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COLLECTED WORKS ON CHINA'S LOESS SOIL

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[Following is a full translation of a Chinese-language book by LIU Tung-sheng (0491 2639 3932) et al, entitled Chung-kuo Te Huang-t'u Tui-chi (English Version Above), published by Science Press, Peiping, September 1965, pp 1-243.]

BRIEF INTRODUCTION

This book is a special publication summarizing studies on China's loess made by the Quaternary Geology Research Section of the Institute of Geology, Chinese Academy of Sciences since 1955. It is also an explanation to the 1:4,000,000 "China's Loess Soil Distribution Map." The book has five chapters, consisting of two parts.

The first part is the regional descriptions, discussing the distribution, lithological characters, thickness, stratigraphic division and origin of loess and loess-like rocks in the Northeast, North China, central basin of Huang Ho and the Northwest Regions of China.

The second part studies the characteristics of distribution, stratigraphic age, grain composition, mineral composition and chemical composition of loess and loess-like rocks; and based on field survey and laboratory analysis, discusses the distribution pattern, stratigraphic division, contact relations, conditions for formation, lithofacies variations and their relationships with the river-lake facies, of Chinese loess and loess-like rocks of different ages in various regions.

Furthermore, the content of this book is useful as a reference in soil preservation, civil construction, soil improvement and agricultural disposition works and may be used as reference material by workers engaged in regional geology, Quaternary geology, hydrogeology, engineering geology, soil preservation and improvement works and by teachers and students of higher institutions.

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Summing up the above, several preliminary conclusions can be arrived:

(1) The center of thickness of China's loess is situated at the Chin river and Lo river basins; the thickness decreases toward the west and the east.

(2) Loess of different ages are in different thickness; among them, Li-shih loess is most thick, Malan and Wu-ch'eng loess are comparatively thinner, and the Holocene loess is most thin.

(3) The thickness of loess of different ages has regional variations. The young Upper Pleistocene Malan loess gradually decreases in thickness from north to south and from west to east. The thickness of Li-shih - Wu-ch'eng loess is centered in the Chin and Lo rivers, it gradually thins out toward the east and west.

(4) The thickness of loess has something to do with the paleotopography, thicker in previous lowland area and thinner in previous highland area.

(5) Loess is thickner on the western and northern slopes of a mountain and thinner on the eastern and southern slopes.

(6) Although the thickness of loess has regional variations, the tendency of variation is not completely determined by paleotopography. The thickness is still quite steady within a relatively large area. This is quite different from the rapid change of thickness of other deposits related to the running water action within a short distance or under a certain geological structural condition.

2. Characteristics of the Age of China's Loess and Loess-like Strata

(1) Fossils in China's Loess Strata

Based on field observations and studies in recent years, the authors conducted comparison and division of loess strata when preparing the Chin's Loess Distribution Map (see Section 4, Chapter 3). Preliminary studies have also been made on mammal fossils in loess (including red clay). Although data on loess are scattered, this did not affect the arrival of the following general conclusions because important information has all been accounted for.

Many previous important studies (Yang 1927[38], 1935[61], Yang 1930[19], 1931[70], Teilhard de Chardin, Pei 1934[60]) have quite detailed description of vertebrate fossils which laid a good foundation for the understanding of loess strata. From known information, it can be noted that vertebrate fossils in loess are not few but many that had been identified. Stratigraphic division can be made by identifying the vertebrate fossils in loess down to "stage" below "series."

The mammal fossils refered to in this paper are those found in loess (including red clay). Othems whether their location, position and occurrence are doubtful or they were not found in loess but in

