denuded planes, are very important in the chronology of the Quaternary period. Studies of this line have not progressed to an extent that the level planes in all of Manchuria can be correlated. There are piedmont plains developed in a position lower than the so-called Mongolian peneplain or Pei-tai peneplain. For example, the hilly plain at Fu-lung-chuan and the erosion planes of sand and gravel underlying the loess belong to the piedmont plain.

Erosion of the Ching-shui stage is generally found in Manchuria; for example, the eroison of the Liao-tung peneplain corresponds to this stage. The Kuang-ning-ssu plane (120–200 m), which was studied by Zenkyō IMAMURA and Teijirō TSUCHIDA (1935), and many other high-level planes are cut directly into the basal rock. In some parts, the planes coincide with the deposition planes of the Pu-lan-tien clay group or the Kai-ping clay group in the valley bottoms. However, considering that the plane of unconformity between the Pu-lan-tien clay and the reddish clay formation may correspond to the Kuang-ning-ssu plane, the author correlated the erosion of the Liao-tung peneplain with the Ching-shui stage (1950A). The erosion stage of Ta-ling-ho, which makes the unconformity between the Pei-piao red earth bed and the reddish clay formation, may correspond to the Huang-shui stage. The Fen-ho stage is not common in Manchuria. In the post-Ma-lan stage, since the sedimentary facies in Manchuria are well developed as compared to those of north China, it is possible to study in detail the erosion stages in the post-Huangshui stage.

In a certain sense, the division of the level planes of Jehol by Fumio TADA is contrary to Soki YAMAMOTO's views. In contrast with YAMAMOTO, TADA divided the denudation stages only, leaving the relations between the denudation stages and the deposition stages unknown (TADA, 1937). TADA distinguished about six horizons of denuded planes in the regions of Lan-ho, Lao-ha-ho, and Ta-ling-ho, and correlated them with those of north China. It seems that TADA owes his classification to the developmental history of the topography at Szechingtao in Chih-feng district, which was studied by BARBOUR. The present writer correlated the chronology in Manchuria with the new chronology in north China and revised the correlation table. The present erosion in the post-Lao-ha erosion stage was named the Ling-ho stage by BARBOUR. However, since it is liable to be confused with CHARDIN's Ling-ho stage and it is also not so important, the use of BARBOUR's Ling-ho stage has been avoided in this paper. BARBOUR's loam formation in TADA's correlation was correlated not to the San-men series, but to the Chou-kou-tien series. The Ta-ling Ho erosion stage was merely an erosion stage between the red earth stage and the loam stage, and it is as yet unknown if it can be correlated with the erosion stage between Huangshui and Fen-ho or that between Pao-te and Yu-she. At any rate, the denuded planes reported by TADA from Jehol are three, between the Kien-ping plane and the Tung-liao plane, and they correspond to the three stages of erosion in north China.

**Table 2.** Correlation of Erosion Planes in North China and Manchuria.

| | North China | Manchuria |
|---|---|---|
| a. | Tang-hsien stage erosion (Foundation of Pao-te series). | Kien-ping plane. Fifth denuded plane. Fu-lung-chuan plane. Roppyakuzan plane. |
| b. | Erosion between Pao-te and Yu-she series. | Denuded plane. |
| c. | Fen-ho stage erosion (between Yu-she and San-men). | Chahatam plane. Fourth denuded plane. |
| d. | Huangshui stage erosion (between Chou-kou-tien and San-men). | Liao-tung stage erosion (Chatara plane. Third denuded plane). |
| e. | Ching-shui stage erosion (between Chou-kou-tien and Ma-lan). | Liao-tung stage erosion (Tung-liao plane. Second denuded plane. Kuang-ning-ssu plane). |
| f. | Liao-ho stage erosion (between Ma-lan loess and Djalaossogor sand bed). | Erosion between loess and redeposited loess. Wo-pen-yao stage erosion (Chang-tu plane. First denuded plane). |
| g. | Pan-chiao stage erosion (Erosion of the present time). | Sung-hua-chiang stage erosion. |

In Pei-piao district, the presence of reddish clay formation between the red earth and the loess was pointed out by Shigeru KUSAMITSU and the number of erosion planes increased.

The Ching-shui, or the Liao-tung, erosion stage is very important as it divides the Diluvium into upper and lower parts; thus the confirmation of this stage will be most important for the chronology of the Diluvium in Manchuria.

### 4. Hsiao-sheng-shui-ssu Group and Niu-hsin-shan Group

In 1942, the presence of cave deposits in the magnesite quarry at Ta-shih-chiao was brought to light. In the same year, Mitsuo NODA did field work at this place, and in 1943 the writer and Shigeru KUSAMITSU visited there and collected many fossils. There is a fissure-like cave (25 m long and 5 to 10 m wide) on the slope of a hill, 60 m in relative height and 130 m above sea level, at the magnesite quarry of Hsiao-sheng-shui-ssu. The deposits in the cave consist of a white sand bed (lower part) and a reddish-brown residual clay bed (upper part). The residual clay filled up small fissures and depressions which are found in the *Karrenfeld* in the upper part of the quarry. The hill of Hsiao-sheng-shui-ssu itself is a kind of monadnock, and the formation of residual clay seems to have acompanied the erosion of the monadnock. Consequently, the cave deposits seem to be older than the Kai-ping clay group, which is distributed extensively from the foot of the hill to the valley bottoms. The writer proposes to name this the Hsiao-sheng-shui-ssu group.

Niu-hsin-shan is a small hill 69 m above sea level, located about 4 km south of Ta-shih-chiao station on the Lien-Ching Railway Line. It consists of magnesite and there is a fissure running north-south in the part about 62 m in relative height and 40 m above sea level (the southwestern part of the hill and facing the railway track). This fissure is filled with gravelly clay. The clay consists mainly of breccia of magnesite, and the greater part of the breccia is cemented by clacareous matter. Many fossil bones are found in this breccia formation. The upper part of this fissure is also filled with reddish-brown residual clay. There is another fissure at a point about 20 m above sea level on the eastern slope of the same hill. The interior is filled by coarse gravelly clay which is not cemented by calcareous matter, and a fossil deer had been previously collected from the clay. This bed is considered to lie in the upper horizon as compared with the above-mentioned breccia formation. The writer named the fissure deposit at Niu-hsin-shan the Niu-hsin-shan group.

| | | |
|---|---|---|
| Niu-hsin-shan group | Lower part: | Breccial clay (breccia bed)<br>*Trogontherium* bed |
| | Upper part: | Gravelly clay bed and<br>Reddish-brown residual clay bed |

The foot of the hill is also extensively covered by the Kai-ping clay group.

The lower bed closely resembles the breccia bed of the *Sinanthropus* group at Chou-kou-tien. The fossils collected from the lower bed at Niu-hsin-shan are as follows:

| | |
|---|---|
| *Cervus* sp. | limb bones |
| *Lepus* sp. | teeth |
| *Trogontherium* cf. *cuvieri* FISCHER | skull, R $M_1$ or $M_3$ |
| *Castor* sp. | lower right jaw |
| *Microtus* sp. | teeth |
| *Erinaceous* cf. *algai* YOUNG | skull, lower jaw |
| *Canis* (?) sp. | skull |
| *Felis* sp. | skull |
| *Phasianus* sp. | skeleton |
| Ohidia, gen. & sp. indet. | |
| *Geoclemys reevesii* (GRAY) | plastron |
| Anura , gen. & sp. indet. | humerus |

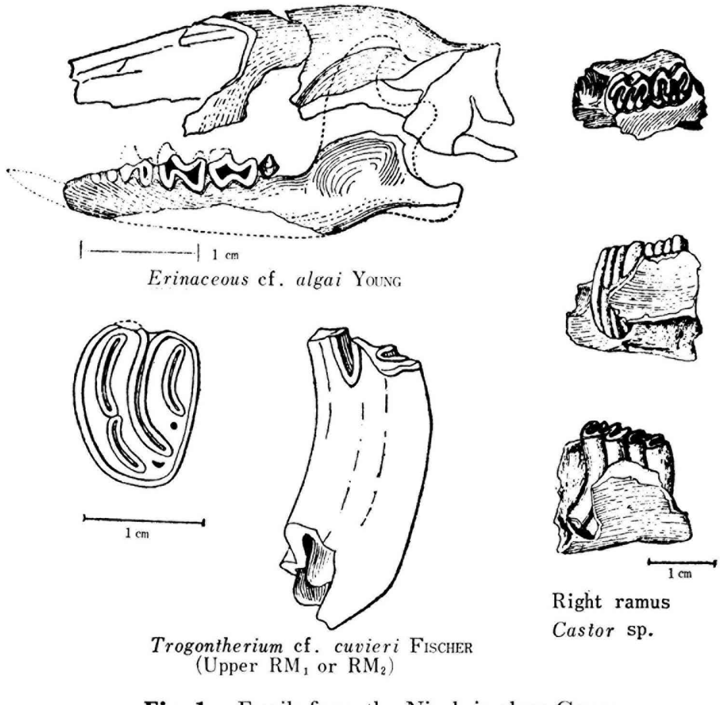



**Fig. 1.** Fossils from the Niu-hsin-shan Group.

Among the above-listed fossils, *Phasianus* is most abundant, and therefore it is no exaggeration to say that the present bed is the *Phasianus* bed. Since *Trogontherium* cf. *cuvieri* occurs in the *Sinanthropus* group at Chou-kou-tien, it is an important datum by which the present bed can be correlated with the *Sinanthropus* group. *Castor* sp. is not similar to *Castor* from the *Sinanthropus* group and *Sinocastor* from China; it is rather nearer to *Eucastor,* the living beaver in Canada. These two species of beaver rarely occur in Manchuria. The lower part of the Niu-hsing-shan group is correlated with the *Sinanthropus* group at Chou-kou-tien, and the sand bed in the lower part of the Hsiao-sheng-shui-ssu group may be older, in spite of its occurrence in a higher horizon than the former. The upper part of the Niu-hsin-shan group may be regarded as approximately the same age as the clay bed in the upper part of the Hsiao-shang-shui-ssu group. Thus it has been confirmed that the cave-fissure deposits of the Chou-kou-tien stage are distributed in south Manchuria.

**Table 3.** Correlation of the Niu-hsin-shan Group and the Hsiao-sheng-shui-ssu Group.

| Kaiping clay group | |
|---|---|
| Upper part of the Niu-hsin-shan group | Upper part of the Hsiao-sheng-shui-ssu group |
| Lower part of the Niu-hsin-shan group | |
| | Lower part of the Hsiao-sheng-shui-ssu group |

According to Mitsuo NODA (1930), the same fissure deposits are found in a limestone fissure in the vicinity of Chang-tu, between Chang-chun and Shen-yang, from which an antler of *Cervus hortulorum grayi* (ZDANSKY) was collected.

## 5. Liao-ho Plain Group

In south Manchuria, loess or loess-like clay is extensively distributed. According to Fusao UEDA and Masao SASAKURA (1937), the Diluvium series in Chin-chou, Jehol, and Hsing-an Provinces fills the great valleys and covers the hills, and it consists of loess, sandy loess, and aeolian sands. The loess is mainly developed in the southern region and it grades into the sandy loess in the central region. A basal gravel bed is occasionally found and a gravel bed is sometimes intercalated in the middle part. Distribution centers of the loess are Cheng-te, Chang-shan-yu (between Cheng-te and Ku-pei-kou), Ku-pei-kou, Huai-jou (south of Mi-yun), Hsing-lun-hsien, Ping-chuan, Kuan-cheng, Sa-ho-chiao, Chih-feng, Ling-yuan, Chao-yang, Chien-chang (another name for Ling-yuan), and Sui-chung. The sandy loess is distributed extensively and covers the hills in the area north of the line which connects Chih-feng, Pien-chiang-shan, and Kuo-chia-tun as far as Wu-tan-cheng. The sandy loess where it covers the hills is relatively thin, but in the valley bottoms it is as thick as 20 to 30 m and is also intercalated with gravel beds.

