The Huangtu Formation and the Loess of North China

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1. Introduction

F. VON RICHTHOFEN introduced the Huangtu of North China as a loess in 1877. Its wide area of distribution, its thickness and the question of its origin attracted the attention of geologists all over the world. After RICHTHOFEN, the WILLIS and BLACKWELDER (1907) paper was an epoch-making one. The origin of the Huangtu is not yet known, even though many studies have been made. The geological study of the Huangtu formation is connected with primeval man in the Far East and also with the relation of the Far East continent and Japanese islands. It is also an important and interesting geological problem of the Cenozoic Era in North China. This paper includes the results of my observations of the Huangtu formation in South Cha-har, Ho-pei, Shan-hsi, and Shan-tung.[1] It is my contribution to the study of the origin of the Huangtu and I hope it will attract new attention to that formation.

I gratefully acknowledge the help of Prof. T. TOMITA, who kindly directed me and gave me many important suggestions. Next, I express my hearty thanks to Messrs. T. TAKEYAMA, N. KURATA, S. SHOJI, T. YAMAZAKI, and T. KAMIYAMA, who helped my field survey; to Mr. S. NAITO and T. KAWANO, who took charge of the topographic survey; and to K. KUWAHARA and C. C. WANG, who took charge of the mechanical analysis. I would also like to acknowledge the kind encouragement of the late Dr. T. KATO, Dr. S. YAMANE, and Dr. H. FUMIMOTO.

2. The Loess, the Huangtu, and the Huangtu Formation

The Loess

According to F. VON RICHTHOFEN, loess has the following properties:

(1) It is a yellowish-brown soft soil, and is easily crushed by crumbling with the fingers.

[1] The area surveyed by the author is very small compared with the estimated distribution area of the Huangtu, 1,324,000 square km (T. WAKIMIZU, Loess of China: Sekai Chiri, vol. 3, China 1, North China, pp. 83–100). However, the area studied is well exposed and contains much data for the study of the origin of the Huangtu.

(2) It gets into the skin folds of one's finger, and it is a fine soil having no rough feel.

(3) It is rich in calcium carbonate.

(4) It is sometimes coarse.

(5) Slender tubes are developed vertically.

(6) Voids are frequently present.

(7) It has the property of breaking and forming vertical walls in cliffs.

(8) Particles are fresh and angular.

Generally, loess is a silt-rich soil, a brownish-yellow color, porous, coarse, and contains calcium carbonate.

The Huangtu

The Huangtu (a general term which can refer to certain component parts of the Huangtu formation) has many properties of the above-mentioned loess, and in addition has the following properties:

(1) In some places it is almost completely composed of sand, and may contain pebbles.

(2) The results of mechanical analysis differ by region, by deposits in the same region, and by direction (vertical and horizontal) in the same deposit.[2)]

More than seventy years have elapsed since the Huangtu was introduced as a loess, but the two do not always have the same properties. The author proposes that the term loess and Huangtu should be used as they are. A distinction between the two will be made in this paper.

The Huangtu formation

B. WILLIS named the deposits consisting of loess, sand and gravel the Huangtu formation. TOMITA and I used the same term for deposits of loess, sand and gravel.[3)]

3. The Huangtu Formation of North China

Distribution and thickness

The Huangtu formation extends over the Yin-shan mountain range and the Jehol mountains in the north, and the Tsin-ling and Fu-niu mountain range in the south. The location of deposition is from several meters to 1,000 m above sea

[2)] Even if an outcrop looks like a thick Huangtu formation of identical properties, the granularity of specimens differ. Accordingly, the fineness of one specimen does not represent that of the outcrop.

One important fact made clear about the vertical distribution of fineness is the discontinuous plane, supposedly in the primary deposit of the Fan-shan-pu region. It is clear that the granularity differs horizontally in the primary deposit in the Cheng-ho village region.

[3)] According to the geological map of the Chang-hsia district, Province of Shan-tung (WILLIS and BLACKWELDER, 1907), the Huangtu formation (chiefly loess with notable amounts of sand and gravel) is a terrace deposit. As seen in Fig. 6, the Huangtu formation is clearly a terrace deposit cropping out on the right bank of Sha-ho, 2.5 km NNW of Chang-hsia station (TOMITA and SAKAI, 1941).

level, and is rarely as high as 1,500 m. The topographical distribution of the Huangtu formation is (1) the present and old valleys, which are the widest, (2) the periphery of valleys, (3) broad plains, and (4) higher mountain areas.

The distribution of the Huangtu formation shows a characteristic common to both the Tertiary formation and the Diluvial deposits. TOMITA and MASUBUCHI (1943) discovered that its thickness is greatest in the following two regions: from east of Lan-chow to the southeast, and from Ching-yuan to the Shen-pei basin. The thickness varies from 40 to 50 m and is sometimes more than that in the first region. The third region is the Pu-te, Wu-pu and Kung districts on the banks of the Huang-ho (more than 40 m).

The literature of the past tell us that the thickness varies from 100 to 500 m, but it includes the lower Diluvial deposits and the Tertiary deposits.[4] (see distribution map by CRESSEY). I have observed that the actual maximum thickness seems to be from 50 to 60 m. The thickness of the Huangtu varies from 16 m to 17 m, as at Cheng-ho village, Fan-shan-pu and Chang-hsia (see Table 1).

Classification of the Huangtu formation

TOMITA and I divided the deposition layers in ascending order of first, second, and third deposits, etc. for every surveyed area.[5] The division of the Huangtu formation in North China is given in Table 1.[6]

State of deposition[7]

The NW district of Ping-men, Kalgan

Deposit (I) covers the 15 m gravel bed unconformably. The loam of (I–1) has many vertical platy joints, conchoidal fractures and pseudostratification; it contains Huangtu spherulites which are more than 12.5 m thick. The loam of (I-m) is remarkably false-bedded, has vertical joints on its surface exposures, and contains Huangtu concretion and Huangtu spherulites. Deposit (I-u) is a light-yellowish-brown or yellowish-brown Huangtu; it is lighter-colored than (I-1) and (I-m), and is noteworthy because of its vertical joints. Deposit (II) is composed of Huangtu sand and gravel and forms river terraces. Vertical joints are also developed. Deposit (III) forms talus deposits or fan deposits in some places, and is com-

[4] Pliocene red clay is included.

[5] Cliff exposure is convenient for the geological exploration of the Huangtu, and it is desirable to divide outcrops into deposition layers by character.

Terms such as "plateau loess" or "primary loess" were used in the past. The purpose of the geological study of the Huangtu formation is to find the origin of the Huangtu, in other words, to determine which is the primary Huangtu. Thus, it is not proper to use the term "primary loess" indiscriminately.

[6] In order to simplify the classification of the deposits, the terms valley-filling "Huangtu formation," the first deposits, the second deposits, the third deposits, and the aeolian Huangtu formation are denoted by Vh, (I), (II), (III), and Ah respectively. The lower, the middle and the upper members of (I) are denoted by 1, m, and u. Vh and Ah do not have a stratigraphic notation of upper or lower.

[7] See also Table 1 in connection with the paragraphs on state of deposition.

posed of gravel, sand, and Huangtu. The gravel is the weathered product of bed rocks (Chang-chia-kou series). Sometimes vertical joints are developed. The first and second, and second and third deposits are clearly related geologically by unconformities. Further, (I-l), (I-m) and (I-u) are not stratigraphic divisions.