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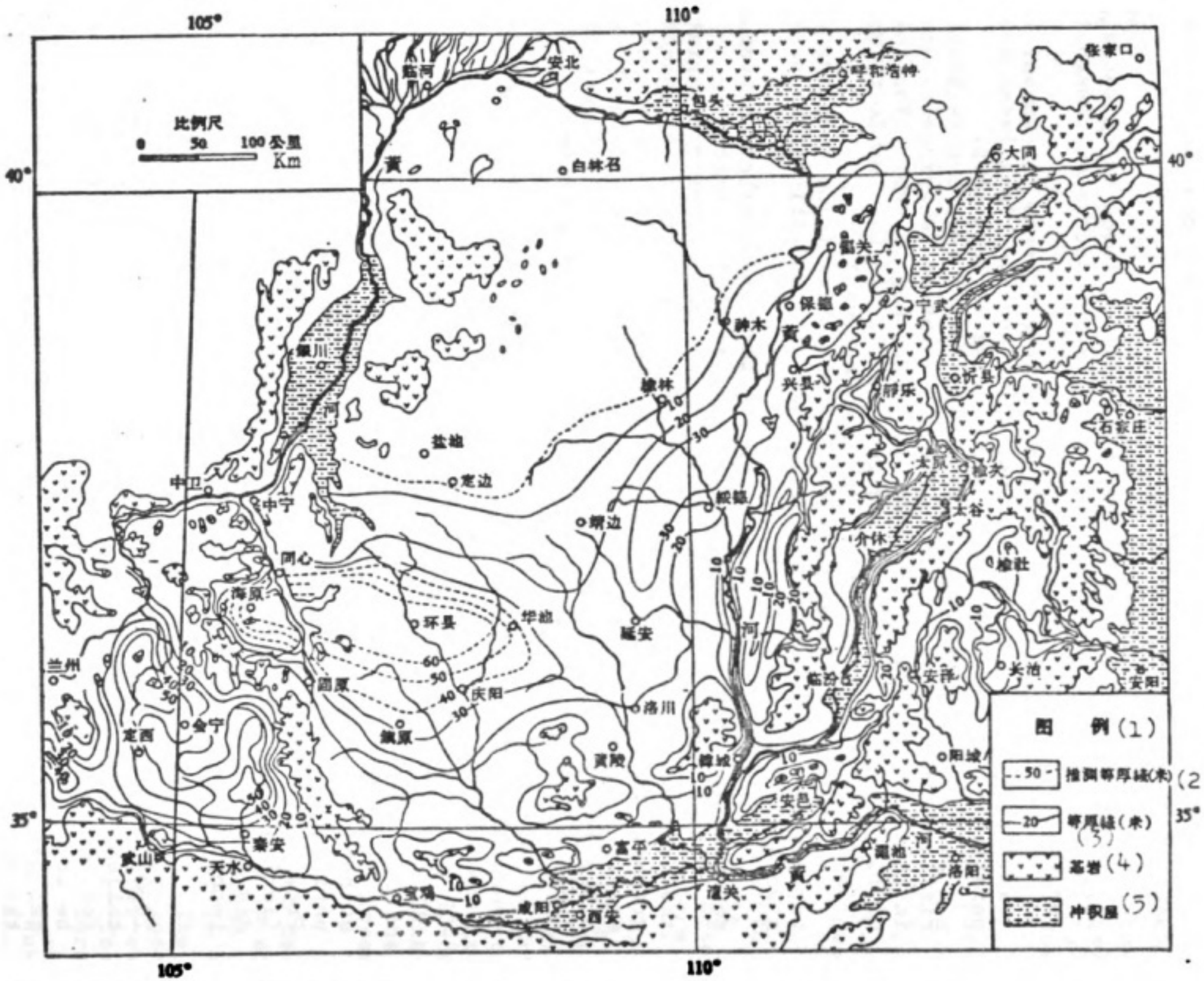
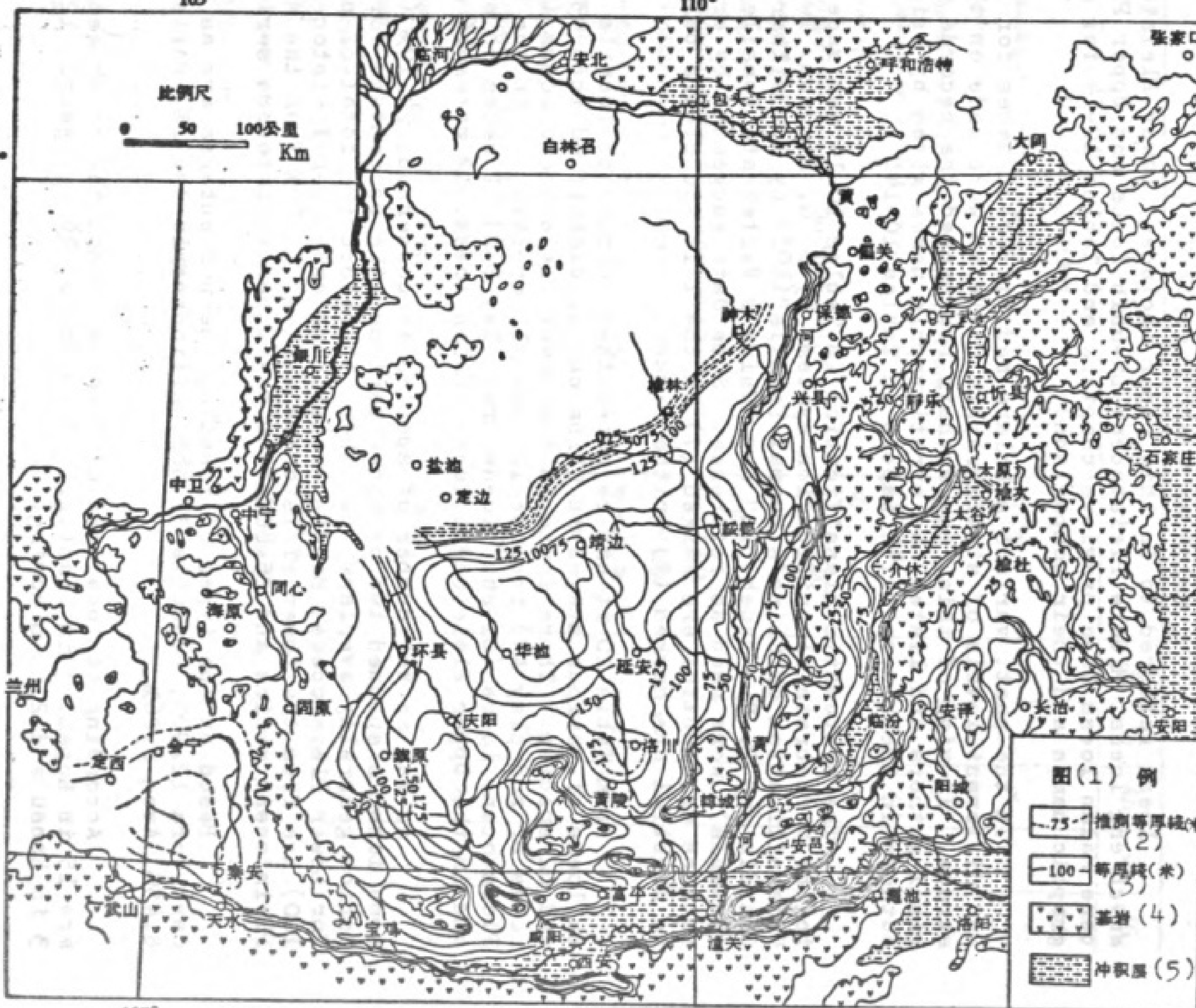
Fig. 65 Isopach of Malan Loess in the Central Basin of Huang Ho



Key: 1) Legend 2) Deduced isopach 3) Isopach (meter) 4) Bed rock 5) Alluvial bed

Fig. 66 Isopach of Li-shih - Wu-ch'eng Loess in the Central Basin of Huang Ho



Key: 1) Legend 2)

non-lossic deposits of the "lossic stage" are not included. They will be discussed separately.

Loess referred to in this paper includes: Lower Pleistocene Wu-ch'eng loess, Middle Pleistocene Li-shih loess and Upper Pleistocene Malan loess (See previous chapters and Tables 10-14 for stratigraphic names and their comparison).

In the past, various scholars had different names for loess and different levels of stratigraphic division were made on the loess strata. In view of this, the authors rearranged the records of original authors and listed the stratigraphic names given by original authors in their respective papers in Tables 10-14.

The systematic classification in Tables 10-14 was made according to the vertebrate classification system by G. G. Simpson. Two works, "Classification of China's Mammal Fossils"(103) by P. Teilhard de Chardin and P. "Lo-hsueh-pin" and "China's Vertebrate Fossils Handbook (Mammals)" were used as reference. Some data suggested by original authors as doubtful are marked (?) on the left and others believed to be doubtful are marked (?) on the right.

From Table 10 it can be noted that vertebrate fossils discovered in loess of various stages in China can be classified into 43 races and 62 species. Those found in the Lower Pleistocene loess (Wu-ch'eng loess or red clay A?) include 12 races 15 species, in the Middle Pleistocene loess (Li-shih loess, red clay B+C) 31 races 38 species and in the Upper Pleistocene loess (Malan loess) 12 races 16 species.