In the Liao-hsi district, which is the coastal area of Liao-tung Bay east of Shan-hai-kuan, especially in the wide valleys of the hills of old mature stage in the Sui-chung district, a loess bed is distributed at a height of scores of meters above sea level. This loess bed intercalates gravel beds and differs somewhat from the loess in north China. A reddish clay bed is sporadically developed in its lower part. In the valleys which dissected this loess bed, black earth bed has been deposited, one to 2 m thick, and a part of it has changed into a peatlike substance. It is note worthy that the loess bed in Liao-hsi resembles the Kai-ping clay in Liao-tung on the whole rather than the loess in Jehol. The same relation is found at Ta-ku-shan and along the Chuang-ho River—the Liao-tung Peninsula on the coast of the Yellow Sea. In the area south of the Chuang-ho, a *terra rossa*-like red clay, which resembles the Chin-chou clay found in the vicinitys of Chin-chou, is developed extensively and covers the plane of the low level hills on the coast. However, in the Ta-ku-shan district, it is completely absent and a yellow clay bed (the Ta-yang-ho yellow clay bed) is extensively distributed. Its characteristics are not very different from that in Liao-hsi. The deposition plane is scores of meters above sea level and it coincides with the Pi-tzu-wo plane, and some of the yellow clay was deposited secondarily in the lower area. On the greater part of the coast a peat bed (Ta-ku-shan peat bed) is found, which is mined by the inhabitants[3)] (Aoji, 1925). This peat bed may be correlated with those in Pyongan-pukto and the Chongju district in Pyongan-namdo, Korea. Such peat beds are extensively distributed in the bay head of an old stage along the drowned coast of the north coast of the Yellow Sea.

In the Liao-tung Peninsula, a remarkable red earth is developed in the Chin-chou district and its characteristics resemble the Pei-piao red earth in Jehol. Though the red earth yields no fossils and positive data are not yet found, the writer wants to correlate tentatively this red earth and the Pei-piao red earth (Chin-chou clay group) with the Pao-te red earth. Red earth is also sporadically distributed on the hills of low altitude in the so-called Liao-tung plain situated between Chin-chou and Ta-shih-chiao (Hanai, 1928). Heretofore these red earths have been regarded as *terra rossa* which is due to the weathering of limestone. However, the red earth is found in places other than limestone districts, and in the limestone districts of northeastern Manchuria, such red earth is not found even in the form of *rendzina*. Therefore, the writer strongly doubts whether such a reddish clay group is distributed in northeastern Manchuria. The Pu-lan-tien clay bed forms the Pi-tzu-wo plane in the vicinity of Pu-lan-tien. The clay is yellowish gray and dense. Its prolongation may be the mammoth-bearing clay bed at Lung-wang-tan in Ta-lien. The Pu-lan-tien peat bed, bearing seeds of Indian lotus (germination experiments were made), was deposited in the bottoms of valleys which dissected the hills consisting of the Pu-lan-tien clay bed. This Pu-lan-tien peat bed is merely a prolongation of the Ta-ku-shan peat bed.

In the Kai-ping and Ta-shih-chiao districts, the Kai-ping clay group, which is the prolongation of the Pu-lan-tien clay bed, is extensively distributed on the low level planes about 7 m above sea level. Small erosion valleys have been developed

[3)] In Chang-chia-pu, 20 km northeast of Ta-ku-shan, there is a peat bed at a depth of about 1 m, which is 80 cm thick. In Chien-shan-tzu, 8 km northeast of Chang-chia-pu, it is 1 to 2 m thick.

in a part of the Kai-ping clay group by present erosion. There are many gullies on the clay which cover the slopes of hills. These gullies may continue to the small erosion ravines in the valleys. The formation from which *Palaeoloxodon namadicus* was collected, in the vicinity of Pei-piao, may be a prolongation of the present clay bed. According to Rinji SAITO (1939), in Tang-kang-tzu hot spring south of Anshan, the earthy formations in descending order from the surface are; black earth (6.2 to 15 m), loess (4.5 to 14.5 m), and sand bed (2.9 to 6.9 m). This is also a northward prolongation of the Kai-ping clay group. According to Shoichi NISHIDA (1939), the following section was obtained in the vicinity of Hsing-cheng hot spring, Chin-chou Province:

| | | |
|---|---|---|
| 1. | Surface soil ............................... | 60 cm |
| 2. | Dark-brown fine sand ....................... | 60 ,, |
| 3. | Brown coarse sand .......................... | 80 ,, |
| 4. | Gray-brown coarse sand .................... | 150 ,, |
| 5. | Gravel (pebbles 3 to 5 cm in diam.) ........... | 100 ,, |
| 6. | Gravel (pebbles 5 to 10 cm in diam.) .......... | 300 ,, |
| 7. | Light-green clay ........................... | 90 ,, |

Granite

This area is the alluvial coast of Po Hai, where sand and gravel transported by the Liao-ho River are extensively distributed. The area surrounded by Shen-yang, Hsin-min, Hei-shan, Hai-cheng and Ying-kou is a representative area of alluvial deposits. Liao-tung Bay, which had extended as far as Shen-yang and Hsin-min in the early Alluvium, may have been buried by the prolongation of deltas formed by the Ta-liao-ho (Liao-ho), Tai-tzu-ho, Hun-ho, Sha-ho, Hsiao-ling-ho and other rivers.

According to Kuman HARAGUCHI (1939), who surveyed the dam of the Liao-ho reservoir northwest of Kai-yuan, loess 20 m thick overlies the Chuan-tou formation on the hills between Hou-to-lo and Chai-chia-wo-peng, and mammoth and deer were collected in the vicinity of Pao-li-chen. On the left bank of the Liao-ho, loess was deposited, while on the right bank aeolian sands (one to 2 m) are found on the surface, and sand mixed with clay is developed under the surface sands. HARAGUCHI considers that this sand bed is younger than the loess.

A thick group of yellow clay is developed in an area from Shen-yang to Chang-chun and forms hills of strong relief (the Liao-ho plain group). The group in part consists of homogeneous compact loesslike clay, though partly mixed with gravel. Mammoth remains were found in the gravel bed which forms a terrace in the Ying-cheng-tzu coal mine, and also from the same bed at Liu-ho east of Shen-yang. In short, the Liao-ho plain group is the southern prolongation of the Ku-hsiang-tun formation and corresponds to the marginal part of the Manchurian facies or the transition part of the north Chinese facies. The Chuan-tou formation (Cretaceous) near Chang-tu extends as far as north of Chang-chun and is overlain by the clay of the Liao-ho plain group. As is seen in Ping-ting-shan at Ta-tun, south of Chang-chun, there is a basalt flow which truncates the Chiang-tu bed and seems to be overlain by the clay group. This basalt flow may have some relation with the volcanic activities of Chi-hising Volcano and Pai-tou-shan as well as the formation of basalt plateaus in Mu-tan-chiang Province.

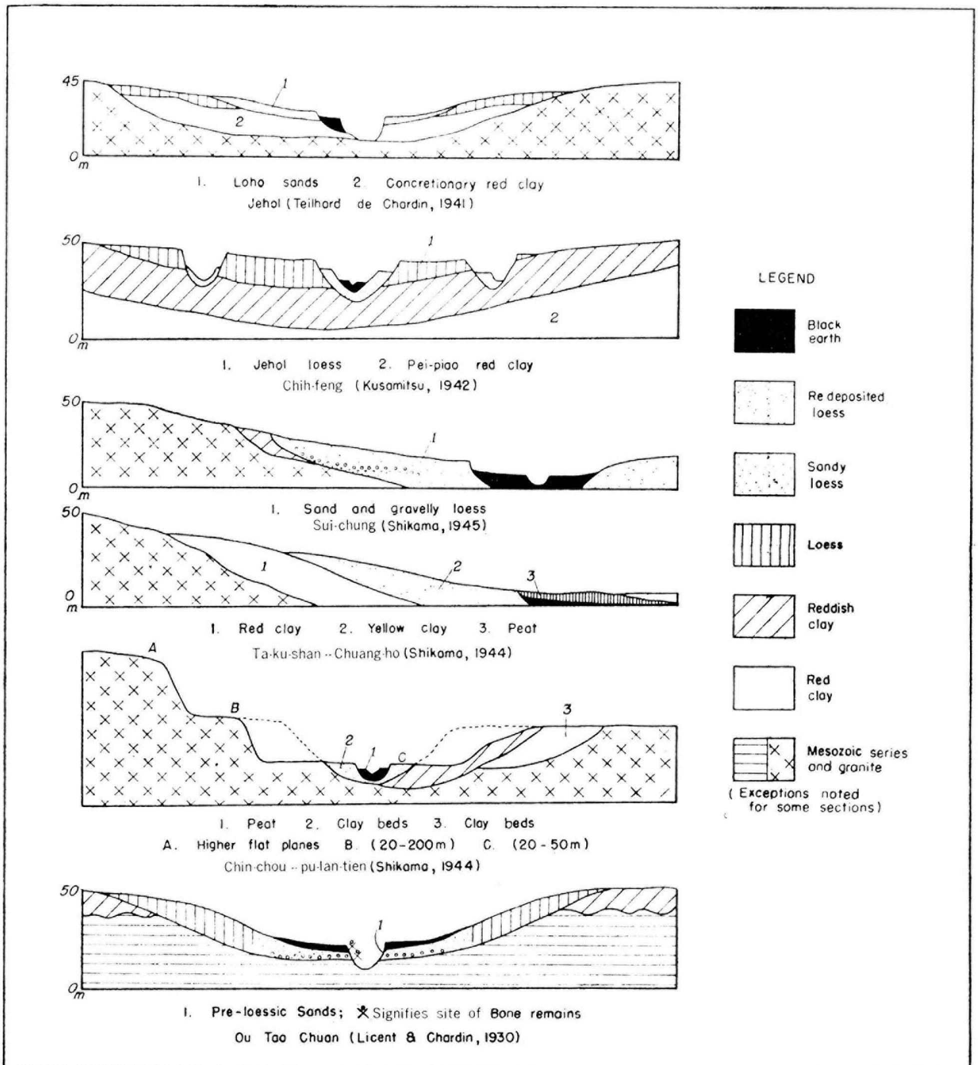



**Fig. 2.** Diagrammatic Section of Quaternary Sediments in Manchuria.

In 1930, LICENT and TEILHARD DE CHARDIN reported the following fossils, which are equivalent to the Ku-hsiang-tun facies, from Ou Tao Chuang, southwest of Chang-chun: *Elephas* sp., *Equus hemionus*, *Equus* cf. *przewalskyi*, *Cervus ordosianus*, *Gazella* sp., *and Bison* sp.