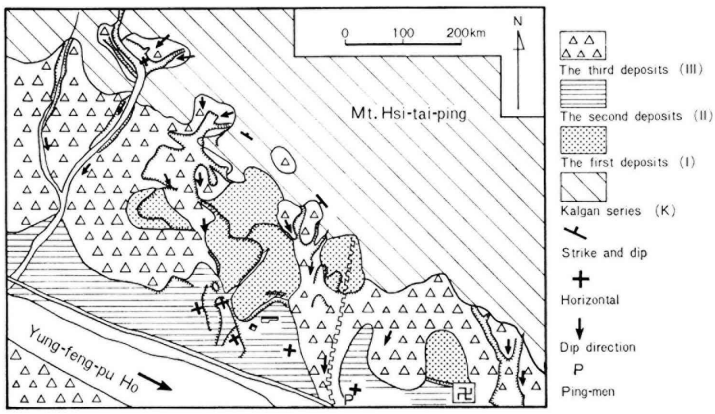


Fig. 1. Geological Map of the Ping-men District, Kalgan, South Cha-har.

The Cheng-ho village district

The valley-filling "Huangtu" formation occurs widely on both banks of the Ta-ho River, and two color bands are developed in the cliff outcrop 25 m above (I) southwest of Tung-pao-sha (Fig. 4). The lower bands (LB of Fig. 4) extend from the north outcrop (N) (Point "N" of Fig. 3) which is 7 m above the south outcrop (S) (Point "S" of Fig. 3) which is 13.5–14.5 m high. The upper band (UB of Fig. 4) bends upward to form a sudden arc at (N) which is about 8 m above (S) and dips southward. The lower part of LB is yellowish-brown or brown loam tinted with red, but in (S) the upper part is a light yellowish brown to yellowish-brown Huangtu. The color bands of the upper and lower parts are dark. Vertical platy joints are developed parallel to the vertical cliff outcrop in the loam at point S, while vertical columnar joints are noteworthy in the Huangtu. It is specially noteworthy that Huangtu spherulites are found not only in the loam and in the lower color band but also in the Huangtu. The second deposits form river terraces and cover (I) unconformably. The third deposit is a gravel bed and is not Huangtu.

The aeolian Huangtu formation (Ah) occurs only in ridges facing northwest (Table 13, No. 41224) or on slopes (Table 13, No. 41235), and its distribution is limited to a narrow area. At higher elevations the thickness and the breadth gradually decrease to the end of the aeolian formation.[8]

[8] The dip angle of the surface of Ah was 20 degrees at the northwestern ridge of Ta-tung-shan and at its northwestern foot. The angle which I measured was 12 degrees at Tai-ping-pu. I called this angle the critical angle of deposition of Ah.

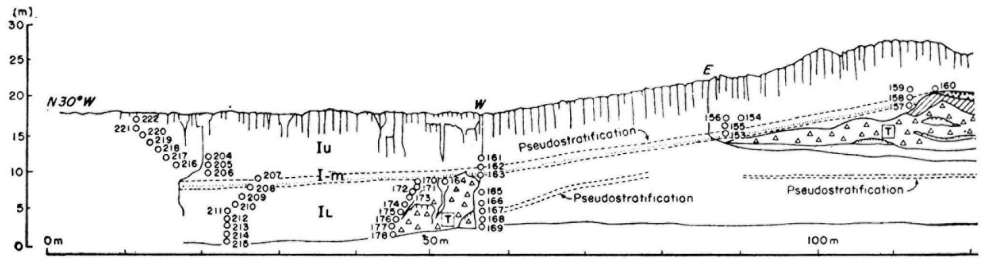


Fig. 2. Panoramic Diagram of the Outcrop of the Central Cliff, Northwest District of Ping-men Kalgan, South Cha-har.

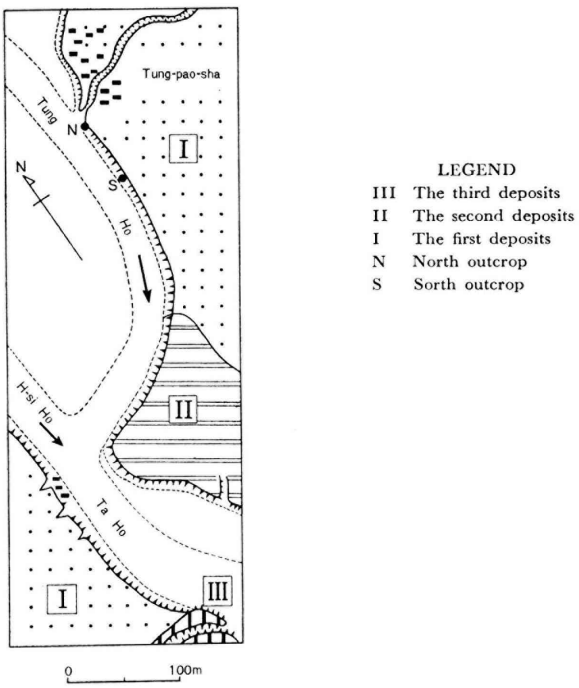
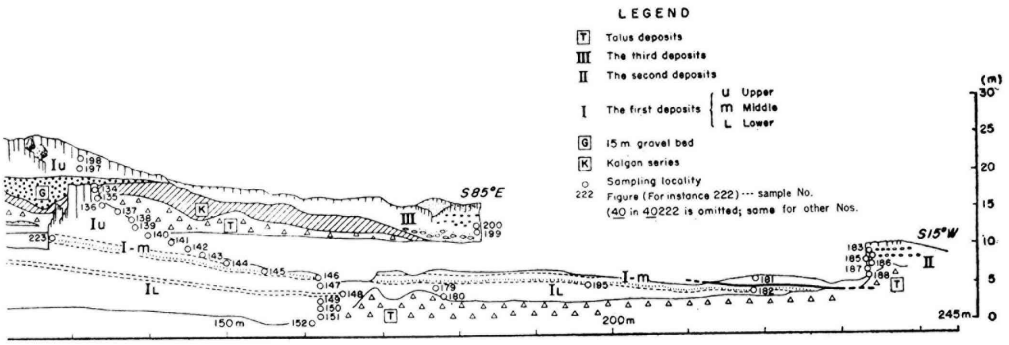
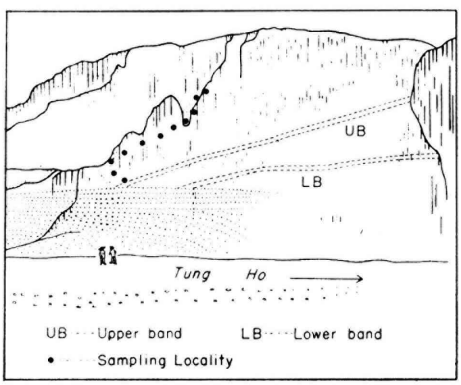


Fig. 3. Geological Sketch Map of the Southwest District of Tung-pao-sha, Cheng-ho Village, Hsuan-hua Prefecture, South Cha-Har.



Kalgan, South Cha-har



Southwest of Tung-pao-sha, Cheng-ho Village, Hsuan-hua Prefecture, South Cha-har.

Fig. 4. Upper and Lower Color Bands in the First Deposits.