As far as the number of species is concerned, 24.19% (because some fossils spanned two or three periods, the percentage for one period generally overlaps the other; therefore the total of percentages for Lower Pleistocene, Middle Pleistocene and Upper Pleistocene exceeds 100) are from the Lower Pleistocene series, 61.29% from the Middle Pleistocene series and 25.80% from the Upper Pleistocene series.

Based on the types of fossils, the percentages are as follows: Carnivora 12.90%, Rodeutia 33.88%, Artiodactyla 38.71%, Perissodactyla 6.45%, Aves 8.06%.

According to locations of fossils found, the rough estimates are 15 in Hopeh, 3 in Shantung, 15 in Honan, 26 in Shansi, 12 in Shensi, 3 in Kansu and 2 in Liaoning.

These fossils and points of discovery have been positively identified. Other scattered discoveries which have not been studied, particularly those discovered in recent years, are not listed.

Though more fossils will be discovered in the future, the present

Table 10 Names of Vertebrate Fossils Found in Loess of Different Times in China

化石 Fossils		N_2	Q_1	Q_2	Q_3	Q_4
Rodentia 兔形目及嚙齒目						
Ochotona cf. *dauurica* (Pallas)	鼠耳兔			×		
Ochotona sp.	鼠耳兔			×		
Ochotonoides complicidens (Boule and Teilhard)	鼠耳兔		?×	?×		
Hypolagus brachypus (Young)	短脚野兔		×	×		
Lepus sp.	兔			×		
Spermophilus cf. *mongolicus* Milne-Edw.	蒙古黃子鼠			×		
Spermophilus sp.				×		
Tamias sp.	金花鼠			×		
Prosiphneus intermedius Teilhard and Young	中間原跗鼠		×			
Myospalax chaoyatseni Teilhard and Young	赵亚曾鼢鼠		?×	×		
Myospalax omegodon Teilhard and Young	欧米加鼢鼠		×			
Myospalax tingi Young	丁氏鼢鼠		?×	×		
Myospalax armandi Milne-Edw.	阿氏鼢鼠				×	
Myospalax epsilanus Thomas	吉林鼢鼠				×	
Myospalax fontanieri Milne-Edw.	方氏鼢鼠			×	×	
Myospalax arvicolinus Nehring	旺鼢鼠		×	×		
Epimys rattus L.	大鼠				×	
Alactaga sp.	跳鼠			×		
Dipus cf. *sowerbyi* Thomas	苏氏跳鼠		×			
Paracricetulus schaubi Young	邵氏付仓鼠			×		
Gerbillus cf. *meridianus* Pallas	野原鼠			×		
Carnivora 食肉目						
Nyctereutes sinensis (Schlosser)	中国貉		×	×		
Vulpes sp.	狐			×		
Ursus arctos L.	棕熊			×		
Meles cf. *leucurus* Hodgson	獾			×		
Hyaena brevirostrus sinensis Owen	中国鬣狗			×		
Crocuta crocuta ultima Matsumoto	洞穴鬣狗			×		
Cynailurus pleistocaenicus Zdansky	更新世猎豹			×		
Felis sp.				×		
Perissodactyla 奇蹄目						
Hipparion (luliangensis)	三趾馬					

Table 10 (cont'd)

化 Fossils 石		N_2	Q_1	Q_2	Q_3	Q_4
Proboscidipparion sinense Selve	中国长鼻三趾马		×			
Equus sanmeniansis Teilhard and Piveteau	三門馬		×	×		
Equus sp.	馬				×	
Artiodactyla 偶蹄目						
Sus lydekkeri Zdansky	李氏野猪		×			
Sus sp.	野猪			×		
Paracamelus gigas Schlossor	巨駝			×		
Capreolus manchuricus Lydekker	滿洲麞鹿				×	×
Rusa sp.	水鹿			×		
Eucladoceros boulei Teilhard and Piveteau	步氏大角鹿		×			
Pseudaxis grayi Zdansky	葛氏麋鹿			×		
Pseudaxis magnus Zdansky (a composite form)	大麋鹿			×		
Pseudaxis hortulorum Swinhoe	麋鹿				×	×
Cervus canadensis (Svertzow)	加拿大赤鹿				×	
Cervus (*Elaphurus*) cf. *bifucatus*	赤鹿			×		
Cervus huailaiensis Zdansky	怀来鹿				×	
Sinomegaceros flabellatus Teilhard	肿骨大角鹿			×		
Sinomegaceros pachyosteus Young	肿骨大角鹿					
Gazella sp.	羚羊			×		
Spirocerus peii Young	裴氏转角羚羊			×		
Ovis shantungensis Matsumoto	山东原羊		×	?×		
Ovis sp.	羊			×		
Bubalus brevicornis Young	短角水牛			×		
Bubalus mephistopheles Hopwood	圣水牛					×
Bubalus sp.	水牛				×	
Bison palaeosinensis Teilhard and Piveteau	古中国野牛		×	×		
Bos sp.	牛				×	
Tapirus sp.	貘					×
鳥 类						
Struthiolithus anderssoni	安氏鸵鳥			×	×	×
Pyrrhocarax sp.	紅嘴鴉				×	
Columbia cf. *livia*	野鴿				×	?
Phasianus sp. A.	雉				×	
Phasianus sp. B.	雉				×	

Table 11 Vertebrate Fossils Found in Loess of the Early Pleistocene Period in China