They reported the presence of a red coarse-grained gravel bed which forms the

Chang-chun hills plane and underlies the Liao-ho plain group, and assigned it to the San-men series. However, the writer considers that it probably belongs to the Chou-kou-tien stage. Moreover, they also reported the presence of white gravel bed (8 to 12 m) in the basal part of the yellow clay bed in the interior of the basin. This may be the sandy facies that is seen in the lower part of the Ku-hsiang-tun formation. The above-mentioned section reported by YAMAMOTO is located in the vicinity of this place, and it is, so to speak, the type section of the area along with the so-called Hei-liao divide (NIINOMY, 1930). The stage of formation of this divide, namely, the stage when the water courses of the Liao-ho and Sung-hua-chiang were fixed, may have been after the deposition of the Liao-ho plain group and before the deposition of the black earth. That is, it was a recurring upheaval which accompanied the Lao-ho erosion. This upheaval movement coincides with the development of a large-scale terrace-forming movement in the Japanese Islands at the end of the $J_2$ stage (Musasino terrace—$Du_1$ plane) (SHIKAMA, 1950B). If the Hei-liao divide can be regarded as the Korean direction, it is considered that this movement may be related with the movement which caused the declination of high level planes in Korea and subsequently caused the difference between the topography of the east coast and that of the west coast in Korea (KOBAYASHI, 1931). The subsidence topography of the Liao-tung Peninsula is in accord with the subsidence topography of the west coast of Korea. The northwestern prolongation of the eastern shore line in Korea coincides with the Hei-liao divide. It is worth considering whether the movement of the Hei-liao divide had already started at the Ching-shui stage or not. Since the boundary between the Manchurian facies and the north Chinese facies approximately coincides with the Hei-liao divide, the first movements of the Hei-liao divide may already have begun in the Ching-shui stage. According to Kunitarō NIINOMY the Nen-chiang and Liao-ho were originally one continuous river; then they were cut in two by the Hei-liao divide and the Nen-chiang became a tributary of the Sung-hua-chiang. The cutting of this antecedent valley probably occurred in the Lao-ha stage. If the Nen-chiang and Liao-ho had flowed southward as one river, the Manchurian facies and north Chinese facies would have come into contact along it, and the Ssu-ping-chieh—Cheng-chia-tun (Liao-yuan) districts would not have been dissected. Therefore, NIINOMY's opinion conflicts with the facts. It is more reasonable to consider that one continuous river flowed northward and emptied into the Sung-hua-chiang, and the Lao-ha River flowed via the upper stream of the former Liao-ho and poured into the Sung-hua-chiang. It is noticeable that the district of Cheng-chia-tun, Kan-an, Chien-kuo-chi, and Ta-lai is a vast alluvial zone and no hill consisting of loess is found.

The localities where fossils have been found in the Liao-ho plain group are as follows:

(1) Water reservoir at Lung-wang-tan, Ta-lien (TOKUNAGA & NAORA, 1939): In 1921, an elephant tusk and a tooth were found in the clay and gravel bed under the river bed during the engineering work. They are in the possession of OKUWA.

(2) Water reservoir at Lo-chia-tun in the vicinity of Ta-lien: Elephant tusk.

(3) Creek connecting the first with the third creek at Ling-shui-ho, Hsiao-ping-tao-hui in Ta-lien district: Tusk, vertebrae, and scapula of mammoth were found in 1916; they are owned by the former Museum of Port Arthur.

(4) Southwest of Chao-yang in Jehol Province: *Rhinoceros antiquitatis* was found by TEILHARD DE CHARDIN in the loess.

(5) Chao-yang-kou, north of Chih-feng, Jehol Province: *Rhinoceros antiquitatis* (molar), *Ovis ammon* (occipital bone), mammoth and bone implements were found by Saburō SHIMIZU, Isao MATSUZAWA, and others in the loess deposits.

(6) Shore of Lake Borden, Jehol Province: Fragment of deer antler which was artificially worked and skull of *Meles*. They were found by Kyukichi KISHIDA in 1920.

(7) Luan-ping district in Jehol Province: Megacerid.

(8) Hsin-min Hsien, Feng-tien Province (Shen-yan Province): A skull with horn cores of *Bos primigenius*. It is said that this specimen was at one time possessed by the Shen-yang Museum. It was found in the sand bed.

(9) Liu-ho (A village now called Chih-an-pu): Molar of mammoth found in a river bed.

(10) Hsiao-ku-lun (Ku-lun-chieh) in Jehol Province: Molar of mammoth once in collection of the Geological Survey Museum of the South Manchurian Railway Co. under Japanese mandate in Ta-lien.

(11) Ssu-ping-chieh in Chi-lin Province: Fragment of incisor of mammoth and fragment of horn core of *Bos primigenius* which were possessed by the former Museum of Port Arthur.

(12) Kung-chu-ling in Chi-lin Province: Tusk and femur of mammoth as well as skull, and molar of *Rhinoceros antiquitatis* and other bones which were found in the loess-like clay and were possessed by the former Manchurian Medical College in Mukden.

(13) Huo-shih-ling (Ying-cheng-tzu) coal mine (near Chiu-tai), east of Chang-chun.

(14) Ou-tao-chuan, southwest of Chang-chun.

(15) In the vicinity of Pei-piao: *Palaeoloxodon namadicus*.

### 6. Ku-hsiang-tung Formation

Fossil mammalian discoveries in north Manchuria (after TOKUNAGA and NAORA (1939):

1905—A. D. HITROB collected a buffalo skull on the River Bodounet, the upper stream of the Sung-hua-chiang, and sent it to the Kiakhata Museum (USSR). It was later studied by M. PAVLOW.

1909—BAIKOB found a bone which is probably mammoth on the bank of Mu-tan Chiang south of Ning-ku-ta (Ning-an).

1911—Baikob found a fossil bone on the River Ushagou in the vicinity of Mt. Hunchung.

1918—The skulls of mammoth, *Bison*, *Rhinoceros* and others were found in the upper deposit at the Dalay Nor coal mine.

1923—*Rhinoceros* was found on the bank of the Nen-chiang.

1924—Mammoth was found at Shduch'ya village on the River Derubur (Reka Derbul or Chieh-erh-pu-erh-lo Ho), a tributary of the Argun River, in the Barwa district.

1925—*Rhinoceros* and mammoth were found alongside the lower stream of the Nen-chiang, 5 km from Fularki (Fu-la-erh-chi).

1926—A tusk of mammoth was unearthed in a cliff 100 m east of Nichiro Kyokai College, Harbin.

1926—*Bison* was discovered on the River Umingora (I-min Ho), 25 km south of Hai-la-erh.

1927—Mammoth was found 10 km from Bodounet where buffalo was unearthed in 1905.

1927—*Bison* and mammoth were found at "Gordor" (probably Gorbunor [O-erh-pu-no-erh] village) on the left bank of the River Mergera (Mo-erh Ho) 80 km north of Yakeshih (Ya-ko-shih) station.

1927—Cranium of *Rhinoceros* was unearthed 12 km southwest of Man-chou-li station (Lu-pin). Mammoth was found near a school in Man-chou-li.

1927—A milk molar of mammoth was discovered at Tao-lai-chao on the bank of the Sung-hua-chiang.

1927—Mammoth was found during the sinking of a well in the vicinity of No. 551 Branch Office in Harbin.

1927—*Rhinoceros* and mammoth were found in a cliff of a small river 2 km from the No-erh Railway.

1927—Fossils of mammoth were found on the banks of the I-min-ho and the Uhelohe River, a tributary of the former.

1928—A fossil bone was found during the sinking of a well at Cartu Station. (Location uncertain; may be Ho-erh-hung-te near Hai-la-erh).

1928—Vertebrae of *Rhinoceros* were found 20 km northwest of Hai-la-erh.

1928–29—Belebeki (phonetic rendering) collected many fossil bones from the bottom of the Sung-hua-chiang between Harbin and Chenghe. (Location of Chenghe uncertain; may be Tung-ho, Lat. 45° 59', Long. 128° 43').

1930—A bison skull was unearthed on the Amur River in the vicinity of Hei-ho (Ai-hun).

1931—The Harbin Museum and the Peiping Geological Survey carried out excavations at Ku-hsiang-tun.

1932—Mandible of *Rhinoceros* and other fossils were recovered from sand in the river bed of Sung-hua-chiang during the construction of piers.[4]

[4] Ed. Note:— This refers to the construction of a bridge where the railroad from Chang-chun to Harbin crosses the Sung-hua Chiang.

1933—The first digging at Ku-hsiang-tun by Shigeyasu TOKUNAGA, Nobuo NAORA, and others who took part in the First Scientific Expedition to Manchoukuo and Mongolia.

1934—The second digging at Ku-hsiang-tun by TOKUNAGA and NAORA (also Shimeji OTA and Seikō MAKIDA).

1937—The first digging at Ku-shiang-tun by the Central Museum of Manchoukuo (Riuji ENDO, Wataru ISHIJIMA, and Naoei OKUDA).

1938—The second digging at Ku-hsiang-tun by the same museum (Tokio SHIKAMA and Mitsuo NODA, also ENDO, ISHIJIMA and OKUDA).

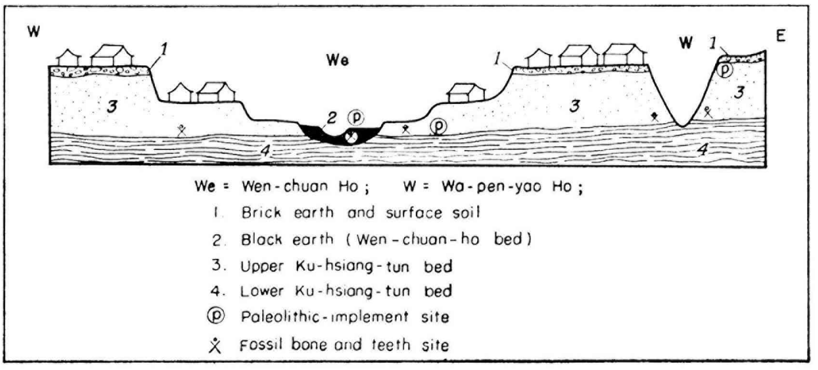



**Fig. 3.** Profile in Vicinity of Ku-Hsiang-Tun.

Ku-hsiang-tun, a treasury of Diluvium fossils, is a village located along the Wen-chuan-ho, a tributary of Sung-hua-chiang, 5 km southwest of the center of Harbin. The Diluvium series crop out along the Wen-chuan-ho and its tributary Wa-pen-yao-chuan. The Diluvium series, which forms the terrace group in the vicinity of Harbin, is estimated to be about 25 km. In the vicinity of Ku-hsiang-tun, its average thickness is about 10 m. It consists of a succession of clay, mud, sand, sandy clay and other sediments, and it is a flood plain lacustrine deposit. It is different from the Ma-lan loess while remarkable gravel beds are not found in it. The succession of the Ku-hsiang-tun formation is as follows (SHIKAMA, 1941):

| | | | |
|---|---|---|---|
| Ku-hsiang-tun formation | Lower part: | Bluish-gray to dark-gray clay bed and sandy clay bed .................. | 2.8 m |
| | Upper part: | Yellowish-gray argillaceous sand to sandy clay bed .............. | 10 m |
| Forming of terrace: | | Dissection of the Wa-pen-yao-chuan (Wa-pen-yao stage) | |
| Wen-chuan-ho bed: | | Black mud bed (one m average thickness) | |

Forming of terrace: Dissection of the Wen-chuan Ho (Sung-hua-chiang stage)

Though the upper Ku-hsiang-tung formation consists of apparently homogeneous loesslike clay, it is remarkably arenaceous as compared with the Ma-lan loess.

**Lower bed**

The variation is remarkable; a clay bed is predominant in the lower part and an arenaceous clay bed in the upper part. The beds are, in ascending order:

a) Dark-gray clay bed (2.7 m maximum thickness): It consists of fine-grained and highly coagulated clay, and it passes into dark compact massive clay and in places into yellow clay in the upper. Lenticular zone of yellow compact medium-grained sand is intercalated within it.

b) Bluish-gray arenaceous clay bed (1–2 m): Arenaceous clay or arenaceous mud in which a fine blue color is predominant. Compact, soft and massive. Drift-wood and other inclusions are scanty.