The NW district of Hsi-men, Fan-shan-pu

Deposit (I) is well exposed in the cliff outcrops at points E and W (these two cliffs are 50–60 m apart) (Fig. 2). At E (17 m high, the portion lower than 5 m is not exposed), a sand bed (10–20 m thick, cross-bedded) is intercalated at a height of 6 m and an apparently homogeneous Huangtu occurs in the upper portion. At W (22 m high, the portion lower than 3 m is not exposed), loam (3 m thick, Huangtu spherulites included), Huangtu (3 m thick, vertical columnar joints developed), a gravel bed (less than 2 m thick, gravel is arranged imbricatedly), and Huangtu (11 m thick) occur in ascending order, above the elevation of 3 m. The author once thought a discontinuous plane of fineness of grain existed in that portion of the section 10–11 m high at point E.[9]

Deposit Ah of Tai-ping-pu (Nos. 4013 and 4014 in Table 13) south of Fan-shan-

[9] The screen used for mechanical analysis was defective at the time the author considered the existence of the discontinuous plane of fine grains. Therefore, the material was sorted again and the results of the first study were corrected as shown in Table 9. However, the height of the discontinuous plane is the same.

pu occurring in the western side of a saddle, is 15–16 m in maximum thickness which decreases gradually toward the ridge until the deposit disappears. The area of deposition is very small, like the Ah of the Cheng-ho village district.

The SSW district of Yung-ting-chiao

The lowest part of outcrop (I) faces south, is 15 m high, and is a gravel bed less than one m thick. Its upper portion is a light brownish-yellow sand bed and is apparently homogeneous. Vertical columnar joints in the upper part and vertical platy joints in the lower part are seen in this sand bed, but there are no joints in the middle part. Sieve analysis shows that the joints are developed in that portion of deposit (I) which has more than 5 per cent (by weight) of silt and clay particles (size less than 0.005 mm). Specimens from the sand bed effervesce when dilute hydrochloric acid is poured on them. The chemical study will be left for the future, but this is an important district for the study of the origin of joints.

Along the Shih-Tai Railway (between Shih-chia-chuang and Tai-yuan)

The columnar sections of deposit (I) are represented in Fig. 5; A for Chin-chuan, B for Chuang-tsun, C for Yang-chuan, D for Wei-shui, and E for Shang-an. As is shown, the Huangtu overlies a reddish clay, and there is neither unconformity nor disconformity between the two. The reddish clay gradually changes upward into a yellow clay, and there is no distinct border between the two (A, C, D, and E). The Huangtu concretion is remarkable in sections A and D, while Huangtu spherulites are found only in the reddish clay of sections A and C. Effervescence is conspicuous in the lower part of the Huangtu in sections A, B, and C. The effervescence in the upper part is remarkable in section C but not in A, and does not exist in D, E, and the lower part of A. Section B shows flat breccias arranged horizontally in the lower part of the Huangtu and contains round pebbles. The Huangtu of section E yields fossils of *Cathaica* sp.

The Chang-hsia and Chieh-shou district

The reddish loam (III-a) of the Chang-hsia district overlies (I) and (II) of the pre-Huangtu formation (loam) and the Man-tou shale. The relation between (III-a) and (III-b) is not that of an unconformity. Deposit (III-b) is a light yellowish-brown, intercalates horizontal and lenticular gravel beds, has vertical columnar joints, and shows the character of the Huangtu. Deposit (IV) covers (III-a) and (III-b), and (V) overlies (IV). Besides, (IV) and (V) are post-Huangtu formation and not Huangtu (a material term).

The hillside deposits (gentle slope) occur southwest of Hsia-lung-hua, unconformably overlie the Tai-shan metamorphic rocks and the Man-tou shale, and are composed of gravel bed, sand bed, and Huangtu (Table 8, No. 41237). These hillside deposits are clearly aqueous deposits. The Huangtu contains weathering products of bed rocks. The valley-filling deposits southeast of Tai-tien NNW of Chieh-shou are light greyish-brown to light reddish-brown, and effervescence is remarkable especially in No. 262; gravel beds are also found in the valley-filling deposits (Fig. 7). The gravel and sand are clearly aqueous deposits and are derived from gneisses and granites of higher elevations to the southeast.

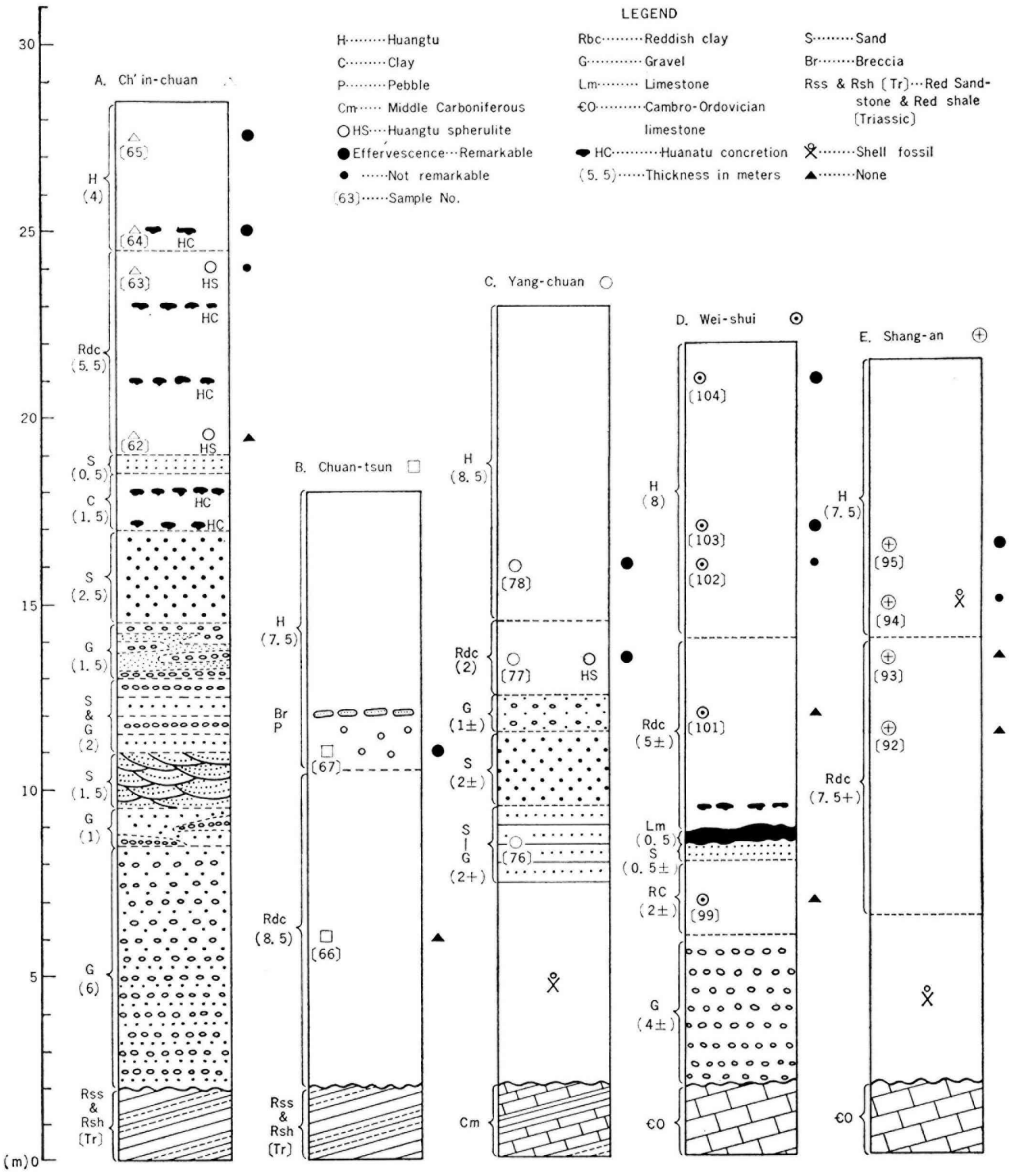
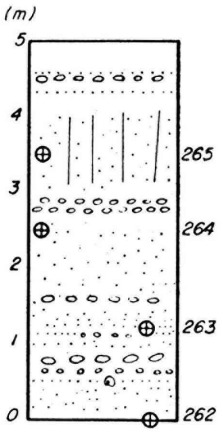


Fig. 5. Columnar Sketch of the "Huangtu Formation" (First Deposits) Along the Shih-tai Railway.