(1) 化石名称	产(2)地	层(3)位	来(4)源
Hypolagus brachypus (Young) 短脚野兎	1.山西陽县午城(5) 2.山西靜乐？(6)	午城黃土(19) 紅色土(?)(20)	刘东生、張宗祜, 1962 (26) 徳日进、楊钟健, 1931(27)
Prosiphneus intermedius Teilhard and Young 中間原鼢鼠	1.山西保德火山 (7)	紅色土底部(21)	徳日进、楊钟健, 1931 (27)
Myospalax chaoyatseni Teilhard and Young 赵亚曾鼢鼠	1.山西保德火山 (7) 2.山西中阳許家坪(8) 3.山西靜乐賀风 (9) 4.山西靜乐高家崖(10) 5.陕西府谷镇羌堡以东(11) 6.山西陽县午城 (5) 7.山西大宁下坡地(12)	紅色土(22)	同 (28) 上
Myospalax omegodon Teilhard and Young 欧来加鼢鼠	1.山西保德火山(7) 2.陕西府谷馬兰管(13) 3.山西中阳許家坪(8)	紅色土(22)	徳日进、楊钟健, 1931, p. 36 (27)
Myospalax tingi Young 丁氏鼢鼠	見表12地点(14)	紅色土(22)	同 (28) 上
Myospalax arvicolinus Nehring 旋鼢鼠		紅色土(22)	同 上
Paracricetulus schaubi Young 邵氏付仓鼠	1.甘肅兰州附近(15) 2.甘肅永登威水河(16)	黃土 (23) 紅棕色粘土(24)	楊钟健, 1927 (29) 楊钟健, 1927, p. 82 (29) 楊钟健, 1934, p. 71 (29)
Nycterutes sinensis (Schlosser) 中国貉	1.山西陽县午城(5) 2.河南(17)	午城黃土(19)	刘东生、張宗祜, 1962 (26) 師丹斯基, 1924 (30)
Hipparion 三趾馬	1.山西陽县午城 (5)	午城黃土(19)	刘东生、張宗祜, 1962 (26)
Proboscidipparion sinense Sefve 中国长鼻三趾馬	1.山西陽县午城 (5)	午城黃土(19)	刘东生、張宗祜, 1962 (26)
Equus sanmeniensis Teilhard and Piveteau 三門馬	1.山西陽县午城(5)	午城黃土(19)(25)	刘东生、張宗祜, 1962 (26)
Eucladoceros boulei Teilhard and Piveteau 步氏大角鹿	1.山西陽县午城(5) 2.山西中阳 (18)	紅色土(下) 紅色土(下)(25)	徳日进、楊钟健, 1931, p. 60 (27) (27)
Bison Palaeosinensis Teilhard and Piveteau 古中国野牛	1.山西中阳許家坪(8)	紅色土(22)	徳日进、楊钟健, 1931, p. 60

Key: 1) Name of fossil 2) Where found 3) Position 4) Source
5) Wu-ch'eng, Shih Hsien, Shansi 6) Chin-lo (?), Shansi
7) Huo-shan, Pao-te, Shansi 8) Hsu-chia-p'ing, Chung-yang, Shansi 9) Ho-feng, Chin-lo, Shansi 10) Kao-chia-ya, Chin-lo, Shansi 11)East of Chiang-pao, Fu-ku Chen, Shensi 12) Hsia-po-ti, Ta-ning, Shansi 13) Ma-lan-ying, Fu-ku, Shansi
14) See Table 12 15) Vicinity of Lanchow, Kansu 16) Hsien-shui river, Yung-teng, Kansu 17) Honan 18) Chung-yang, Shansi
19) Wu-ch'eng loess 20) Red clay (?) 21) Bottom part of red clay 22) Red clay 23) Loess 24) Reddish brown clay
25) Red clay (lower) 26) Liu Tung-sheng, Chang Tsung-ku
27) Teilhard de Chardin, Yang Chung-chien 28) Ditto
29) Yang Chung-chien 30) Zdansky

Table 12 Vertebrate Fossils Found in Loess of the Middle Pleistocene Period in China

(1) 化石名称	产 (2) 地	层(3)位	来 (4) 源
Ochotona cf. *dauurica* (Pallas) 短耳兔	1.陕西榆林城西約五里 (5)	紅色土 (21)	德日进、楊钟健 1931, p. 32 (25)
Ochotona sp. 短耳兔	1.山西靜乐高家崖 (6) 2.山西靜乐賀风 (7)	紅色土 (21)	德日进、楊钟健 1931, p. 33 (25)
Ochotona sp. A 短耳兔	1.甘肅东部庆阳(?) (8)	紅色土(?) (22)	楊钟健 1934, p. 121 (27)
Ochotona sp. B 短耳兔	1.陕西油房头 (9)		
Ochotonoides complicidens (Bcule and Teilhard) 短耳兔	1.山西靜乐賀风 (7) 2.陕西榆林城西約5里 (5) 3.山西中阳許家坪 (10) 4.山西大宁下坡地 (11) 5.甘肅东部(庆阳)黃土底部底礫状結核中 (12)	紅色土 (21)	德日进、楊钟健 1931, p. 30 (25) (27) 楊钟健 1934, p. 121 巴尔博、德日进 1928 (29)
Hypolagus brachypus (Young) 短脚野兔	1.河北菀平县 (13) 2.山西靜乐高家崖 (6)	(23) 紅色土中层	楊钟健 1927 (27) 德日进、楊钟健 1931, p. 29 (25)
Lepus sp. 兔	1.陕西榆林城西北約 5 里 (14)	紅色土 (21)	德日进、楊钟健 1931, p. 29 (25)
Spermophilus cf. *mongolicus* Milne-Edw. 蒙古真子鼠	(14) 1.陕西榆林城西北五里 2.山西大宁下坡地 (11)	紅色土 (21)	(25) 德日进、楊钟健 1931, p. 4 楊钟健 1927 (27) 德日进 1926, 1928 (30)
Spermophilus sp.	(15) 1.陕西府谷鎮羌堡以西	紅色土 (21)	(25) 德日进、楊钟健 1931, p. 4
Tamias sp. 金花鼠	1.山西保德火山 (16)	紅色土 (21)	(25) 德日进、楊钟健 1931, p. 4
Prosiphneus intermedius Teilhard and Young 中間原跗鼠	1.山西保德火山 (16)	紅色土 (21)	德日进、楊钟健 (25)
Myospalax chaoyatseni Teilhard and Young 超亚官跗鼠	(10) 1.山西中阳許家坪 2.山西靜乐高家崖 (6) 3.山西保德火山 (16) 4.陕西府谷鎮羌堡以东 (17) 5.山西隰县午城鎮 (18) 6.山西大宁下坡地 (11) 7.山西浮山 (19) 8.河南鄧池 (37) 9.河南新安王沟 (20)	(21) 紅色土 紅色土 (21) 紅色土 (21) 紅色土	(25) 德日进、楊钟健 1931 (27) 楊钟健 1935, p. 32 楊钟健 1935 (27) 楊钟健 1935 (27)

Table 12 (cont'd)