**Upper bed**

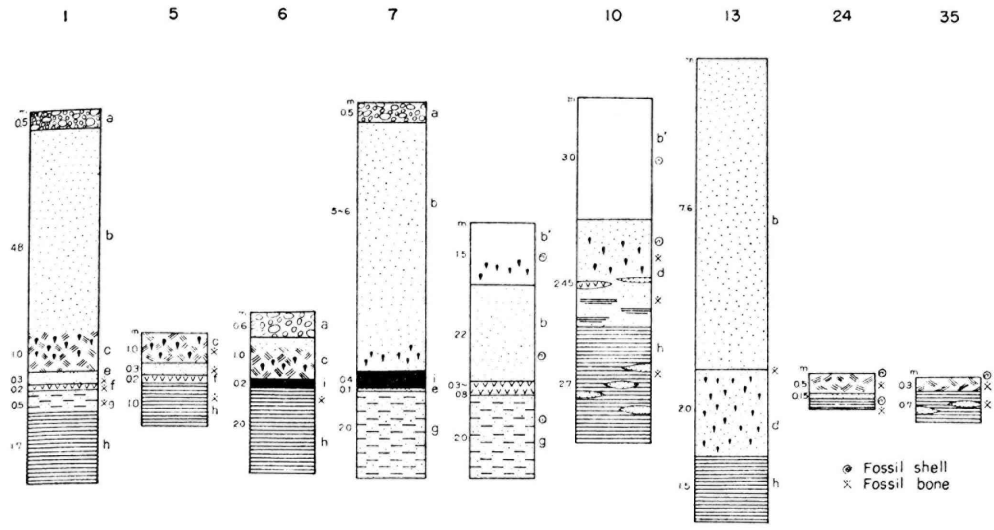
In general, sands predominate and cross-bedding is common in its lower part. One kind of basal gravel is found in the lowest part and it seems that a slight unconformity exists, though not yet confirmed.

c) Bluish-gray clay bed consisting of clay pebbles (0.8 m maximum thickness, 0.2 m average thickness): It is well exposed along the Wa-pen-yao Ho and sometimes it is intercalated in lenticular form. The pebbles consist of well-rounded clay pebbles or breccia, 1 mm in diameter, which are derived from b bed. It may be a kind of basal conglomerate. It contains sporadically dark-colored compact humuslike or peatlike clay, and it also contains much driftwood.

d) Yellowish-gray to yellowish-brown sands, argillaceous sands, and arenaceous clay bed (10 m maximum thickness. Its upper limit is still unknown). Cross-laminae are predominant in the lower part, and bog irons of 5–10 mm wide are distributed uniformly. This bed corresponds with TOKUNAGA and NAORA's loesslike clay bed as well as PONOSOFF's argillaceous loesslike clay bed. The upper part of this bed has been changed partially into black porous soil and in the part near the surface PONOSOFF recognized some podsolization. In some parts the following minute land molluscs are aggregated densely.

*Gyraulus schmacheri* CLESSIN
*Lymnaea* (*Galva*) *pervia* MARTENS
*L.* (*Radix*) *auricularia coreana* MARTENS

Mammals and other fossils are abundant in the lower part of the *d* bed, where cross-laminae are predominant, and in the upper part of the beds of *c*, *b* and *a*. Zoning based on fossils is impossible. The upper and lower part are of similar character; they are probably of the same age. Most fossil mammals are water-worn fragments and a complete skeleton is seldom found. In this respect the bed coincides with the flood-plain deposits which are rich in cross-laminae. A Mousterian-type point was found in the upper part of the *a* bed. Localities No. 19 and No. 20 (Fig.




(Numbers refer to locations in text and fig. 5.)
(Ponosoff, 1937)

**Fig. 4.** Cross-section of each Excavation Trench (1938).

5), in which the most abundant fossils and human relics were found in the second digging by Tokunaga and Naora, are in the upper part of the *a* bed and the localities do not belong to the Wen-chuan-ho bed. The Wen-chuan-ho bed contains many fossil bones which were carried from the Ku-hsiang-tun formation by running water. The fossils of *Juglans manchurica* Max. are an example of the peculiar fossils of this bed. Fragments of fossil bones which were carried from the Ku-hsiang-tun formation or the Wen-chuan-ho bed by running water are found on the present river bed mixed with bones of domestic animals of the present time. The width of the river flood plain of the Wen-chuan-ho, namely, that of the deposition plain of the Wen-chuan-ho bed, is estimated to be about 240 to 260 m. It is flat and is utilized as a clay pit by brick-manufacturing factories at Ku-hsiang-tun; in this way, the presence of fossil bones became known. Many excavation trenches by Tokunaga and Naora are located in the vicinity of the confluence of the Wen-chuan-ho and Wa-pen-yao-chuan and at a point downstream from the railroad bridge which crosses the Wen-chuan-ho. They dug in the deposition plane of the Wen-chuan-ho in each excavation. The Wen-chuan-ho bed is thickest in the vicinity of the bridge. In contrast, the Ku-hsiang-tun formation crops out in the area downstream from the confluence of the Wen-chuan-ho and Wa-pen-yao-chuan.

In the second digging by the Central Museum of Manchoukuo, stress was laid on research into the Ku-hsiang-tun formation and every possible effort was made in the excavation at the Wa-pen-yao-ho. Excavation sites Nos. 1, 2 and 8 (Fig. 5) were in the Wen-chuan-ho bed alone. Many good specimens were collected by dredging the river floor. This method was faster than digging in the solid beds.

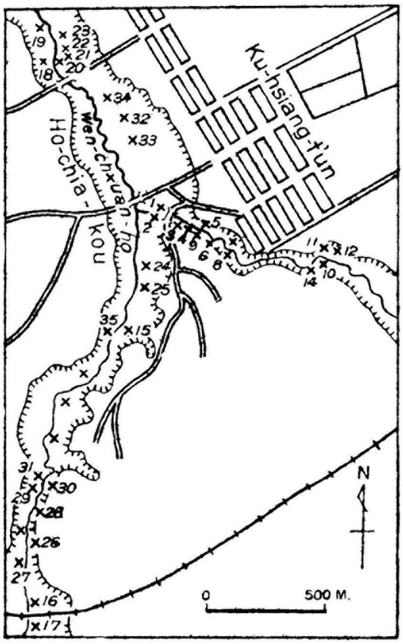



**Fig. 5.** Distribution Map of the Excavation Trench at Ku-Hsiang-Tun in 1938. (Numbers refer to text and fig. 4.)

The fossils from the Ku-hsiang-tun are abundant, and if the TOKUNAGA and NAORA collection is included, they are as follows:

## MOLLUSCA

1. *Unio eulasiae amurensis* MOUSON
2. *Cristaria plicata* (Lea.) var. SUZUKI
3. *Sphaerium lacustre compresum* MOUSON
*4. *Valvata piscinalis manchurica* SUZUKI
*5. *Stenothyra tokunagai* SUZUKI
6. *Bulimus ussuriensis harupinensis* SUZUKI
7. *B.* (*Parafossarulus*) *striatulus* BENSON
8. *B.* (*Gobbia*) *kiusiuensis naorai* SUZUKI
9. *Semisulcospira cancelata amurensis* (GERS.)
10. *Carychium pessimum gerstfeldti* SCHI.
11. *Aplexa hypnorum* (L.) subsp.
12. *Lymnaea* (*Galba*) *pervia* MARTENS
13. *L.* (*Stagnicola*) *tokunagai* SUZUKI
14. *L.* (*Radix*) *auricularia eoreana* MARTENS
15. *L.* (*Radix*) *plicatula* BENSON
16. *Anisus gredderi* (BIEL.)
*17. *Hippeutis manchuricus* SUZUKI

18. *Succinea pfeifferi pingi* SUZUKI
19. *S. alpestris* ALDER
20. *Cochlicopa lubrica* (MULL)
21. *Vertigo alpestris* ALDER
22. *V. alpestris harbinensis* SUZUKI
*23. *Gastrocopta coreana* PILS.
*24. *Vallonia chinensis* SUZUKI
25. *Gonyodiscus ruderata pauper* (GOULD)
26. *Euconulus* sp.
27. *Bradybaena staoi* SUZUKI
28. *B. virgo* (PILS.)

## INSECTA

Coleoptera indet. NAORA

## PISCES

1. *Ctenopharyngdon* cf. *idella* (VALD.)
2. *C.* sp.
3. *Carassius* sp.
4. *Pelteobagrus* sp.
5. *Leiocassis* sp.

## AVES

1. *Struthio* sp.
2. *Phasianus* sp.

## REPTILIA

*Amyda maackii* (BRANDT.)

## MAMMALIA

## CARNIVORA

1. *Canis lupus* L.
2. *C.* sp.
3. *Nyctereutes* sp.
4. *Vulpes* cf. *vulpes* (L.)
5. *Ursus* cf. *spelaeus* BLUM.
6. *Meles* sp.
7. *Mustela* cf. *sibirica* PALLAS
8. *Hyaena ultima* MATSUMOTO
9. *Panthera tigris* (L.)
10. *Felis catus* L.

## RODENTIA

1. *Clethrionomys rufocanus* (SUND.)
2. *Microtus* cf. *ratticeps* (YOUNG)
3. *Microtus* cf. *pelliceus* THOMAS
4. *M.* (*Lasiopadomys*) *brandti* (RADDE)
5. *M. obscurus* (EVERS)
6. *M.* cf. *mongolicus* RADDE
7. *M. Stenocranius gregalis* (PALL.)
8. *Cricetulus griseus* MILNE-EDWARDS
9. *Siphneus* sp.
10. *Ochotona* cf. *mantchurica* THOMAS
11. *Citellus mongolicus* (MILNE-EDWARDS)
12. *Marmota mantchurica* TOKUNAGA & NAORA
13. *M. robusta* (MILNE-EDWARDS)
14. *M. bobac sibirica* (RADDE)
15. *Tamias* sp.
16. *Castor orientalis* TOKUNAGA & NAORA

## PERISSODACTYLA

1. *Atelodus antiquitatis* (BLUM.)
2. *Rhinoceros sinensis* OWEN
3. *R.* cf. *mercki* JÄGER
4. *Equus przewalskii* POL.
5. *E. hemionus* PALLAS

## ARTIODACTYLA

1. *Sus continentalis* NEHR.
2. *S.* cf. *lydekkeri* ZD.
3. *Capreolus mantchuricus* (NOAK)
4. *Cervus* (*Cervus*) *canadensis xanthopygus* MILNE-EDWARDS
5. *C.* (*Cervus*) *elaphus* L.
6. *C.* (*Sinomegaceroides*) *ordosianus* YOUNG
7. *C.* (*Rusa*) *elegans* TEILHARD DE CHARDIN & PIVETEAU
8. *C.* (*Sika*) *horthulorum grayi* (ZDANSKY)
9. *C.* (*Sika*) *nippon mantchuricus* (SWINHOE)
10. *Alces* sp.
11. *Elaphurus* cf. *menziesianus* (SOW.)
12. Giraffidae, gen. & sp. indet.
13. *Gazella* cf. *gutturosa* PALLAS
14. *Spiroceros kiakhtensis* PAVLOVA
15. *Bos primigenius* BOJ.
16. *Bison priscus* BOJ.
17. *Bubalus teilhardi* YOUNG

18. *Probubalus* sp.
19. *Bibos kuhsiangtungensis* TOK. & NAORA
20. *Camelus* sp.

PROBOSCIDEA

1. *Mammuthus primigenius* (BLUM.)
2. *Parelephas armeniacus* (FALCONER)

PRIMATES

1. Gen & sp. indt.

Among them, Mollusca were identified mainly by Kōichi SUZUKI (1935). However, it is not clear how many species were from the Ku-hsiang-tun formation and how many from the Wen-chuan-ho bed; moreover, the fossiliferous horizons in the Ku-hsiang-tun formation itself are indist nct. Therefore, the writer listed them merely as one group. The following plant fossils were reported by TOKUNAGA and NAORA, and most of them belong to the Wen-chuan-ho bed.

1. *Trapa natans* L. subsp.
2. *Salix* sp.
3. *Juglans manchurica naorai* Endo
4. *J. manchurica tokunagai* Endo
5. *Betula alba* L.
6. *Hordeum* sp.

According to the writer's identification (ENDO, 1942), the collection from the second digging of the Central Museum of Manchoukuo expedition (in 1939) follows. From this list, one may see the frequency of fossils from the Ku-hsiang-tun formation, and of these, which were washed out by water. The numbers that follow the names of bone indicate the number of specimens; the fossils without number mean that only one specimen was found. (The trench numbers refer to Fig. 5).