Road cut southeast of Tai-tien, 3 km NNW of Chieh-shou station, Chin-Pu Railway, Shan-tung (Sample Nos. 262-265)

Fig. 7. Gravel Beds in the Huangtu Formation.

General properties

Joints

Vertical columnar joints occur almost everywhere in the cliffs of the Huangtu. Examples: (I), (II) and (III) in the Ping-men district. Vertical platy joints parallel to the exposed plane of the cliff are seen in (I) loam in the Cheng-ho district, in (I) of the Yung-ting-chia sand within the author's surveyed area, and in (I-1) of the Ping-men district discovered by TOMITA in 1941.

Fractures

Generally earthy, splendid conchoidal fractures over one m long in diameter are seen on the face of the platy joints of (I-1) at Ping-men. (Discovered by TOMITA in 1941).

Brittleness

Breaks if crumpled between the thumb and forefinger. The Huangtu generally has this conspicuous characteristic. According to the findings of mechanical analysis, this characteristic is not conspicuous when the clay content is high.

Huangtu concretion

Called a loess child or loess doll in the past, it corresponds to the so-called Sha-chiang or Shih-chiang of North China. It is a concretion rich in calcium carbonate. It is found not only in the Huangtu but also in loam, reddish clay, and elsewhere and sometimes forms a bed. The size of the Huangtu concretions from (I-m) at Ping-men varies from one cm in diameter and 2 cm in height to 2 cm in diameter and 5 cm or so in height. Most of them are elongated vertically, and the lower end is pointed. Those collected from (I-m) in other places are generally 2–3 cm long in a horizontal direction, several mm thick, concave at the top, and pointed at the bottom. Globular ones and flat ones oriented vertically are rarely found. One of the Huangtu concretions collected from (I) north of Po-shan station, Shan-tung Province is approximately 10 cm in diameter, and the end of the projection which is elongated downward is hollow as in the lower end of a stalactite.

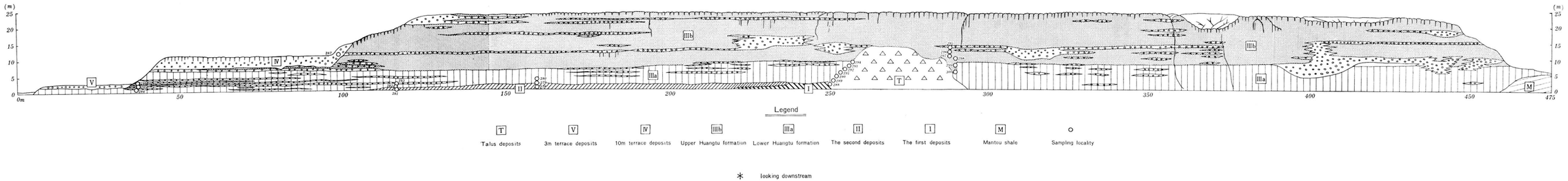


Fig. 6 Sketch of the "Huangtu Formation" the Cliff Along the Right Bank of the Sha Ho, 2.5 km. NNW of Chang-hsia Station, Chin-pu Railway, Shan-tung

Huangtu spherulite

These average one cm in diameter. The shapes are generally globular. Sometimes the center is hollow and rich in fissures which are nearly radial but not regular (Fig. 8). Concentric fissures are developed in the outermost margin. The soil which forms this globular body is a darker shade of brown than the other parts.

The first deposits (loam), SW of Tung-pao-sha, Cheng-ho village, Hsuan-hua Prefecture, South Cha-har.

Fig. 8. Sketch of the Huangtu Spherulite.

This distinction is difficult to make if the soil has been weathered. Vertical outcrops are commonly dotted with them, and they are sometimes connected vertically. They are sometimes gathered thickly in clusters. TOMITA and the author once reported that the Huangtu spherulites were found only in (I-1) at Ping-men in 1941, but the author confirmed their occurrence in the (I-m) deposit in September of that year. The author also confirmed that they are found not only in loam but also in the lower color band and in the Huangtu (I) of the Cheng-ho district. The location of Huangtu spherulites in North China is shown in Table 2. The Huangtu spherulite is the "loess spherulite," as named by TOMITA in 1941. P. TEILHARD DE CHARDIN and C. C. YOUNG (1933) called it a "hollow star."

It is geologically important that the hollow star is found in reddish and light-red loam, a typical "reddish loess" of the Chou-kou-tien geologic age. Twenty-five Huangtu spherulites (5–16 mm in diameter) were also found in a 8.8 sq. cm area within a vertical fissure face of (I) at point S at Cheng-ho village (Fig. 3). The area ratio is about 18 per cent (Fig. 8).

Adsorption

A fresh face of a small fragment adheres to the tip of the tongue. The mechanical analysis shows that this power of adsorption varies in direct proportion to the clay content.

Effervescence

If dilute hydrochloric acid is dropped on a specimen, effervescence occurs. The degree of effervescence depends on the calcium carbonate content.

Color

The Huangtu is light yellowish-brown to yellowish-brown but ranges sometimes from light greyish-brown to greyish-brown. The loam is light brown, greyish-brown, light reddish-brown, and sometimes yellowish-brown. The reddish clay varies from light red tinted with grey to dark reddish-brown.

Thickness

The thicknesses of the Huangtu loam and reddish clay are as shown in Table 1. The Huangtu of (I) in the Cheng-ho district is 16 m at point N, but 10 m at point S. Such difference in spite of continuous deposit is due to the color bands. It is of great interest that the color bands are related to the fineness of the grain.

Gravels

Spots of gravel from the bed rock and round fluvial pebbles from beds in the Huangtu formation were found. These are interesting for the study of the origin of the Huangtu of North China, which was regarded in the past as aeolian. The classification of the gravels and their distribution in North China are shown in Table 3.

Fossils

Non-marine shells found in the Huangtu formation are listed in Table 4.

Traces of plant roots

Deposits (I-l) and (I-u) of the Ping-men district contain many vertical traces of plant roots, but horizontal traces are rare.

Lateral holes (named by TOMITA in 1941)

In a vertical outcrop lateral holes are nearly-elliptic or long-elliptic holes 1–3 cm in length horizontally along the long axis, one cm or so in width, and of unknown depth. They are conspicuous in acqueous deposits, but the origin is unknown. Examples: (II) and (III) at Ping-men.