化石名称	产地	层位	来源
Myospalax Omegodon Teilhard and Young 欧米加鼢鼠	1.山西保德火山 (16) 2.陕西府谷馬岔三 (31) 3.山西中阳許家坪 (10)	紅色土(21)	德日进、楊钟健 1931, p. 26 (25) (27)
Myospalax tingi Young 丁氏鼢鼠	1.山西靜乐賀风 (7) 2.山西保德火山(16) 3.山西保德火山以北約十里 (32) 4.山西中阳許家坪(10) 5.山西大宁下坡地 (11) 6.山西乡宁 (33) 7.山西稷山 (34) 8.山西太谷仁村(35) 9.山西寿阳羊头崖(36) 10.山西浮山 (19) 11.河南龜池(共九个地点)(37) 12.河南新安县(38) 13.河北宣化县(39) 14.河北(40)	紅色土 紅色土 紅色土 紅色土 紅色土 紅色土 紅色土 紅色土 紅色土 紅色土	楊钟健 1931, p. 23 楊钟健 1931, p. 23 楊钟健 1931, p. 23 楊钟健 1931, p. 23 楊钟健 1931, p. 23 楊钟健 1931, p. 23 楊钟健 1931, p. 23 楊钟健 1932, p. 9 楊钟健 1935 楊钟健 1935, p. 32 楊钟健 1927, p. 45 楊钟健 1927, p. 45 楊钟健 1927, p. 45 楊钟健 1927, p. 45
Myospalax fontanieri Milne-Edw. 方氏鼢鼠	1.山西靜乐賀风(7) 2.山西陽曲午城(18) 3.山西大宁下坡地(11) 4.山西中阳許家坪 (10) 5.陕西榆林城西約5里 (5) 6.陕西榆林柳巴滩(41) (50) 7.河南龜池新安(42) 8.山西寿阳道坪(43) 9.山西武乡四合子(44)	紅色土 上三門 紅色土 紅色土	德日进、楊钟健 1931, p. 18—19 楊钟健 1935, p. 34 楊钟健 1935, p. 9 楊钟健 1935, p. 15
Myospalax arvicolinus Nehring 旋鼢鼠	1.甘肅兰州附近 (45) 2.甘肅庆阳 (46) 3.山西繁寺 (47) 4.山西靜乐(6) 5.山西中阳許家坪(10) 6.山西保德火山(16) 7.陕西吳堡石堆山(48) 8.山西榆社侯馬(49)	紅色土 紅色土 紅色土 紅色土 紅色土 紅色土(?) (22)	德日进、楊钟健 1931, p. 22 德日进、楊钟健 1931, p. 22 德日进、楊钟健 1931, p. 22 德日进、楊钟健 1931, p. 22 德日进、楊钟健 1931, p. 22 楊钟健 1935, p. 15
Alactaga sp. 跳鼠	1.陕西榆林城西約5里 (5)	紅色土	德日进、楊钟健 1931, p. 59
Dipus cf. *sowerbyi* Thomas 苏氏跳鼠	1.陕西榆林城西約5里 (5)	紅色土	德日进、楊钟健 1931, p. 9

Table 12 (cont'd)

化石名称	产地	层位	来源
Gerbillus cf. *meridianus* Pallas 野原鼠	1.陕西吳堡石堆山 (48)	紅色土(?) (22)	德日进、楊钟健 1931, p. 10 (25)
Nyctereutes sinensis (Schlosser) 中国貉	1.山西保德火山 (16) 2.陕西榆林佛巴滩 (41) 3.陕西榆林城西約5里 (5) 4.河南新安鴈池 (42)	紅色土 (21) 紅色土 紅色土	德日进、楊钟健 1931, p. 57 德日进、楊钟健 1931, p. 57 (27) 楊钟健 1935, p. 36
Vulpes sp. 狐	1.山西垣曲南沟裕子村 (51)	标准黃土 (59)	師丹斯基 1925, p. 6 (Zdansky)
Ursus arctos L. 棕熊	1.山西垣曲南沟(52) 2.河南宜阳县(53)	黃土(60) 黃土	師丹斯基 1925, p. 7 師丹斯基 1925, p. 7
Meles cf. *leucurus* Hodgson 獾	1.山西垣曲南沟 (52)	黃土	師丹斯基 1925, p. 10
Hyaena brevirostris sinensis Owen 中国鬣狗	1.山西垣曲南沟(52) 2.山西垣曲李家疙瘩 (54)	标准黃土 标准黃土	師丹斯基 1925, p. 22 師丹斯基 1925, p. 22
Crocuta crocuta ultima Matsumoto 洞穴鬣狗	1.河南新安上河上坡(55) 2.山西垣曲南沟(52)	标准黃土 黃土	師丹斯基 1925, p. 14 師丹斯基 1925, p. 14
Cynailurus pleistocaenicus Zdansky 更新世猎豹	1.山西垣曲南沟(52)	黃土	師丹斯基 1925, p. 23
Felis sp.	1.山西垣曲李家疙瘩 (54) (5)	黃土	師丹斯基 1925, p. 26
Equus sanmeniansis Teilhard and Piveteau 三門馬	1.陕西榆林城西約6里 2.陕西榆林归德堡(56) 3.河南鴈池 (37)	紅色土 紅色土 三門期 (61)	德日进、楊钟健 1931, p. 59 德日进、楊钟健 1931, p. 59 楊钟健 1935, p. 37
Sus sp. 野猪	1.山东益都清水溝 (57)	紅色土	楊钟健 1936, p. 182 松本 1926 (63) 師丹斯基 1925 皮尔森 1928 (64)
Paracamelus gigas Schlosser 巨駱	1.河南鴈池 (37)	黃土?	史劳寨 192 (65)
Rusa sp. 水鹿	1.河南鴈池 (37) 2.山西垣曲南沟 (52) 3.河北宣化 (39) 4.河北怀来 (58)	紅色土 上三門 (50)	師丹斯基 1925, p. 53 師丹斯基 1927, p. 9 楊钟健 1932, p. 63 楊钟健 1932, p. 65 師丹斯基 1925, p. 72 師丹斯基 1927, p. 13 師丹斯基 1925, 1927, p. 13

Table 12 (cont'd)