Trench No. 1

*Equus hemionus* PALLAS .................lower tooth
*Bos primigenius* BOJ. ....................lower jaw, phalange
*Alces* sp. ............................antler
*Atelodus antiquitatis* (BLUM.) ...........skull fragment, scapula fragment
*Bison priscus* BOJ. ......................humerus, scapula
*Cervus (Sika) nippon mantchuricus* (SWINH.)..pelvis

Trench No. 2

*Atelodus antiquitatis* (BLUM.) ...........upper tooth, axis, manus.
*Equus hemionus* B.OJ ...................lower teeth (3), phalange

| | |
|---|---|
| *Cervus (Sika) nippon mantchuricus* (SWINH.) | lower teeth (2), axis, pes, manus, Femur |
| *Capreolus* sp. | humerus |
| *Bos primigenius* BOJ. | pes, manus, tibia (?), pelvis, bone implements (9) |
| *Canis lupus* L. | manus |

Trench No. 3

| | |
|---|---|
| Bovidae | upper tooth |
| *Bos primigenius* BOJ. | manus |
| *Atelodus antiquitatis* (BLUM.) | skull fragment, pes. |
| Felidae | manus |

Trench No. 4

| | |
|---|---|
| *Atelodus antiquitatis* (BLUM.) | upper tooth, vertebrate, femur |

Trench No. 5

| | |
|---|---|
| *Atelodus antiquitatis* (BLUM.) | lower teeth (4), skull fragments (2), atlas, cervical vertebrae (3), lumbar vertebrae (2), femur (3), manus, costa (3) |
| *Equus hemionus* PALLAS | phalange |
| *Cervus (Sika) nippon mantchuricus* (SWINH.) | lumbar vertebrae (3), femur |
| *Bos primigenius* BOJ. | lower teeth (6), manus, pes (2), calcaneum (2), scapula, ulna |
| *Gazella* cf. *gutturosa* PALLAS | horn core |
| *Nyctereutes* sp. | femur |
| Felidae | manus |
| *Mammuthus primigenius* (BLUM.) | vertebra, costa |

Trench No. 6

| | |
|---|---|
| *Equus hemionus* PALLAS | pes, manus (2) |
| *Capreolus mantchuricus* (NOAK) | antler, scapula, lower tooth |
| *Cervus (Sika) nippon mantchuricus* (SWINH.) | pes. lumbar vertebrae, atlas, pelvis, femur, ulna |
| *Bos primigenius* BOJ. | horn core, lumbar vertebrae (2), manus (2) |
| Felidae | manus |
| *Mammuthus primigenius* (BLUM.) | costa (12) |
| Bone implements | 12 |

Trench No. 10

| | |
|---|---|
| *Atelodus antiquitatis* (BLUM.) | upper tooth |

*Equus hemionus* PALLAS . . . . . . . . . . . . . . . . . phalange, manus (2)
*Cervus* sp. . . . . . . . . . . . . . . . . . . . . . . . . . . radius
*Bos primigenius* BOJ. . . . . . . . . . . . . . . . . . . . lower tooth, calcaneum, manus, radius, tibia, scapula, astragalus
Bone implement . . . . . . . . . . . . . . . . . . . . . 1

Trench No. 13

*Equus hemionus* PALLAS . . . . . . . . . . . . . . . . . phalange
*Capreolus* sp. . . . . . . . . . . . . . . . . . . . . . . . . scapula
*Bison priscus* BOJ. . . . . . . . . . . . . . . . . . . . . . ulna, calcaneum
*Mammuthus primigenius* (BLUM.) . . . . . . . . . crapus, scapula

Trench No. 18

*Equus hemionus* PALLAS . . . . . . . . . . . . . . . . . manus
*Cervus (Sika) nippon mantchuricus* (SWINH.) . femur
*Bison priscus* BOJ. . . . . . . . . . . . . . . . . . . . . . calcaneum, tibia
*Martes* sp. . . . . . . . . . . . . . . . . . . . . . . . . . . lower jaw

Trench No. 32

Pisces . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . operculum
*Struthio* sp. . . . . . . . . . . . . . . . . . . . . . . . . . egg shell
*Atelodus antiquitatis* (BLUM.) . . . . . . . . . . . lower tooth, axis, pelvis, manus
*Equus hemionus* PALLAS . . . . . . . . . . . . . . . . . lower tooth, manus, phalange
*Capreolus mantchuricus* (NOAK) . . . . . . . . . . . humerus, phalange, calcaneum, costa
*Bos primigenius* BOJ. . . . . . . . . . . . . . . . . . . . lower tooth, lower jaws (2)
Stone implement . . . . . . . . . . . . . . . . . . . . . 1

Trench No. 33

*Equus hemionus* PALLAS . . . . . . . . . . . . . . . . . lower tooth
*Cervus* sp. . . . . . . . . . . . . . . . . . . . . . . . . . . femur, sternum
*Meles* sp. . . . . . . . . . . . . . . . . . . . . . . . . . . femur

Trench No. 35

*Atelodus antiquitatis* (BLUM.) . . . . . . . . . . . . . upper tooth, lumbar vertebra, axis, manus, radius, scapula (2), humerus, costa
*Equus hemionus* PALLAS . . . . . . . . . . . . . . . . . upper tooth, lower teeth (2), manus
*Cervus (Sika) nippon mantchuricus* (SWINH.) . atlas, ulna, manus, pelvis
*Bos primigenius* BOJ. . . . . . . . . . . . . . . . . . . . upper teeth (2), lower tooth, calcaneum, astragalus, ulna
*Mammuthus primigenius* (BLUM.) . . . . . . . . . . tusk, molar
Bone implement . . . . . . . . . . . . . . . . . . . . . 1

Dredged from the Wenchuanho River

| | |
|---|---|
| *Atelodus antiquitatis* (BLUM.) ........... | upper teeth (13), lower teeth (5), manus (2), skull fragments (2), radius, ulna, cervical vertebrae (3), pelvis (2) |
| *Equus hemionus* PALLAS ................. | lower teeth (9), upper teeth (5), lower jaw, manus (3), phalanges (3) metatarsus (5), phalanges (2) |
| *Capreolus mantchuricus* (NOAK) ........... | antler. manus (3), calcaneum (2), phalange, manus, scapula, radius, humerus |
| *Cervus canadensis xanthopygus* M.E. ....... | antler |
| *Cervus* (*Sika*) *nippon mantchuricus* (SWINH.) . | teeth (4), humerus (6), manus (7), phalanges (2), lumbar vertebrae, costa, astragalus, carpus |
| *Bos primigenius* BOJ. ................... | lower teeth (7), upper teeth (7), phalange, calcaneum (3), tibia, metatarsus (5), costa (5), lumbar vertebrae (2), pelvis, radius, astragalus |
| *Bos* sp. .......................... | lower jaw |
| *Bison priscus* BOJ. ..................... | ulna |
| *Bison* sp. ........................... | tibia |
| *Canis lupus* L. ....................... | skull, teeth (10), manus |
| *Canidae* ............................ | manus, humerus, radius |
| *Microtus* sp. ....................... | lower jaw (many) |
| *Siphneus* sp. ....................... | lower jaw (many) |
| *Mammuthus primigenius* (BLUM.) .......... | manus |
| *Phasianus* sp. ........................ | scapula |

Of the above fossils, most abundant are rhinoceros, wild Bovidae (*Bison*), wild horse, and deer; and rats are next. Rodentia were especially abundant in No. 19 trench. In the above list, *Equus przewalskii* was included in E. *hemionus*. The presence of *Struthio, Castor, Gazella, Bubalus,* and *Camelus* is interesting. According to Tokunaga and Naora, mammals of 61 species in all show the following percentages. Numbers in parenthesis indicate specific number of specimens.

| | Percentage of living species | Percentage of extinct species |
|---|---|---|
| Carnivora | 9% (6) | 8% (5) |
| Rodentia | 19% (12) | 6% (4) |
| Artiodactyla | 14% (9) | 29% (18) |
| Perissodactyla | 3% (2) | 6% (4) |
| Proboscidea | — | 1% (1) |

Of these 61 species, the numbers of extinct and living species respectively are 32 (52%) and 29 (47%). Forest, steppe and marsh-river animals are respectively 26 (42%), 30 (49%) and 5 (8%). Species now living in Manchuria are 20 (32%), while those living outside of Manchuria are 8 (13%). Of the extinct species, 5 (8%) are known in the Far East, 7 (11%) are reported from outside of Manchuria, and the remaining 21 (34%) are found in Manchuria alone. It is said that 8 (13%) were found in the lower Pleistocene, while 53 (85%) were collected from the middle and upper Pleistocene (the Ma-lan stage). The percentage of the extinct species is not as great as the 75% of the *Sinanthropus* group at Chou-kou-tien; however, it surpasses the 43% of the Sjara-Ossa-Gol bed at Ordos and 28% of the lower bed of Afontova along the River Yenisei. Thus, the fauna belongs approximately to the range from the middle to the late Pleistocene.

In the list of mollusca, five species marked with asterisks are said not to be known as living species.

The climatic conditions of 52 mammalian fossils from the Ku-hsiang-tun formation are as follows (numbers in parentheses indicate specific numbers of specimens):

| | Living species (21 species) | Extinct species (31 species) | Total |
|---|---|---|---|
| Species which lived under approximately the same climatic conditions as at present: | 30% (16) | 28% (15) | 58% |
| Boreal type | 7% (4) | 19% (10) | 26% |
| Tropical type | 1% (1) | 11% (6) | 12% |

That is, among the living species, the species which correspond to the present climatic conditions of north Manchuria are abundant. If the extinct species are included, the percentage becomes 58%, so it is probable that the climate of that age was not very different from the present climate. The species of the frigid type which migrated southward and those of the tropical type which migrated northward exist together. It is inferred that the yearly variation between the summer and winter seasons was conspicuous. However, species which live in more frigid areas, such as *Rangifer* and *Ovibos*, were not found at all. This can be said not only of Ku-hsiang-tun but of all Manchuria. The southern limit of distribution of mammoth is Ta-lien, 39° north latitude, while in south Hokkaido it is 42° north latitude.

No human skeletons were found; however, some bone and stone implements have been found. Because of the conditions of the locality, stone implements are very rare; however, those of *racloir* type have been found. The lithic characters are basalt, quartz, chert, and other rocks. Artificially worked bone implements are rather abundant, and many implements such as spear-heads, chisels, and knives have been found. In addition, bone pieces cut to fairly uniform length, bone pieces with traces showing that they were bound by strings, a rhinoceros skull with hammer impressions, and a deer-antler implement were unearthed.

Coarse and fine implements are mixed with microlithic implements. The degree of culture generally corresponds with that of Mousterian-Aurignacian in western Europe. However, it is also said that this culture, together with that of Dalay Nor, may be correlated with the Siberian paleolithic culture (TOKUNAGA & NAORA, 1936). At least, the abundance of bone implements is a remarkable feature. It is considered that the remains of human culture may belong to loess camps. Some charcoal lumps were found, so it is noted that fire was used by paleolithic men. PONOSOFF collected some paleolithic stone implements in the upper part of the upper bed and he correlated them with Magdalenian. However, according to CHARDIN and PEI Wei-chung, the implements which were considered paleolithic by TOKUNAGA and NAORA belong, on the whole, to the mesolithic. However, in this case the frequency of stone implements in the Ku-hsiang-tun formation and in the Wen-chuan-ho bed is not yet distinct. A splendid stone implement collected in No. 32 trench by the writer and others in the course of the digging in 1938 was of Mousterian type; this stone implement was collected at the lowest part of the upper bed.

The Ku-hsiang-tun formation is rich in fossils and paleolithic remains, and it is a valuable formation which may be correlated with the Ordos. In 1943, the writer correlated these two localities as follows:

| Manchuria | Ordos | |
|---|---|---|
| Wen-chuan-ho bed | Black earth | —Culture of black earth stage |
| Upper Ku-hsiang-tun formation | Sjara-Osso-Gol bed | —Culture of mesolithic type (Azilian type culture) |
| Lower Ku-hsiang-tun formation | Lower part of the Sjara-Osso-Gol bed | —Culture of Moustero-Aurignacian type |
| -?- | Ma-lan loess | —Moustero-Aurignacian |

In general, in a chronological correlation with European cultures, the paleolithic remains from north Manchuria to eastern Siberia show features ranging from Mousterian to Magdalenian, and they belong to an age with the Würm glacier stage as the center.