Pseudostratification (named by TOMITA in 1941)

This phenomenon is found in (I-l) and (I-m) of the cliff exposed in the center of the Ping-men district (Fig. 2). In (I-l), a light-grey band 30–40 cm in width extends continuously almost parallel to the present surface. Deposit (I-l) is less than one m thick; the lower part is rich in Huangtu concretion and the upper half contains a large amount of calcium carbonate and is greyish white. The light-grey band of (I-l) and (I-m) appears stratified if viewed from the south.

Color bands

As we have already stated, two color bands are seen in deposit (I) of Cheng-ho (Fig. 4). If we compare the lower color band at point S (Fig. 3) with the loam in the lower and upper parts of the Huangtu, the lower colored band is brittle and has a greater clay content (Table 8). The two color bands are noticeably darker in color than the other part and their north ends disappear diagonally into the horizontal sand bed (Fig. 4). Strictly speaking, the two color bands are not parallel to each other nor to the present surface. Comparing the grain size at points N and S, we see that the sand is richer at N and seems to be related to the development of the color bands (Table 8).

General properties to be considered will be confined within the above stated range.

Mechanical analysis

Tables 5–13 indicate the findings of the mechanical analysis of the Huangtu loam and reddish clay.

Characteristics of the particles

The crystal fragments of anorthoclase from (I-l) in the Ping-men district (3 mm; collected by TOMITA) are found only in the rhyolite and the trachyte of the Kalgan series of North China.

Mechanical analysis shows that the Huangtu at Chuang-tsun contains decomposed matter derived from the bed rock (red sandstone).

The particles greater than 1 mm in diameter found in the Huangtu formation southeast of Tai-tien are clearly all fragments of Tai-shan metamorphic rocks. The particles of less than 1 mm in diameter are microcline, plagioclase, muscovite, biotite, hornblende, epidote, tourmaline, zircon, and apatite. In addition hair-like rutile is sometimes found in the quartz. According to TOMITA, microcline is characteristic of the Tai-shan granite among the acidic plutonic rocks of the pre-Sinian period of North China. These minerals are all those composing the Tai-shan gneiss and the Tai-shan granite which are the bed rocks of this area.

The hillside deposits at Hsia-lung-hua contain many particles from the Tai-shan gneiss bed rock and Man-tou shale.

4. Summary

Vertical joints

The vertical joints are thought to have been formed by the cohesion of the deposit caused by a dry climate. Examples: (I) and (II) C4 in Ying-ting-chia district (Table 10).

Peculiarity of the locality

A considerable amount of weathering products from the bed rocks are found in the Huangtu formation at Ping-men, Chuang-tsun, Tai-tien, and Hsia-lung-hua. That of Tai-tien especially is an autochthonous deposit, which has not been transported from other places. Example: Meng-chiang region. The peculiarity of locality of the Huangtu deposit is thus clear.

Evidence of chemical and physical changes after deposition

The three pieces of evidence are: calcium carbonate is present; Huangtu concretion is formed; and color bands are developed.

The Huangtu spherulite

Huangtu concretions are found not only in the brown loam or the reddish clay

of Chou-kou-tien age but also in the Huangtu of (I) in the Cheng-ho district. There is neither unconformity nor disconformity between the brown loam or reddish clay and the Huangtu.

Vertical distribution of fineness

There is a remarkable discontinuous plane formed by a vertical distribution of fine-grained particles in the Huangtu formation, which appears homogeneous in the outcrop (deposit I at Fan-shan-pu).

5. Conclusion

We have outlined the Huangtu formation. Considering the facts stated in this paper, the process of "huangtization", proposed by TOMITA, evidently took place in the districts stated above. Namely, the Huangtu of (I) and (III-b), mentioned earlier, seem to have been altered from A1 and A3 of the Chou-kou-tien bed of the lower Diluvium by "huangtization" (an unknown weathering process) *in situ*.

Table 1. Classification of the "Huangtu Formation".

District / Division	South Cha-har				Ho-pei • Shanhsi (13)(15) (Along the Shih-tai Railway)	Shan-tung (28) (NNW of Chang-hsia station)
	NW of Ping-men, Kalgan (16)(27)	Cheng-ho village, Hsuan-hua Prefecture (14)	NW of Fan-shan-pu, Huai-lai Prefecture (17)	SSW of Yung-ting-chiao, Huai-lai Prefecture (13)(19)		
Aeolian "Huangtu" formation (Ah)	x	Ah (Huangtu) [2–6 m]	x	x	x	x
Valley-filling "Huangtu" formation (Vh)	III (Gravel, sand and Huangtu) Fan . . . [5–6 m], Talus . . . [10 m±]	III (Gravel) [3–4 m]	II (Gravel and sand) [3 m+]	II (Gravel and sand) [3 m +]	III (Gravel and sand) [2–3 m]	V (Gravel and sand) [1 m +]
	II (Huangtu, sand and gravel) [5–6 m]	II (Huangtu, sand and gravel) [10 m ±]	x	x	II (Huangtu, sand and gravel) [15–21 m]	IV (Gravel, sand and silt) [4 m±]
	Iu (Huangtu) [10 m] Im (Loam) [1 m ±] Il (Loam) [12 m ±]	I Upper (Huangtu) [10–16 m] Lower (Loam or sand and gravel) [14 m +]	I Upper (Huangtu) [16 m] Lower (loam, sand and gravel) [3 m +]	I Upper (Huangtu) [13 m] Lower (Loam, sand and gravel) [15 m]	I Upper (Huangtu) [7.5–8.5 m] Lower (Reddish or red clay) [2–8.5 m+]	IIIb (Huangtu and gravel) [17 m] IIIa (Huangtu-reddish loam) [8 m]
Pre-"Huangtu" formation	15 m gravel bed	x	x	x	Gravel and sand	II (Dark-brown soil) [2 m −] I (Dark-red-brown soil) [2 m +]

Figures in brackets show the thickness of the bed.
Numbers in parentheses refer to Bibliography.

Table 2. Localities of Huangtu Spherulite (Sakai, 1947).

South Cha-har	• NW of Ping-men, Kalgan	M
	• SW of Ping-men, Kalgan	R
	• NNW of Hsi-men, Fan-shan-pu, Huai-lai Prefecture	M
	°• SSW of Tung-pao-sha, Cheng-ho village, Hsuan-hua Prefecture	VM
Shan-hsi	◎ About one km E of the northern end of Yang-chuan-ta-chiao	R
	◎ Northern cliff of Chin-chuan station	R
Shan-tung	• W of Ta-chien-kou, Li-cheng prefecture	R
	• Northern foot of Chin-lu-shan hill, Tao-ko village, Li-cheng Prefecture	R

VM.....Very much; M....Much; R....rare. ◎....Reddish clay;
• ....Yellow-brown loam, °....Huangtu.

Table 3. Arrangement of Pebbles in the "Huangtu Formation", Their Distribution According to the Enclosing Beds (SAKAI, 1950).

Arrangement / District	Horizontal	Imbricate
Ping-men	II	II, III
Cheng-ho village	II	II, III
Fan-shan-p'u	–	I, II
Yung-ting-chiao	–	I
Chuang-tsun	I	–
Yang-chuan	–	II
Chang-hsia	IIIa, IIIb	IIIa, IIIb, IV, V
Tai-tien	(Lower)	(Lower and Upper)
Pi-chia-tien	(B)	(C)

Table 4. Non-Marine Shells from the Huangtu Formation (SAKAI, 1943).