化石名称	产地	层位	来源
Pseudaxis grayi Zdansky 葛氏斑鹿	1.山西垣曲南沟(52)	黄土 (60)	(Zdansky) 师丹斯基 1925, p.65
	2.山西垣曲李家疙瘩(54)	黄土	师丹斯基 1925, p. 65
	3.山东益都清水澗 (57)	紅色土(21)	楊钟健 1936, p. 182 松本 1926 (63)
	4.河北(40)	黄土	师丹斯基 1927, p. 17
Pseudaxis magnus Zdansky (a composite form) 大斑鹿	1.山东益都清水澗 (57)	紅色土	楊钟健 1936, p. 182 师丹斯基 1925, p. 48 楊钟健 1932, p. 63
Cervus (Elaphurus) cf. *bifucatus* Teilhard and Piveteau 赤鹿	1.山西武乡張家沟 (66)	紅色土	楊钟健 1935, p. 18
Sinomegaceros flabellatus Teilhard 肿骨大角鹿	1.陝西榆林城約 5 里 (5)	紅色土	德日进、楊钟健 1931, p. 59
	2.河南渑池东沟(67)	上三門 (50)	楊钟健 1935, p. 37
	3.山西垣曲南沟(52)	黄土	师丹斯基 1925, p. 72
	4.山西垣曲李家疙瘩(54)	黄土	师丹斯基 1925, p. 72
	5.河北宣化 (39)	黄土	师丹斯基 1925, p. 73
	6.山东益都清水澗(69) (包括以前之 *Cervus higgms*, *Epirusa hilzheimeri*)	紅色土	楊钟健 1936, p. 182
	7.河南渑池 (70) (原訂为 *Epirusa hilzheimeri*)	上三門	楊钟健 1933, p. 63
Spirocerus peii Young 裴氏螺角羚羊	1.山西關县午城 (18)	离石黄土 (77)	(24) 刘东生、殷宗荫 1962
Ovis shantungensis Matsumoto 山东盤羊	1.山东益都清水澗 (57)	紅色土	楊钟健 1936, p. 183
Ovis sp. 羊	1.陝西榆林鎮川堡 (71)	紅色土 (78)	
Bubalus brevicornis Young 短角水牛	1.河南渑池庙山(72)	含結核紅黏土底部	楊钟健 1936, p. 509
	2.山东昌乐李庄(73)	紅色土	楊钟健 1936, p. 512
Bison palaeosinensis Teilhard and Piveteau 古中国野牛	1.陝西榆林归德堡(56)	紅色土	德日进、楊钟健 1931, p. 60
	2.山西中阳許家坪(10)	三門組(79)	德日进、楊钟健 1931, p. 60
	3.山西關县午城(18)	三門組	德日进、楊钟健 1931, p. 60
	4.河南渑池兰沟(74)	下三門 (80)	楊钟健 1935, p. 37
Struthiolithus anderssoni 安氏鴕鳥	1.山西保德火山(16)	紅色土	楊钟健 1933, p. 148
	2.陝西府谷馬营三(31)	紅色土	楊钟健 1933, p. 148
	3.陝西吳堡石堆山(48)	紅色土	楊钟健 1933, p. 148
	4.山西 (Shansi)	紅色土	杨钟健 1959, p. 124
	5.山东章丘内湾村(75)	紅色土	安特生 1923, p. 69 (81)
	6.河南新安 (38)	紅色土	安特生 1923, p. 69
(76)	7.山西五台县羊召庄	紅色土	安特生 1923, p. 60

Key: 1) Name of fossil 2) Where found 3) Position 4) Source 5) About 5 li west of Yu-lin, Shensi 6) Kao-chia-ya, Chin-lo, Shansi 7) Ho-feng, Chin-lo, Shansi 8) Ch'ing-yang (?) in east Kansu 9) Yu-fang-t'ou, Shensi 10) Hsu-chia-p'ing, Chung-yang, Shansi 11) Hsia-po-ti, Ta-ning, Shansi 12) Basal conglomerate-like nodule in the bottom part of loess in eastern Kansu (Ch'ing-yang) 13) Wan-p'ing Hsien, Hopeh 14) About 5 li northwest of Yu-lin, Shensi 15) West of Chiang-pao, Fu-ku Chen, Shensi 16) Huo-shan, Pao-te, Shansi 17) East of Chiang-pao, Fu-ku Chen, Shensi 18) Wu-ch'eng Chen, Shih Hsien, Shansi 19) Fu-shan, Shansi 20) Wang-kou, Hsin-an, Honan 21) Red clay 22) Red clay (?) 23) Middle layer of red clay 24) Liu Tung-shen, Chang Tsung-ku, 1962 25) Tailhard de Chardin, Yang Chung-chien, 1931 26) Ditto 27) Yang Chung-chien 28) "Sai-tan-szu-chi" /Russian/ 29) Barbour, Tailhard de Chardin 30) Teilhard de Chardin 31) Ma-ying-san, Fu-ku, Shensi 32) About 10 li north of Huo-shan, Pao-te, Shansi 33) Hsiang-ning , Shansi 34) Chi-shan, Shansi 35) Jen-ts'un, T'ai-ku, Shansi 36) Yang-t'ou-ya, Shou-yang, Shansi 37) Shen-ch'ih, Honan (a total of 9 locations) 38) Hsin-an Hsien, Honan 39) Hsuan-hua Hsien, Hopeh 40) Hopeh 41) Liu-pa-t'an, Yu-lin, Shensi 42) Hsin-an, Shen-ch'ih, Honan 43) Tao-p'ing, Shou-yang, Shansi 44) Szu-ho-tzu, Wu-hsiang, Shansi 45) Vicinity of Lanchow, Kansu 46) Ch'ing-yang, Kansu 47) Fan-szu, Shansi 48) Shih-tui-shan, Wu-pao, Shensi 49) Hou-ma, Yu-she, Shansi 50) Upper San-men 51) Yu-tzu Ts'un, Nan-kou, Heng-ch'u, Shansi 52) Nan-kou, Heng-ch'u, Shansi 53) Hsuan-yang Hsien, Honan 54) Li-chia-ko-ta, Heng-ch'u, Shansi 55) Shang-ho-shang-po, Hsin-an, Honan 56) Kuei-te-pao, Yu-lin, Shensi 57) Ch'ing-shui-chien, I-tu, Shantung 58) Huai-lai, Hopeh 59) Standard loess 60) Loess 61) San-men stage 62) Loess 63) Matsumoto. 64) "P'i-erh-sun" /nationality unknown/ 65) Schlosser 66) Chang-chia-kou, Wu-hsiang, Shansi 67) Tung-kou, Shen-ch'ih, Honan 68) Nan-kou, Heng-ch'u, Shansi 69) Ch'ing-shui-chien, I-tu, Shantung (including Cervus higgms, Epirusa hilzheimeri of previous periods) 70) Shen-ch'ih, Honan (previously Epirusa hilzheimeri) 71) Ch'uan-pao, Yu-lin Chen, Shensi 72) Miao-shan, Shen-ch'ih, Honan 73) Li-chuang, Ch'ang-lo, Shantung 74) Lan-kou, Shen-ch'ih, Honan 75) Nei-wan Ts'un, Chang-ch'iu, Shantung 76) Yang-chao-chuang, Wu-t'ai Hsien, Shansi 77) Li-shih loess 78) Bottom of nodule-bearing red clay 79) San-men group 80) Lower San-men (?) 81) Anderson

Table 13 Vertebrate Fossils Found in Loess of the Late Pleistocene Period in China