It is inferred that the Ku-hsiang-tun formation is rather extensively distributed in the drainage basin of the Sung-hua-chiang, and the following fossil localities are known:

1. Tao-lai-chao, Chi-lin (Kirin) Province: Mammoth.
2. San-ko-shu, northeast of Harbin: Mammoth, *Bison*, *Bubalus*, *Equus*
3. "Tanolin" tunnel,[5] Chi-tao-kou, Pin-chiang (Pinkiang) Province: Mammoth.
4. Mu-leng coal mine, Pin-chiang Province: Artificially worked deer antler (*Cervus elaphus?*) from the surface soil in the upper bed of the mine.
5. In the vicinity of Hei-ho (Ai-hun): Skull of *Bison* from the sands along the river.

[5] Ed. Note: Precise location unknown.

6. Niu-la-cheng-tzu, Pin-chiang Province, adjoining village west of Ku-hsiang-tun: Mammoth.
7. River floor of Sung-hua Chiang at a suburb of Harbin: Mammoth.
8. In the vicinity of Fularki Station (Fu-la-erh-chi) along the Nen-chiang, Hei-lung-chiang Province: *Rhinoceros antiquitatis.*
9. Tsitsihar (Chi-chi-ha-erh), Hei-lung-chiang Province: Molar of mammoth unearthed when the Tsitsihar castle was constructed about 300 years ago and formerly possessed by the Li family (Now in the National Science Museum in Tokyo).
10. Foot of the Ta-hsing-an-ling range, Hsing-an Province: *Poephagus grumiens* (Przew.)
11. Hai-lun.
12. Ko-shan and Pai-chuan: Splendid tusks, skull, mandible, and other bones of mammoth.
13. Along the La-lin-ho, south of Harbin: Mammoth.
14. In the vicinity of Ningguda (Ning-an) along the A-shi-ho.
15. In the vicinity of Man-kou (Tien-tsao-kang): *Gazella.*
16. East of Fu-yu and Ta-lai: Mammoth.
17. Iyasaka village and Ta-ku-tung in the vicinity of Chu-lien: Mammoth.
18. Hao-li-kang (Hao-li) coal field.
19. Shang-i-hsiang and Ssu-tung in the vicinity of Yen-chi, Chien-tao Province: Mammoth.
    Ssu-tung is located on the Tu-men Chiang and opposite Sangsambong in Korea. In both localities, loess-like clay which is equivalent to the Ku-hsiang-tun formation is developed. At the digging in 1936, Tamezō Mori and Fu-cheng Chao collected the following fossils from the yellow clay bed which underlies the yellowish clay bed at Ta-ma-lu-kou, Shang-i-hsiang. However, most of them are fragments.

    *Cervus elaphus* L.
    *C.* sp.
    *Equus* sp.
    *Atelodus* sp.
    *Mammuthus primigenius* (Blum.)

### 7. Djalainor (Darinor) Formation

The Djalainor coal mine in Hsing-an Province is north of Lake Djalai (Dalai Nor or Hu-lun Chin), and is situated at a corner of the Mongolian facies.

According to Tolmatchev's report in 1927, a columnar section of a trench in the Djalainor coal mine shows the following, in descending order:

| | |
|---|---|
| 1. Surface soil bed of humus | 3.5 m |
| 2. Dried sand bed | 2 ,, |
| 3. Compact mud bed | 1 ,, |

4. Sand bed ........................................ 2 „
5. Perpetually frozen mud bed ...................... 1 „
6. „ „ small-grained gravel bed ........ 1 „
7. Clay-like shale bed ............................ 3 „

Unconformity

8. Coal seam ...................................... 6.5 „
9. Gray clayey earth bed

The 1st to 7th beds belong to the Quaternary period, and a skull of *Rhinoceros antiquitatis*, a tusk of mammoth, a skull of *Bison* and others were collected from the 5th through 7th beds. Artificially worked deer antlers were found in the upper part of the frozen bed. Some of the deer antlers are shaped like a square hammer-head with a rectangular hole. A similar implement was collected at Chih-feng, and sculptured vertebral bone of *Rhinoceros antiquitatis* was collected in a sand dune near Hailar (Hai-la-erh).

In 1933, Djalainor skull No. I was found in the gray sand bed with gravel which is situated between the surface soil and the coal seam. Then in 1943 Yoshirō YUDA found skull No. II. These skulls were studied by Riuji ENDO (1944). In September, 1944, Endō and Wen Chung PEI surveyed the field and collected the so-called skull No. III, namely, the left half of a mandible, right ulna, left ulna, and a fragment of a rib together with several mammalian fossils and about 10,000 microlithic implements. According to ENDŌ, a section of the Nan-mei-kou open mine shows the following, in descending order:

1. Surface soil (5 to 10 cm)
2. Peat bed (10 to 30 cm)
3. Yellowish-brown gravel bed (15 to 30 cm) with fresh water bivalve shells
4. Grayish sand bed (one to 2 m)
5. Gray to yellowish-gray sand bed with gravel (2 to 4 m)
6. Gravel bed (one m)
7. Coal seam

It is said that skull No. I was found in the 5th bed, which may correspond to TOLMATCHEV's 6th bed. Skull No. II was collected at the 3rd colliery; the section in this vicinity is similar to that of Nan-mei-kou, and it is said that skull No. II was unearthed from the fine sands with gravel, about 10 m below the surface. Among the mammalian fossils collected by ENDŌ and others were *Rhinoceros antiquitatis* Blum, mammoth, *Equus przewalskyi* Polliakoff.

Skull No. I probably belonged to a middle-aged female, while skull No. II belonged to a middle-aged male. The breadth of orbit is rather large and the breadth of foramen magnum is relatively narrow. The basion-bregma height, maximum length, and maximum breadth are 147 mm, 177 mm and 137 mm respectively. The head had suffered some deformation, that is, it shows that the forehead had been strongly pressed by some plate or hide during life.

Many microlithic implements are abundantly scattered on the terraces on the west side of the River Moutonaya, which runs between Lake Dalay and Dalay Nor mine. These implements are arrowheads, spearheads, knives, flakes, scrapers, and cores which were made of agate, obsidian, or vein quartz. According to PEI's opinion, these implements belong to the Lin-hsi type culture and indicate the mesolithic age. Around the Nan-mei-kou open mine, some microlithic stone implements of the Lin-hsi type were found, and, in addition, one bifacial implement of definite paleolithic appearance was formerly collected.

According to Hoichi YOSHIZAWA and Jun'ichi IWAI (1937), the formation underlying the alluvial deposits of the River Hailar [Hai-la-erh Ho] and the sandy clay bed in the lowland north of Lake Djalai belong to the Hailar formation and can be correlated with the Djalainor formation. Mammoth and *Bison* were found during the construction of bridge piers in the River Hailar north of Hailar.

The Hulunbuyer formation in the Hulunbuyer plain[6] is composed of aeolian sands, consisting of fine grains of quartz and feldspar. Though the plain shows a rolling topography on a large scale, it may have been sand dunes at the time of its deposition. It alternates with the Hailar formation of lacustrine facies. A river terrace formation crops out at 5 to 19 m above the present alluvial plain and consists of gravels. The boring cores obtained in the Hulunbuyer plain indicate the following successions:

East of Hailar

1.1 m ................ Surface soil
32.0 ,, ................ Yellowish-brown to yellowish-gray fine sands
34.0 ,, ................ Arenaceous clay
40.5 ,, ................ Gravel-bearing blue clay
46.8 ,, ................ Gravel

North of Hailar (Ta-liang-shang)

1.0 ,, ................ Brown sand
5.0 ,, ................ Light brown clay
9.0 ,, ................ Grayish-white fine sand
13.0 ,, ................ Light brown clay, mixed with sand
15.0 ,, ................ Light brown fine sand
19.0 ,, ................ Brown fine gravel
20.0 ,, ................ Coarse sand
22.0 ,, ................ Light brown fine sand
31.0 ,, ................ Coarse sand
32.0 ,, ................ Gravel
37.0 ,, ................ Light brown sand
38.2 ,, ................ Light brown coarse sand

5 km north of "Oronur", northeast of Kanchur
(Kan-chu-erh-miao)

0.9 m ................ Surface soil

[6] Ed. Note: The Hulunbuyer plain is the area between the two lakes Hu-lun Chin (or Dalay Nuur) and Pei-erh Hu (or Buyr Nuur).

| | |
|---|---|
| 4.9 ,, .................. | Grayish-white clay |
| 12.5 ,, .................. | Blue clay mixed with sand |
| 17.0 ,, .................. | Black clay |
| 18.3 ,, .................. | Fine gravel |
| ? .................. | Brown clay |

In the San-ho[7] district the surface soil, about 1 m thick, is underlain by a gravel bed about 2 m thick, with alternation of clay and sand, or alternation of gravel and clay, from which mammoth and other fossils were unearthed.

According to Fusao UEDA and Masao SASAKURA (1937), an aeolian sand bed is extensively developed in the area north of Wu-tan-cheng, Hsing-an-hsi (west Hsing-an) Province, and shows the Mongolian facies. A tableland 20–40 m above the adjoining alluvial plain is distributed along the south bank of the River Shara-muren (Hsi-la-mu-lun Ho). Remarkable aeolian sand, 60 or 70 m thick, is extensively distributed near Lin-hsi, in the area between Ta-pan-shang and Lin-tung and in the Chakhar (Chahar) district, just north of Lin-hsi, as well as in the area between Hsi-ching-peng and Tarinor (Ta-erh Hu). The aeolian sand is developed in the meridional direction along the margin of Ta-hsing-an-ling mountain range from the east of Tarinor. A white clay bed, several meters thick, is developed in the lower part of the basin 100 m southeast of Ta-wang-miao on the southeastern shore of Tarinor ("nor" means lake in the Mongolian language), and from this bed the following fossils have been found:[8] *Lymnaea* (*Radix*) *teilhardi* (PING), *Gyraulus chiliensis* (PING), and *Pisidium* sp.

The above fossiliferous bed is also developed in the sand-dune zone, 20 km south of Tarinor, and its succession is as follows, in descending order:

| | | |
|---|---|---|
| 1. Surface soil and sand .............. | 60 cm | |
| 2. Brown sand ........................ | 30 ,, | |
| 3. Black sand ...................... | 15 ,, | |
| 4. White clay ........................ | 20 ,, | (fossiliferous bed) |
| 5. Sand ............................ | | |

The result of boring at Dalainor city is as follows:

| | Thickness |
|---|---|
| 1. Surface soil and sand<br>2. Blackish-brown surface soil ........................ | 5 m |
| 3. Light brown fine sand<br>4. Small gravel ............................ | 5 ,, |
| 5. Gravel<br>6. Blue clay .................................. | 5 ,, |

[7] Ed. Note: The San-ho district is an area about 120 km north of Hai-la-erh, where several rivers flow into the Argun River.

[8] In 1931, Isao Matsuzawa, Namio Egami, and others collected fresh water shells from the brown sand bed (overlain by the Ma-lan loess) on the south bank of the River Balga in the vicinity of Ulan-hosho and on the east bank of the River Nuhus in the neighborhood of Zakustai-Sume. According to Koichi Suzuki, the following fossils are among them:

*Lymnaea* (*Galba*) *pervia* von MARTENS, *L.* (*Radix*) *auricularia obriquatus* von MARTENS, *Anisius* (*Gyraulus*) *gredleri* ("BIELZ" GREDLER), and *A.* (*Segmentin*) *nitidellus* von MARTENS.