Genus and Species	Site						
	(1)*	(2)	(3)*	(4)*	(5)*	(6)	(7)*
1. *Anisus* (*Gyraulus*) sp.	−	−	−	−	−	+	−
2. *Bradybaena* (*Manchurohelix* TAKAI) *lavrushini* (COCKERELL)	−	+	−	−	−	−	−
3. *Bulimus striatulus* BENSON	−	−	−	−	−	−	+
4. *Cathaica fasciola* (DRAPAUNAUD) SUZUKI	−	+	−	−	−	−	−
5. *Cathaica pulveratrix* (VON MARTENS) SUZUKI	−	+	−	−	−	−	−
6. *Cathaica* sp.	−	−	+	+	−	−	−
7. *Gyraulus* sp.	+	−	−	−	+	−	−
8. *Hyppeutis schmackeri* (CROSSE)	+	−	−	−	−	−	−
9. *Lymnaea auricularia* LINNE var.	−	−	−	−	+	−	−
10. *Lymnaea* (*Galba*) *pervia* VON MARTENS	−	−	−	−	−	+	−
11. *Lymnaea* (*Radix*) *plicatula* BENSON SUZUKI	−	−	−	−	−	+	−
12. *Lymnaea* sp.	+	−	−	−	−	−	−
13. *Metodontia houaiensis* ? (CROSSE) [weathered]	+	−	−	−	+	−	−
14. *Metodontia yantaiensis* (CROSSE and DEBEAUX) SUZUKI	−	−	−	−	−	+	−
15. *Opeas pyrgula* SCHMACKER & BOETTGER	+	−	−	−	−	−	−
16. *Unio douglasiae* GRIFFITH et PEDGION	−	−	−	−	−	−	+
17. *Viviparus chinensis* REEVE	−	−	−	−	−	−	+
18. *Viviparus heudei* REEVE	−	−	−	−	−	−	+

(1) Between Huang-tu-chia-chen and Ta-meng-chen, NNE of Tai-yuan, Shan-hsi Province. (I) (SAKAI, No. 4055)
(2) Huangtu formation, west of Ching-hsing station, Ho-pei Province. (SUZUKI, 1939)
(3) About 200 m east of Shang-an station, Ho-pei Province. (I) (SAKAI, No. 4094)
(4) Tung-tu-men, SW of Huai-lu station, Ho-pei Province. (II?) (SAKAI, No. 40106)
(5) NE of Shih-men station, Ho-pei Province. (III) (SAKAI, No. 4091)
(6) East of Shih-men station, Ho-pei Province. (III) (SUZUKI, 1939)
(7) Hsi-ta-yuan, about 500 m north of Pao-ting station, Ho-pei Province. (II or III) (SAKAI, No. 40112)

*Specimens from (1), (3), (4), (5) and (7) were collected by the writer and identified by Y. OTUKA.

Table 5. Granularity of the Huangtu, Area Northwest of Ping-men, Kalgan, Southern Cha-har (Upper Part of the First Deposits) (SAKAI, 1950).

No.	Sample No.	(m)* Height	Diameter (mm)							Sum
			<4	4–2	2–1	1–0.5	0.5–0.05	0.05–0.01	<0.01	
1	40222	17	–	–	0.02	0.01	58.89	22.54	18.54	100.00
2	40221	16	–	–	–	0.02	56.46	24.48	19.04	100.00
3	40220	15	–	–	–	0.02	46.62	29.10	24.26	100.00
4	40219	14	–	–	0.02	0.08	40.02	33.12	27.76	100.00
5	40218	13	–	–	–	0.02	55.30	23.70	20.98	100.00
6	40217	12	–	–	–	–	59.08	21.84	19.08	100.00
7	40216	11	–	0.32	0.08	0.12	41.16	31.66	26.66	100.00
8	40204	12	–	–	0.02	0.08	32.20	44.66	23.04	100.00
9	40205	11	–	0.01	0.01	0.02	45.30	30.50	24.16	100.00
10	40206	10	–	0.02	0.02	0.28	42.98	34.00	22.70	100.00
11	40161	11.5	–	–	0.22	0.32	41.64	41.16	16.66	100.00
12	40156	16.5	–	–	–	0.01	61.01	23.80	15.18	100.00
13	40154	16.5	–	–	0.02	0.17	57.50	20.47	21.84	100.00
14	40155	15.5	–	–	0.01	0.07	59.72	21.96	18.24	100.00
15	40134	18	–	–	0.03	0.18	47.34	31.58	20.86	100.00
16	40135	17	–	–	–	0.08	40.86	34.22	24.84	100.00
17	40136	16	–	–	0.02	0.04	29.60	43.36	26.98	100.00
18	40137	15	–	–	–	0.12	36.80	39.16	23.92	100.00
19	40138	14	–	–	0.02	0 .08	29.58	37.84	32.48	100.00
20	40139	13	–	–	–	0.02	40.06	36.57	23.35	100.00
21	40140	12	–	–	–	0.07	51.74	29.66	18.53	100.00
22	40141	11	–	–	–	0.05	47.92	31.47	20.56	100.00
23	40142	10	–	–	–	0.18	39.80	37.03	23.00	100.00
24	40143	9	–	0.07	0.16	0.24	40.62	36.10	22.82	100.00
25	41159	20.5	–	–	0.26	0.20	52.75	23.90	22.89	100.00
26	40198	22	–	0.32	0.44	0.72	25.46	37.76	35.30	100.00
27	40197	21	0.15	1.22	0.79	1.12	36.39	30.89	29.44	100.00

* The height of the site where the sample was collected. (The vertical distance from the base of the outcrop exposure up to the spot where the sample was collected.)

Table 6. Granularity of the Loam, Area Northwest of Ping-men, Kalgan, Southern Cha-har (Middle Part of the First Deposits) (SAKAI, 1950).

No.	Sample No.	(m)* Height	Diameter (mm)							Sum
			>4	4–2	2–1	1–0.5	0.5–0.05	0.05–0.01	<0.01	
28	40207	9	3.34	3.84	4.34	4.74	28.74	29.66	25.34	100.00
29	40208	8	1.32	1.16	3.06	3.10	36.28	25.92	29.16	100.00
30	40162	10.5	–	0.12	0.54	1.24	39.90	29.24	28.96	100.00
31	40163	9.5	0.34	–	0.04	0.18	32.32	38.34	28.78	100.00
32	40153	14.5	–	0.39	1.98	1.92	26.92	32.67	36.12	100.00
33	40144	8	–	–	0.60	1.34	28.49	31.45	38.12	100.00
34	40145	7	–	0.16	0.04	0.06	38.83	24.25	36.67	100.00
35	40146	6	2.47	0.32	0.07	0.05	38.87	30.29	27.93	100.00
36	40160	20.5	1.03	5.18	6.09	7.02	51.94	20.58	8.16	100.00
37	40158	19	–	0.51	1.08	1.53	33.36	30.90	32.62	100.00
38	40157	18	0.95	1.47	1.92	3.23	31.66	30.68	30.10	100.00
39	40182	4	–	–	0.02	0.19	37.75	36.85	25.19	100.00

* The height of the site where the sample was collected.

Table 7. Granularity of the Loam, Area Northwest of Ping-men, Kalgan, Southern Cha-har (Lower Part of the First Deposits) (SAKAI, 1950).