(1) 化石名称	产(2)地	层(3)位	来(4)源
Cervus canadensis (Svertsow) 加拿大赤鹿	1.河北宣化(5)	原生黄土	师丹斯基 1925, 1926, p. 80
	2.河北张家口(6)	原生黄土	师丹斯基 1925, 1926, p. 80
	3.河北龙关县(7)	原生黄土	师丹斯基 1925, 1926, p. 80
	4.河北涿鹿(8)	原生黄土	师丹斯基 1925, 1926, p. 80
	5.辽宁朝阳(9)	原生黄土	师丹斯基 1925, 1926, p. 80
	6.山西乡宁县(10)	黄土?	师丹斯基 1925, 1926, p. 80
	7.山西长治县(11)	黄土?	师丹斯基 1925, 1926, p. 80
	8.山西垣曲县(12)	黄土?	师丹斯基 1925, 1926, p. 80
Cervus huailaiensis Zdansky	1.河北怀来(13)	黄土?	师丹斯基 1927, p. 14
Struthiolithus anderssoni 安氏鸵鸟	1.山西右玉来家庄(14)	黄土	杨钟健 1933, p. 145
	2.河北行唐陈庄镇(15)	黄土	杨钟健 1933, p. 146
	3.河南汜水(16)	黄土	杨钟健 1933, p. 145—146
	4.山西静乐贺风(17)	黄土	杨钟健 1933, p. 148
	5.河北行唐(18)	黄土	杨钟健、孙爱玲 1959, p. 124
	6.山西(19)	黄土	(43)
	7.陕西蓝田(20)	黄土	古生物会讯 1956, 8 期
	8.河南新安县蔡家庄(21)	黄土	安特生 1923, p. 69 (40)
Myospalax armandi Milne-Edw. 阿氏鼢鼠	1.辽宁朝阳(9)	黄土	杨钟健 1934, p. 107
Myospalax cf. *Psilurus*	1.河南新安县(22)		杨钟健 1935, p. 36
Myospalax fontanieri Milne-Edw. 方氏鼢鼠	1.河北承德附近县家营(23)		德日进、杨钟健 1931, p. 18
	2.河北禹县(24)	?	杨钟健 1927, p. 43
	3.河北龙关白响水(25)	?	杨钟健 1927, p. 43
	4.河北张家口小马坪(26)		杨钟健 1927, p. 43
	5.河北赤城李家沟(27)	黄土	杨钟健 1927, p. 43
	6.河北承德鸡冠山(28)		杨钟健 1927
Epimys rattus L. 大鼠	1.河北承德县家营(23)	黄土?	杨钟健 1927
Capreolus manchuricus Lyd. 满洲麋鹿	1.河北宣化(5)	黄土	师丹斯基 1925, p. 87
	2.河南渑池(30)		?
Pseudaxis hortulorum Swinhoe 麋鹿	1.河南(29)(31)		松本 1926 (41)
	2.河南渑池县凤鸣坡	黄土	安特生 1923, p. 69 (40)
	3.河南渑池县蛤沟(42)	黄土	安特生 1923, p. 69
	4.陕西乾县(32)	黄土	古生物会讯 1955, 8 期 (38)

Key: 1) Name of fossil 2) Where found 3) Position 4) Source 5) Hsuan-hua, Hopeh 6) Chang-chia-k'ou, Hopeh 7) Lung-kuan Hsien, Hopeh 8) Cho-lu, Hopeh 9) Ch'ao-yang, Liaoning 10) Hsiang-ning Hsien, Shansi 11) Ch'ang-chih Hsien, Shansi 12) Heng-ch'u Hsien, Shansi 13) Huai-lai, Hopeh 14) Mi-chia-chuang, Yu-yu, Shansi 15) Ch'en-chuang Chen, Hsing-t'ang, Hopeh 16) Shih-shui, Honan 17) Ho-feng, Chin-lo, Shansi 18) Hsing-t'ang, Hopeh 19) Shansi 20) Ling-t'ung, Shensi 21) Ts'ai-chia-chuang, Hsin-an Hsien, Honan 22) Hsin-an Hsien, Honan 23) Hsien-chia-ying in the vicinity of Ch'eng-te, Hopeh 24) Yu Hsien, Hopeh 25) Pai-hsiang-shui, Lung-kuan, Hopeh 26) Hsiao-ma-p'ing, Chang-chia-k'ou, Hopeh 27) Li-chia-kou, Ch'ih-ch'eng, Hopeh 28) Chi-kuan-shan, Ch'eng-te, Hopeh 29) Honan 30) Shen-ch'ih, Honan 31) Feng-ming-po, Shen-ch'ih Hsien, Honan 32) Chien Hsien, Shensi 33) Primary loess 34) Loess? 35) Loess 36) Zdansky 37) Yang Chung-chien 38) Paleotological Society Bulletin, No. 8, 1955 39) Teilhard de Chardin, Yang Chung-chien 40) Anderson 41) Matsumoto. 42) Yu-kou, Shen-ch'ih Hsien, Honan 43) Yang Chung-chien, Sun Ai-ling

Table 14 Vertebrate Fossils Found in Loess and Loess-like Rocks of the Holocene Period in China

(1) 化石名称	产 (2) 地	层(3)位	来 (4) 源
Elephas indicus L. 印度象	1.河南安阳 (5)		
Capreolus manchuricus Lydekker 满洲斐鹿	1.河北宣化 (6)	(18) 次生黄土	(21) 师丹斯基 1925, p. 87 杨钟健 1932, p. 66
Pseudaxis hortulorum Swinhoe 麋鹿	1.山东(7) 2.河南安阳 (5) 3.河北龙关 (8) 4.河北宣化 (6) 5.河北承德 (9) 6.辽宁朝阳 (10)	次生黄土 次生黄土	松本 1926, p. 31 (22) 德日进、杨钟健 1936, p. 27 (27) 安特生 1923, p. 129 (23) 安特生 1923, p. 129 安特生 1923, p. 129 安特生 1923, p. 129
Bubalus mephistophles Hopwood 圣水牛	1.河南安阳新镇府新镇河 (11)	(19) 全新统沉积	(24) 胡步伍 1925, p. 238 杨钟健 1932, p. 91
Tapirus sp. 貘	1.河南开封 (12)	全新统沉积	杨钟健 1932, p. 91
Struthiolithus anderssoni 安氏鸵鸟	1.河南安阳 (5) 2.河南灌池仰韶村 (13)	次生黄土	安特生 1923, p. 66
Bison exiguus 野牛	1.河南(14)	次生黄土	松本 1915
Bos primigenius Bojanus 原始牛	1.辽河、西拉穆伦 (15)	黄土(20)	(26) 布鲁及德日进 1928, p. 29
Ovis sp. 羊	1.河北(16) 2.张家口附近 (17)	次生黄土	安特生 1923, p. 129 布鲁及德日进 1928, p. 70