7. Reddish-brown arenaceous clay mixed with gravel ........ 5 „
8. Light bluish clay ........ 5 „
9. Reddish-brown fine sand ........ 5 „
10. Light blue clay ........ 5 „
11. Brown fine sand ........ 5 „
12. Dark brown clay mixed with earth and sand ........ 5 „
13. Hard-textured clay ........ 5 „

## 8. Terrace Gravel Beds and Basalt Plateaus

Terrace gravel beds are distributed everywhere in the mountainous regions of Ta-hsing-an-ling, Hsiao-hsing-an-ling, and Chang-pai-shan, and basaltic plateaus are also extensively developed. These piedmont facies pass gradually into the Manchurian facies.

Dilluvial terraces, 50 m above the adjacent plain, are distributed along the Amur River on the northern slope of the Hsiao-hsing-an-ling from the River Fupiehlahe (Fa-pieh-la-ho), upstream from Hei-ho to the Wu-yun district. A succession of gravel and clay is distributed along the Pei-Hei Line (Horiuchi *et al.*, 1937).[9] A gravel bed is developed on the northern slope of Hsiao-hsing-an-ling and a thick clayey bed crops out on the southern slope and is divided into the lower gravel bed (10 to 20 m) and the upper clay bed. Cobbles as large as a human head are mixed in in the area west of Aigun (Ai-hun). Gravels of the gravel bed along the rivers Chan-ho and Ko-erh-fen-ho in the west of the Nan-pei-ho (Chan-ho- is east of Nan-pei-ho) consist of chert, radiolarian chert, quartzite, graywacke and clayslate. It is said that the upper clay bed is developed under the alluvial deposits along the Hu-yu-erh-ho (Wu-yu-erh-ho), Na-mu-erh-ho (Nan-yeng ho) and their tributaries, and it is estimated to be 60 or 70 meters thick. It contains bentonite at Lung-an (Lung-men) and Pei-an, while it also includes lignite at Tai-an.

In the districts of Pai-chuan, Hai-lun, and Sui-hua the lower part consists of a sandy bed with much cross-laminae, while the upper part is composed of a clay bed with bentonite. The thickness is estimated to be 60 or 70 m, as seen along the Pin-Pei Line.[10] That is, the formation in this district is distinctly a prolongation of the Ku-hsiang-tun formation.

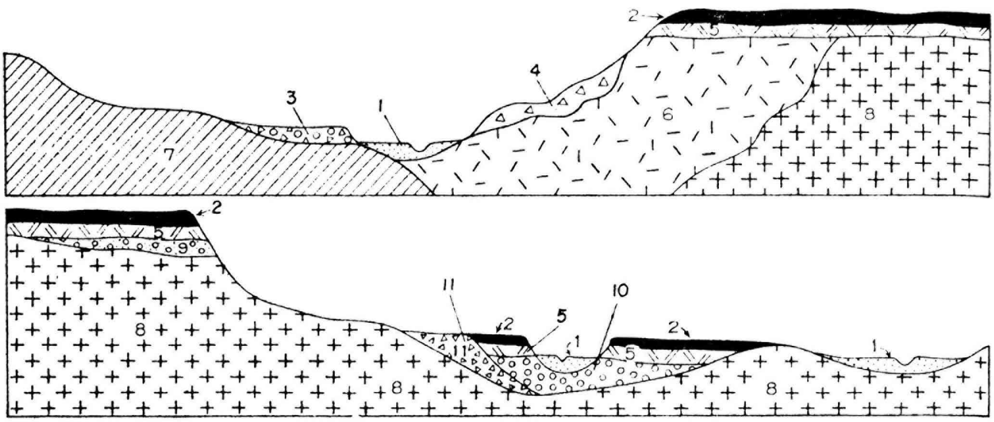
Terrace gravel beds are also distributed along the Nen-chiang.

Basaltic plateaus, 20 to 40 m above the adjacent plain, are distributed along the Kan-ho and No-min-ho on the eastern slope of the Ta-hsing-an-ling. These plateaus and diluvial plateaus are rather difficult to distinguish topographically.

Thick alluvial deposits of fluvial origin are developed along the Hoi-lung-chiang (Amur River) and Nen-chiang and consist of arenaceous clay, sand, and

[9] Ed. Note: Pei-an to Hei-ho (Ai-hun) railway.
[10] Ed. Note: Ha-erh-pin to Pei-an railway.

gravel. A gravel bed several meters thick has been found 5 m below the earth surface in Hei-ho (Ai-gun) city.



1. Alluvium
2. Soil above basalt
3. Terrace deposits or fanglomerate
4. Talus deposits
5. Basalt
6. Andesite
7. Mesozoic
8. Granite
9. Sand and gravel below mesa basalt (Tertiary)
10. Sand and gravel below lower-level basalt
11. Decomposed zone of granite

**Fig. 6.** Pleistocene in Pin-Chiang, San-Chiang and Chi-Lin Provinces (TAKEYAMA and ASANO, 1937).

In a vast triangular area, which is surrounded by the Ussuri River (Wu-su-li-chiang) and the Sung-hua-chiang with Khabarovsk as its apex—namely, the downstream plain composed of thick alluvial deposits—the ground is subsiding. The northeastern prolongation of the Ku-hsiang-tun formation can be found here and there, mostly forming terraces. One example is the area between Harbin and Fu-chin. A gravel bed, 20 m thick, is found in the vicinity of I-lan (ASANO, 1937). A succession of light yellowish-brown arenaceous clay and clay is developed at Fu-chin. Mammoth was unearthed at Ta-ku-tung near Fu-chin. A gravel bed is also found in the Hao-kang coal mine near Hao-li. A gravel bed is most typically developed in the vicinity of Ta-ping-chen along the Wo-ken-ho. A gravel bed is also distributed in the vicinity of Mi-shan south of Tung-an and in the neighborhood of Po-li. In the vicinity of Ping-yang (Ping-yang-chen) a gravel bed is developed under the basaltic lava flow in association with basaltic plateaus. Terraces composed of gravel beds more than 10 m in thickness are distributed in the districts of Mu-tan-chiang, Tung-ning and Tung-king-cheng (Tung-ching-cheng). There are two kinds of gravel beds. One is the gravel bed underlying the plateau basalt and the other is that underlying the new basalt flows which occupy the present river valleys. It is considered that the latter belongs to the Diluvium series. According to Shigemitsu OKADA and Shoichi NISHIDA (1940), the Diluvium series in the vicinity of Tu-men-tzu, Chien-tao Province, is a terrace deposit and consists of gravel and clay. It is distinguished from the Tertiary gravel bed by its basalt pebbles. Most of the pebbles are composed of basalt, and contain secondary placer gold which was washed out from the gold-bearing Tertiary system.

Basaltic plateaus in Mu-tan-chiang and Tung-hua Provinces cover a vast area. In the district from Chi-lin (Kirin) Province to Tung-hua Province in the upper stream of the second Sung-hua-chiang,[11] diatom earth is distributed along the inclined slope of each riverhead of each small river which dissected the low tableland consisting of basalt. According to Shōichi NISHIDA (1941), the diatom earth was formed in the marshes on the basaltic plateaus, and is intercalated between a gravel bed and clay bed; it is estimated to be 1 to 2.5 m thick. The following species of diatoms are found:

*Melosira ambigus* (GRUN) O. MULL.
*Diatoma anceps* (EHR.)
*Fragilaria virescens* RALFS.
*Navicula koreana* SKORTZOV
*N. mutica* KUTZ.
*Pinnularia distinguenda* CLEVE.
*P. brevicostata* CLEVE.
*Synedra vaucheriae* KUTZ. var. *truncata* (GREV.) GRUN.

The surface soil in north Manchuria is different from that of south Manchuria. It is pitch black to grayish-black and can be divided into black soil and alkali soil. The black soil covers the hills of the Diluvial series and forms the so-called black earth zone. It is a tschernosem. It is distributed in the area of the diluvial hills in the vicinity of No-ho, Tai-an, Ko-shan, Pei-an, and Lung-chen (Lung-men) north of Ning-nien as well as the eastern marginal hills in the Hai-lun. Pai-chuan district. The thickness is estimated to be 0.5 to 2 m. The surface soil in the area from the steppe lying in the Tsitsihar (Chui-chi-ha-erh) district to the drainage basin of the Hu-yu-erh-ho is composed of leached tschernosem and the thickness is estimated to be 0.3 to 2 m. The alkali soil consists of solonetz; it is distributed as far as central Manchuria and is particularly remarkable in the areas from the vicinity of Tai-lai and Chen-tung to the area west of Tao-nan, the district of Kai-tung, and the vicinity of Chang-yu and Tu-chuan. In the sand-dune district, alkali-soda is exuded on the earth's surface in the dry season.

## 9. Problems of the Glacial Age in Manchuria

Kazuo FUJITA (1947) mentioned the following noticeable fact in his survey report of the Ta-hsing-an-ling mountain range. A rock detritus bed which con-

[11] Ed. Note: The second Sung-hua-chiang refers to the river above the junction with the Nen-chiang, or the part south of Fu-yu.

sists of fist-sized breccias is found at 200 to 300 m above the adjacent plain (1,000 m average elevation above sea level), and these breccias are frozen by pure ice. He maintained that this detritus was produced under a very cold climate in which the daily and yearly ranges of temperature were very large and vegetation could not grow. The present flora might have migrated in the successive temperate period.

Permanently frozen beds, which predominate in Siberia, might be formed under climatic conditions similar to the present Siberian climate, where the winter is long with very severe cold and scanty rainfall and the temperature in summer is relatively low. However, it is inferred that there was an age of severe cold in the past when the lower limit of the frozen bed was lowered as much as several hundred meters.

FUJITA opposed PLAETSCHKE's view that the permanently frozen bed and the glacial topography of the northern Ta-hsing-an-ling are associated. FUJITA maintained that the permanently frozen bed was formed in an arid high-latitude zone, while the mountain glaciers in east Siberia, which may be related to the glaciated stages of Pai-tou-shan and Kan-po-ho (KANO, 1937), were formed in a period when the air temperatures were rising, which may not have always coincided with the most flourishing stage of the permanently frozen bed. FUJITA's opinion is similar to SIMPSON's view. Though there may be some differences between the glacial ages of north Europe and of north Manchuria, the extent of the difference has not yet been determined. If the detritus bed, i.e., the permanently frozen bed, is prolonged toward the west, it may be correlatable with the frozen bed in Transbaikalia or in the Djalainor district. If the Djalainor formation, the mammoth-bearing frozen bed at Peryozovka, and the fossil bed at Afontova (Magdalenian) correspond with the severe cold stage of these frozen beds, then the Würm glacier stage in north Europe may correspond with the stage of permanently frozen bed in north Manchuria. If this is true, glaciers may not have developed in north Manchuria. This problem may be settled to some extent by the correlation of the Wisconsin glacial stage throughout Kamchatka, Alaska, and Canada.

*Cirques* on Pai-tou-shan (each *cirque* on Taishō peak, Matengu and Sōgan), U-shaped valleys above the timber line (2,000 m), a *cirque* on Mt. Minami Potai, and the *cirque* group on Kanbo peak are found in very scanty snow-fall districts of the present time. According to Gorō ASANO (1947), the Pai-tou glacier stage is considered to have come after the pumice eruption of Pai-tou-shan and before the mud lava eruption. The scantiness of *Pinus pumila* on Pai-tou-shan may be due to the eruption of the mud lava. The formation of the caldera, the formation of *cirques*, the migration of *P. pumila*, the eruption of mud lava, and the recession of *P. pumila* may have occurred in this order. It is regrettable that the relation between the Pai-tou glacial stage and the Ku-hsiang-tun formation has not yet been determined. This problem cannot be solved by studying only the relation between the plateau basalt and the Sangsambong clay bed, which is equivalent to the Ku-hsiang-tun formation and distributed in Sangsambong, Tonggwandong, Yen-chi, Lung-ching-chieh, and vicinity. We acutely feel the lack of data for Siberia.