No.	Sample No.	(m)* Height	Diameter (mm)							Sum
			>4	4–2	2–1	1–0.5	0.5–0.05	0.05–0.01	<0.01	
40	40209	7	1.74	2.48	3.02	3.22	39.44	22.94	27.16	100.00
41	40210	6	–	0.12	0.14	0.44	53.12	25.42	20.76	100.00
42	40211	5	–	0.38	0.56	0.50	38.02	34.08	26.46	100.00
43	40212	4	4.22	3.98	4.10	3.48	30.42	26.62	27.18	100.00
44	41213	3	–	1.37	6.40	7.96	35.77	28.58	19.92	100.00
45	40214	2	8.70	0.78	0.60	0.90	24.06	25.84	39.12	100.00
46	40215	1	0.25	1.02	0.80	1.24	46.05	24.10	26.54	100.00
47	40170	9	0.22	0.50	0.20	0.33	33.07	39.54	26.14	100.00
48	40171	8	0.98	0.30	0.70	1.14	31.86	38.18	26.84	100.00
49	40172	7.5	–	0.10	0.16	0.26	31.68	40.16	27.64	100.00
50	40173	6.5	0.16	0.44	1.70	1.96	35.46	35.58	24.70	100.00
51	40174	5.5	0.18	1.90	2.32	2.86	39.66	32.90	20.18	100.00
52	40175	4.5	0.86	0.36	0.28	0.42	37.52	34.78	25.78	100.00
53	40176	3.5	–	–	0.01	0.04	36.09	33.82	30.04	100.00
54	40177	2.5	–	0.18	0.28	0.32	30.40	38.46	30.36	100.00
55	40178	1.5	–	0.02	–	0.01	43.59	31.28	25.10	100.00
56	40164	8.5	8.58	0.26	0.12	0.16	35.62	29.60	25.66	100.00
57	40165	7.0	–	–	0.02	0.16	39.52	30.68	29.62	100.00
58	40166	5.5	–	0.08	0.01	0.20	33.99	34.38	31.34	100.00
59	40167	4.5	–	–	0.02	0.10	30.66	34.80	34.42	100.00
60	40168	3.5	–	–	0.04	0.34	38.36	32.40	28.86	100.00
61	40169	2.5	–	–	0.06	0.20	37.24	38.70	33.80	100.00
62	40147	5	2.73	0.05	0.01	0.09	37.18	34.00	25.94	100.00
63	40148	4	–	0.02	0.02	0.11	33.52	33.93	32.41	100.00
64	40149	3	–	–	0.01	0.33	39.30	31.89	28.46	100.00
65	40150	2	–	–	0.04	0.40	54.19	21.11	24.26	100.00
66	40151	1	–	–	0.05	0.13	45.17	30.78	23.33	100.00
67	40152	0	–	–	0.02	0.17	34.37	42.14	23.30	100.00
68	40180	3.5	0.99	0.49	0.75	0.95	371.7	32.35	27.30	100.00

* The height of the site where the sample was collected.

Table 8. Granularity of the Valley-Filling Huangtu Formation, the Area of Cheng-ho-ts'un, Hsuan-hua-hsien, Southern Cha-har (First Deposits) (SAKAI, 1950).

No.	Sample No.	(m)* Height	Diameter (mm)					Sum	Remarks
			2–1	1–0.5	0.5–0.05	0.05–0.005	<0.005		
69	41255	18	–	0.01	54.35	28.02	17.62	100.00	Huangtu
70	41256	17	–	0.02	48.12	22.38	19.48	100.00	"
71	41257	16	–	0.02	35.04	38.26	26.68	100.00	"
72	41262	15	0.01	0.01	37.76	38.66	23.56	100.00	"
73	41263	14	0.06	0.18	33.22	38.68	27.86	100.00	"
74	41264	13	0.24	0.20	39.18	32.78	27.60	100.00	"
75	41265	12	–	0.12	64.58	13.30	22.00	100.00	"
76	41266	11	0.02	0.04	46.00	26.58	27.36	100.00	"
77	41267	10	0.02	1.08	53.70	21.22	23.90	100.00	"
78	41268	9	0.04	0.22	54.86	20.60	24.28	100.00	"
79	41269	8	0.02	0.94	64.12	17.84	17.08	100.00	"
80	41236	15	–	0.02	37.20	33.58	29.20	100.00	" HS
81	41237	14.5	0.01	0.03	25.44	41.28	33.24	100.00	Loam HS
82	41238	13.3	–	0.01	49.35	24.84	25.80	100.00	" HS
83	41239	12.3		42		29	29	100	" HS
84	41240	11		35		38	27	100	" HS
85	41241	10		28		40	32	100	" HS
86	41242	9		31		38	31	100	" HS very rich
87	41243	8		32		41	27	100	" HS
88	41244	7		27		39	34	100	"
89	41245	6		29		42	29	100	"
90	41246	5		28		44	28	100	"
91	41247	4		28		43	29	100	"
92	41248	3		40		34	26	100	"
93	41249	2		51		31	18	100	" HS
94	41250	1		32		35	33	100	"
95	51251	0		39		27	34	100	" HS

* The height of the site where the sample was collected.

Note: nos. 69–79: north outcrop; nos. 80–95: south outcrop; HS Huangtu spherulite.

Table 9. Granularity of the Valley-Filling Huangtu Formation, Northwestern Area of Fan-shan-pu, Huai-lai-hsien, Southern Cha-har (Eastern Outcrops, First Deposits) (SAKAI, 1950).

No.	Sample No.	(m)* Height	Diameter (mm)						Sum	Remarks
			4–2	2–1	1–0.5	0.5–0.05	0.05–0.01	<0.01		
96	4036	22	–	0.02	0.13	40.96	34.02	24.87	100.00	Light-yellow-brown
97	4035	21	–	0.21	0.51	37.30	37.67	24.31	100.00	"
98	4034	20	–	0.03	0.19	59.30	24.18	16.30	100.00	"
99	4033	19	–	–	0.22	57.65	26.12	16.01	100.00	"
100	4032	18	–	0.03	0.16	41.24	36.91	21.66	100.00	"
101	4031	17	–	–	0.20	40.22	37.54	22.04	100.00	"
102	4030	16	–	0.01	0.12	44.50	35.53	19.84	100.00	"
103	4029	15	–	0.30	1.61	40.88	35.07	22.14	100.00	"
104	4028	14	–	0.01	0.07	53.81	26.24	19.87	100.00	"
105	4027	13	–	0.01	0.49	51.11	29.88	18.51	100.00	"
106	4026	12	–	0.02	0.16	44.14	36.85	18.83	100.00	"
107	4025	11	–	0.17	1.42	61.38	24.00	13.03	100.00	"
108	4024	10	0.17	0.40	1.48	48.60	26.81	22.54	100.00	Light-brown
109	4023	9	–	–	0.04	49.93	28.36	21.67	100.00	"
110	4022	8	–	0.17	0.75	64.41	16.12	18.55	100.00	"
111	4021	7	0.14	0.43	1.35	68.09	15.05	14.94	100.00	"
112	4020	6	0.38	3.37	2.10	62.32	23.94	7.89	100.00	"
113	4019	5	–	0.35	1.44	70.52	25.19	2.50	100.00	Light-yellow-brown

Table 10. Granularity of the Huangtu in the Terrace Deposit, Area of Yung-ting-chiao, Hu-lai-hsien, Southern Cha-har (First Deposits) (SAKAI, 1950).