## 10. Conclusion

1. The Quaternary system in Manchuria is roughly divided into three divisions, namely, the north Chinese facies (loess facies), the Mongolian facies (aeolian facies), and the Manchurian facies (flood-plain lacustrine facies). The first facies is distributed in the districts of Liao-hsi and Liao-tung with Jehol as its center. The second facies is mainly developed in the area west of the western slope of Ta-hsing-an-ling range, while the third facies is distributed mainly along the Sung-hua-chiang with the Manchurian plain as its distributive center. The trend of the boundary line between the north Chinese facies and the Manchurian facies is approximately NNE—SSW; it is a line connecting Cheng-chia-tun and Kai-yuan and corresponds to the Hei-liao divide. A piedmont facies is developed in the mountain district, and basaltic plateaus are also extensively distributed.

2. Types of the north Chinese facies, Mongolian facies, and Manchurian facies are the Liao-ho plain group, Djalainor formation, and Ku-hsiang-tun formation respectively.

3. Chronology of the Quaternary system in Manchuria approximately corresponds with that of north China and is divided into three sedimentation stages: the Chou-kou-tien stage in the lower Pleistocene, the Ma-lan stage in the upper Pleistocene, and the black earth stage in the Holocene, in ascending order. The Malan series is better developed than in north China, while the Chou-kou-tien series is not so remarkable. The Liao-tung stage, which is equivalent to the Ching-shui stage in north China, is found between the above-mentioned two stages (Chou-kou-tien and Ma-lan) and was a remarkable erosion stage. The so-called Liao-tung peneplain was formed in this stage. The flows of plateau basalt may have occurred then. Moreover, the Liao-ho erosion stage intervened between the Jehol loess, which corresponds with the Ma-lan loess, and the redeposited loess (equivalent to the Ku-hsiang-tun formation). The present erosion stage is the Sung-hua-chiang stage which can be correlated with the Pan-chiao stage in north China. The erosion stage between the Ma-lan stage and black earth stage (the Wen-chuan-ho) is the Wa-pen-yao stage or the Lao-ha stage.

4. Fissure deposits of the Chou-kou-tien type are found in the Hsiao-sheng-shui-ssu group or the Niu-hsin-shan group, and the lower part of the Niu-hsin-shan group is correlatable with the *Sinanthropus* group at Chou-kou-tien.

5. The complete formation of the Hei-liao divide was in the Lao-ho stage. Its slow upheaval movement may correspond with the terrace movement of $Du_1$ plane on the Japanese Islands, and it seems that a tectonic movement which divided the Manchurian facies and north Chinese facies was in progress from the Ching-shui stage. The Hei-liao divide is related to the tilting movement of the Korean Peninsula.

6. The fossil facies of the Ku-hsiang-tun formation is rich and contains plants, Mollusca, Insecta, Pisces, Reptilia, Aves, Mammalia, and others. The percentage of extinct Mammalia is less than the 75% of the *Sinathropus* group in Chou-kou-tien, but it surpasses the 43% of the Sjara-Osso-Gol in Ordos; it indicates an age of approximately middle to later Pleistocene. Rhinoceros, bison, wild horse, and deer are most abundant, and the appearances of *Struthio, Castor, Gazella, Bubalus,* and *Camelus* are noticeable. *Rangifer* has not been found.

7. The stone implement culture of the Ku-hsiang-tun formation shows the facies from the Mousterian to the Magdalenian, and was developed with the Würm glacier stage as the center. However, some geologists consider it to be a mesolithic culture.

8. Three human skulls (the Djalainor man) were found from the Djalainor formation. Stone implements which were unearthed with the skulls are small and are regarded to belong to the mesolithic culture.

9. It is considered that there is some relation between the detritus bed—permanently frozen bed on the Ta-hsing-an-ling range and the Würm glacier stage in Europe or the Wisconsin glacier stage in North America. The problem of the relation between the permanently frozen bed and the Djalainor formation or the Ku-hsiang-tun formation should be given attention in the future.

## REFERENCES


AOJI, Otoji (1925). Geologic map of Manchuria and its explanatory text. Ta-ku-shan sheet. *Geol. Inst., S. Man. Ry. Co.,* [Darien, Manchuria] (J).

ASANO, Goro (1947). Several facts found out by the Pai-tou-shan expedition in 1942–1943. *Minerol. and Geology* [Kyoto], v. 1, no. 1 (J).

——, and Toshio TAKEYAMA (1937). Geology and geography in the eastern part of Manchuria. *Geol. Inst., S. Man. Ry. Co.,* [Darien, Manchuria] (J).

BARBOUR, G. B. (1935). Physiology of Jehol. *Bull. Geol. Soc. Amer.,* v. 46 (E).

ENDO, Riuji (1942). Report of research work at a fossil locality at Ku-hsing-t'un near Harbin, Ping-ching Province. *Manchurian Assoc. for Preservation of Historic Sites and Natural Monuments,* [Hsin-ching, Manchuria] (J).

—— (1944). Report of research on the Djalainor human skeleton. *Current Rev.* [Cent. Nat. Museum Manchoukuo, Hsin-ching, Manchuria], no. 23 (J).

—— (1945). On the Djalainor skulls. *Japan Acad. Proc.,* v. 21, no. 9 (E).

—— (1949). On the Djalainor human skeleton. *Kagaku* [Tokyo], v. 19, no. 9 (J).

FUJITA, Kazuo (1947). A consideration of the climatic changes in Eastern Asia. *Minerol. and Geology* [Kyoto], v. 1, no. 3 (J).

HANAI, Juji (1928). The so-called low-level peneplain developed on Liao-tung Peninsula and several of its features. *Geogr. Rev. Japan,* v. 4, no. 10 (J).

HARAGUCHI, Kuma (1939). Report of the geological survey at the first proposed dam site for the Liao-Ho reservoir. *Rept. Geol. Inst. Manchuria,* [Hsin-ching, Manchuria] no. 96 (J).

HORIUCHI, Kazuo, Hikoji MORITA and Shiro YAMAGUCHI (1937). Geology and geography in the northern part of Manchuria. *Geol. Inst., S. Man. Ry. Co.* [Darien, Manchuria], (J).

IMAMURA, Zenkyo, and Teijiro TSUCHIDA (1935). Geomorphological considerations of the northern part of Kwan-tung Province. *Rept. Man. Educ. Inst., S. Man. Ry. Co.* [Feng-tien, Manchuria] (J).

KANO, Tadao (1937). On the glaciated topography in the northeastern mountainland in Korea. *Geogr. Rev. Japan*, v. 13, no. 12 (J).

KOBAYASHI, Teiichi (1931). A consideration of the relation between the history of the topographical development of the Korean Peninsula and the Cenozoic geological history. *Geogr. Rev. Japan.*, v. 7, nos. 7–9 (J).

KUSAMITSU, Shigeru (1942). On the topography in the vicinity of Pei-piao and the later deposits there. *Bull. Geol. Soc. Manchuria* [Hsin-ching], no. 3 (J).

LICENT, E., and P. TEILHARD DE CHARDIN (1930). Geological observations in northern Manchuria. *Bull. Geol. China* [Peking], v. 9 (E).

LOUKASHKIN, A. S. (1937). Some observations on the remains of Pleistocene fauna of the Paleolithic age in northern Manchuria. *Early Man*, (E).

NIINOMY, Kunitaro (1930). The physiographic system in Manchuria. In *Manchuria, compendium of geography of Japan* [Tokyo], (J).

NISHIDA, Shoichi (1939). Report of research work at Hsing-ching hot spring in Chinchou Province. *Rept. Geol. Inst. Manchuria* [Hsin-ching, Manchuria], no. 95 (J).

—— (1941). Mode of occurrence of diatom earth along the second Sung-hua Chiang. *Rept. Geol. Inst. Manchuria* [Hsin-ching, Manchuria], no. 102 (J).

NODA, Mitsuo (1930). Outline of geology in the vicinity of Chang-tu. *Mammo* [Darien, Manchuria], (J).

OKADA, Shigemitsu, and Shoichi NISHIDA (1940). A gold-bearing tertiary formation distributed in the vicinity of Tu-men-tzu, Chien-tao Province. *Rept. Geol. Inst. Manchuria* [Hsin-ching, Manchuria], no. 98 (J).

PONOSOFF, V. V. (1937). Stone implements from Ku-hsing-t'un. *Bull. Inst. Sci. Res. Manchoukuo* [Hsin-ching, Manchuria], v. 1, no. 3 (E).

SAITO, Rinji (1939). Report of research work at Tang-kang-tzu hot spring. *Rept. Geol. Inst. Manchuria* [Hsin-ching, Manchuria], no. 95 (J).

—— (1940). General observations on geology in Manchuria. *Rept. Geol. Inst. Manchuria* [Hsin-ching, Manchuria], no. 100 (J).

SHIKAMA, Tokio (1941). Vertebrate fossils from the Chinese continent (I). *Tohoku Imp. Univ. Inst. Geol. Paleontol. Contr.*, [Sendai, Japan], no. 36 (J).

—— (1943). The Pleistocene problem in Japan and vicinity, some tentative considerations in paleomammalogy. *Bull. Cent. Nat. Mus. Manchoukuo* [Hsin-ching, Manchuria], no. 6 (J+E).

—— (1950A). A Late Cenozoic formation in Manchuria. *Minerol. and Geology* [Kyoto], v. 3, no. 5 (J).

—— (1950B). Notes on the chronology of the Japanese Quarternary. *Jour. Geol. Soc. Japan*, v. 56, no. 659 (J).

SUZUKI, Koichi (1935). Some fossil Mollusca from Ku-hsing-t'un, near Harbin, Manchoukuo. *Jour. Geol. Soc. Japan*, v. 42, no. 499 (E).

TADA, Fumio (1937). Geography of Jehol. *Rept. First Sci. Exped. to Manchoukuo* [Tokyo], sec. 3 (J+E).

TAKAI, Fuyuji (1941). Fossil elephants from the Hao-kang and Peh-piao coal fields, Manchoukuo. *Bull. Geol. Inst. Manchuria* [Hsin-ching, Manchuria], no. 101 (E).

TEILHARD DE CHARDIN, P. (1941). Early man in China. *Rept. Inst. Geo-biologie* [Peking], no. 7 (E).

TOKUNAGA, Shigeyasu, and Tamezo MORI (1933). Report of excavation at Do-kan-tin, the bank of the Tumen River, Korea. *Rept. First Sci. Exped. to Manchoukuo* [Tokyo], sec. 2, pt. 4 (J+E).

TOKUNAGA, Shigeyasu, and Nobuo NAORA (1934). Report on the first excavation at Ho-chia-kou, Ku-hsiang-t'un, Kirin, Manchoukuo. *Rept. First Sci. Exped. to Manchoukuo* [Tokyo], sec. 2, pt. 1 (J+E).

—— (1936). Paleolithic artifacts excavated at Ho-chia-kou in Kuhsing-t'un, Manchoukuo. *Rept. First Sci. Exped. to Manchoukuo* [Tokyo], sec. 6 (J+E).

—— (1939). Fossil remains excavated at Ku-hsiang-t'un near Harbin, Manchoukuo. *Rept. First Sci. Exped. to Manchoukuo* [Tokyo], sec. 2, pt. 4 (J+E).

TOLMATCHEV, V. J. (1929). Sur le Paleolithique de la Manchurie. *Eurasis Septentrionalis Antiqua*, 4 (F).

UEDA, Fusao, and Masao SASAKURA (1937). Geology and geography in the southwestern part of Manchuria. *Geol. Inst., S. Man, Ry. Co.* [Dairen, Manchuria] (J).

YAMAMOTO, Soki (1948). Latest geological history of Manchuria. *Kagaku* [Tokyo], v. 18, no. 1 (J).

YOSHIZAWA, Hajime, and Jun'ichi IWAI (1937). Geology and geography in the north-western part of Manchuria. *Geol. Inst., S. Man. Ry. Co.* [Darien, Manchuria] (J).