No.	Sample No.	(m)* Height	Diameter (mm)				Sum	Remarks
			4–2	2–0.05	0.05–0.005	<0.005		
114	4120	15	(0.13)	82.60	10.97	6.43	100.00	Vertical columnar joint
115	4121	14	–	96.83	1.77	1.40	100.00	"
116	4122	13	(0.33)	86.90	8.44	4.66	100.00	"
117	4123	12	–	94.59	3.91	1.50	100.00	"
118	4124	11	–	93.57	4.51	1.92	100.00	"
119	4125	10	–	98.55	0.85	0.60	100.00	"
120	4126	9	–	93.70	4.23	2.07	100.00	"
121	4127	8	–	98.49	0.64	0.87	100.00	
122	4128	7	–	97.80	1.33	0.87	100.00	
123	4129	6	–	97.32	1.16	1.52	100.00	
124	4130	5	(0.01)	97.47	1.67	0.86	100.00	
125	4131	4	–	96.79	2.24	0.97	100.00	
126	4132	3	–	94.90	3.65	1.45	100.00	Vertical platy joint
127	4133	2	(0.56)	91.86	4.64	3.50	100.00	"

* The height of the site where the sample was collected.

Table 11. Granularity of the Huangtu Formation, along the Shih-Tai Railway (First Deposit) (SAKAI, 1950).

No.	Sample No.	(m)* Height	Diameter (mm)								Sum	Locality
			>4	4–2	2–1	1–0.5	0.5–0.05	0.05–0.01	0.01–0.005	<0.005		
128	4065	25.5	–	0.06	0.02	0.40	31.80	45.82	21.90		100.00	North of Chin-chuan station, Shanshi.
129	4064	23	–	–	0.05	0.54	31.73	40.60	27.08		100.00	
130	4063	22	–	–	0.34	0.90	20.54	42.08	36.16		100.00	
131	4067	9	–	–	–	0.02	41.18	31.62	12.38	14.30	100.00	Chuang-tsun, near Tse-shih station, Shan-hsi.
132	4066	4	–	0.96	3.08	8.24	46.74	13.07	8.98	18.93	100.00	
133	4078	8.5	–	–	0.02	0.04	23.14	49.86	3.48	23.46	100.00	About 1 km E of P.C.I.W., Yang-chuan, Shan-hsi.
134	4077	6	0.14	0.38	1.66	3.56	30.36	32.94	4.62	26.34	100.00	
135	40104	19	–	0.11	0.11	0.14	18.52	44.60	7.68	28.84	100.00	
136	40103	15	0.76	–	0.08	0.18	16.76	47.82	7.92	26.48	100.00	About 500 m SW of Wei-shui station, Ho-pei.
137	40102	14	0.60	0.24	0.19	0.36	34.20	40.90	4.56	18.95	100.00	
138	40101	10	–	0.05	0.14	0.44	22.59	37.77	0,81	38.20	100.00	
139	4099	5	–	–	0.24	2.11	26.95	27.14	43.56		100.00	
140	4095	10	–	–	0.28	1.84	19.53	49.90	28.45		100.00	
141	4094	8.5	–	–	0.04	0.43	20.23	55.02	24.28		100.00	About 200 m E of Shan-an station, Ho-pei.
142	4093	7	–	0.02	0.14	0.13	29.85	45.58	24.28		100.00	
143	4092	5	–	–	0.14	0.19	36.41	31.63	31.63		100.00	

* The height of the site where the sample was collected.

Table 12. Granularity of the Valley-Filling Huangtu Formation and the Hillside Huangtu Formation, Chang-hsia and Chieh-shou Areas Along the Chin-Pu Railway (TOMITA and SAKAI, 1942).

No.	Sample No.	Height (m)*	Diameter (mm)							Sum	Remarks
			>4	4–2	2–1	1–0.5	0.5–0.05	0.05–0.005	<0.005		
144	40288	1	–	–	0.08	0.10	32.14	50.40	17.28	100.00	I
145	40278	1	–	–	0.02	0.08	11.82	43.88	44.20	100.00	II
146	40281	0.5	–	–	0.02	0.08	15.72	46.40	37.78	100.00	,,
147	40294	8.5	–	–	0.22	0.26	32.48	43.54	23.50	100.00	IIIa
148	40293	7.5	–	0.38	0.68	1.28	34.96	41.68	21.02	100.00	,,
149	40292	6.5	–	0.26	0.28	0.78	27.46	45.78	25.44	100.00	,,
150	40291	5	–	–	0.01	0.07	20.98	51.24	27.70	100.00	,,
151	40290	4	–	–	0.06	0.10	22.54	51.20	26.10	100.00	,,
152	40289	2.5	–	–	0.06	0.12	24.48	50.36	24.98	100.00	,,
153	40279	2	–	–	0.04	0.06	24.18	50.58	25.14	100.00	,,
154	40282	1	–	–	0.10	0.14	24.50	54.02	21.24	100.00	,,
155	40284	1	–	–	0.12	0.26	26.38	45.62	27.62	100.00	,,
156	40299	7.5	–	–	0.09	0.19	24.56	50.04	25.12	100.00	,,
157	40300	5.5	–	0.06	0.22	0.28	28.32	44.80	26.32	100.00	,,
158	40295	12.5	–	0.08	0.50	1.32	45.48	41.18	11.44	100.00	”IIIb
159	40296	11.5	0.10	0.38	1.40	4.40	43.64	39.58	10.79	100.00	,,
160	40297	10	–	–	0.10	0.20	37.34	49.00	13.36	100.00	,,
161	40298	9	–	0.10	0.10	0.18	35.64	48.96	15.02	100.00	,,
162	40287	12	2.72	1.08	1.30	1.22	30.06	45.92	17.70	100.00	IV
163	40237	2.5	0.18	0.56	2.48	7.44	44.34	36.68	8.32	100.00	Hillside deposit
164	40265	3.5	0.78	2.16	3.40	2.28	25.02	49.38	16.98	100.00	Valley-filling deposit
165	40264	2.5	2.46	4.40	5.46	6.02	32.40	37.04	12.22	100.00	,,
166	40263	1	4.38	7.98	8.80	14.10	54.36	7.34	3.04	100.00	,,
167	40262	0	–	1.32	3.62	3.68	35.16	38.64	17.58	100.00	,,

* The height of the site where the sample was collected.

Note: Nos. 144–162 (Valley-filling deposit): Chang-hsia; No. 163: Hsia-lung-hua, 2.5 km N 70[W of Chang-hsia station; Nos. 164–167: Tai-tien, 3 km NNW of Chieh-shou station.

Table 13. Granularity of the Aeolian Huangtu Formation, Tai-ping-pu and Ch'eng-ho-tsun, Southern Cha-har (SAKAI, 1950).

No.	Sample No.	Height (m)*	Diameter (mm)						Sum	Locality
			4–2	2–1	1–0.5	0.5–0.05	0.05–0.005	<0.005		
168	41244	1	0.23	0.18	17.99		59.02	22.58	100.00	NW ridge of Mt. Ta-tung-shan, Cheng-ho village, South Cha-har.
169	41235	1	1.32	2.96	4.70	37.90	33.94	19.18	100.00	NW foot of Mt. Ta-tung-shan, Cheng-ho village, South Cha-har.
170	4014	10	–	–	–	32.06	56.55	11.39	100.00	Coal field, SSW of Tai-ping-pu, Huai-lai Prefecture, South Cha-har.
171	4013	3	0.26	0.18	22.22		58.84	18.50	100.00	

* The height of the site where the sample was collected.

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