Key: 1) Name of fossil 2) Where found 3) Position 4) Source 5) An-yang, Honan 6) Hsuan-hua, Hopeh 7) Shantung 8) Lung-kuan, Hopeh 9) Ch'eng-te, Hopeh 10) Ch'ao-yang, Liaoning 11) Hsin-te river, Hsin-te-fu, An-yang, Honan 12) K'ai-feng, Honan 13) Yang-sh'ao Ts'un, Shen-ch'ih, Honan 14) Honan 15) Liao-ho, Hsi-la-mu-lun 16) Hopeh 17) Vicinity of Chang-chia-k'ou 18) Secondary loess 19) Holocene deposit 20) Loess 21) "Sai-tan-szu-chi" 22) Matsumoto 23) Anderson 24) Hu Pu-wu 25) Yang Chung-chien 26) Pu-lu and Teilhard de Chardin 27) Teilhard de Chardin, Yang Chung-chien

figures are typical because they are the result of sampling collected by many people from many locations (about 100) for many years (about 1923-1962).

Compared with mammal fossils in loess of other regions of the world, richer discoveries have been made in loess of "Wei-la-fang" stage in France only. China has a wide area of loess. The understanding of characteristics of fauna in it and the further analysis of ecological environments are important for the task of stratigraphic division and of explaining the process of accumulation of loess.

Analysis of the composition of mammal fossils in loess of various periods showed that the time from the Wu-ch'eng loess to Malan loess passed through the entire Pleistocene period. The composition of animals in loess of various ages form arid steppe type fauna with unique characteristics. For instance, Myospalax, Struthiolithus, Equus and Capreolus are all typical animals of loess region which are notably different (see Table 10) from fauna adaptable to "heat and humidity" such as Elephas and Rhinoceros which are richly found in river and lake facies deposits.

Among the total number of species, Rodeutia occupies more than 90% of mammal fossils in loess. Rodeutia is still the superior animals in the loess region in recent time, except that there has been some evolution from the ancient time (see Tables 10-14). Beside Rodeutia, other animals are few. Among Carnivora, there are only a few kinds of animal found such as Meles cf. leucurus Hodgson, Vulpes sp., Hyaena and bear. Among Perissodactyla, there are Hipparion, Probascidipparion, Sefve and Equus sanmeniensis Teilhard and Piveteau. Among Artiodactyla, there are Sus sp., Sinomegaceros, Pseudaxis hortulorum Swinhoe, Gazella sp., Spirocerus peii Young, Ovis sp., Bos sp., Bison exiguus and Bubalus sp. Besides these there are even fewer other fossils in loess.

In the Low Pleistocene Wu-ch'eng loess, Rodentia has fewer number of species. In the Middle Pleistocene Li-shih loess, the number of Rodentia animals has notable increase while others decrease relatively. In the Upper Pleistocene Malan loess the number of species decreases gradually.

As noted from mammal fossils studied, the Early Pleistocene environment was believed to be relatively humit but the environment gradually changed to arid in the Middle Pleistocene epoch and more arid in the Late Pleistocene epoch.

The grassland ecological environment of loess region can not only be deduced by the large quantity discovery of Rodentia but also by the distribution of Struthiolithus and other grassland type animals.

Furthermore, the distribution of animals of different habits can

also explain the environment of loess region. For instance, fossils of Carnivora, Perissodactyla and Artiodactyla found were mostly from areas near the mountains and in the southern part of loess distribution region and very few were from central zone of loess plateau. But the distribution of Rodentia is just the reverse. This indicates that the loess region had an ecological environment of grassland. The different geographical distributions of animals of different habits and ecological features indicate the difference of paleogeographical environment.

The occurrence of fossils in loess is generally in small number. Fossils are often found individually in loess or buried soil. Very few appeared in groups. This is different from the occurrence of fossils in the river and lake facies deposits where fossils often in groups as a result of running water transportation. The head bones of Rodentia were mostly found in the precipitated bed of buried soil, forming nodules surrounded by calcareous substance. However, the eggs of Struthiolithus are often well preserved in loess. As noted from the angle of buried fossils, it is believed that the location where they were buried is generally not far from where they died. This also indicates that the fossils had seldom been moved, reflecting the grassland environment and geomorphological landscape during the formation of loess.

As to other kinds of research which might explain the environment of loess region during its formation such as the spore-pollen research (105), buried soil research(76) and petromineral research(25) we will not go into detail here.

(2) The Stratigraphic Position of Myospalax tingi and Its Geological Age

China's loess strata are rich in Myospalax fossils. Based on Myospalax fossils found, Yang Chung-chien and associates divided the red earth into three zones, A, B and C. The B zone of red earth contains large number of Myospalax tingi. At first it was thought that the age of Myospalax tingi-bearing bed is the Nihowan stage (Early Pleistocene epoch) but later the age was determined as the Middle Pleistocene epoch on the basis of new materials discovered. However, some people still believe the Early Pleistocene is the correct age. In order to divide and compare loess strata further, it is necessary to make further discussion on the age of Myospalax tingi bed.

Early in 1927, based on some fossils whose stratigraphic position was not clear, Yang Chung-chien(38) established a new species of Myospalax tingi. At that time, Yang was not sure of the age of the new species, believing that it was probably from the Lower Pliocene Hipparion red bed.

In 1930, P. Teilhard de Chardin and J. Piveteau(106) identified

one upper jaw bone and two lower jaw bones found in the Nihowan bed at Ni-ho-wan Ts'un, Wei Hsien in Hopeh as Myospalax tingi and thus erroneously thought that they had found the stratigraphic position of Myospalax tingi. From that time on people began to consider Myospalax tingi as the typical fossil of Nihowan stage.

When studying the loess strata and paleotology in the region between Shansi and Shensi in the central basin of Huang Ho, P. Teilhard de Chardin and Yang Chung-chien[19] in 1930 and 1931 and Yang Chung-chien[61] in 1935 suggested that the B zone of red earth is equivalent to Nihowan on the basis of Myospalax tingi found. Therefore, it was generally recognized at that time that the age of Myospalax tingi bed is Nihowan. No other typical Nihowan fossil had been found in the Myospalax tingi-bearing B zone of red earth, but no typical Choukoutien fossil had been found to prove that the strata are not of Nihowan stage either.

In 1934, P. Teilhard de Chardin and Pei Wen-chung[60] discovered large number of Myospalax tingi (the name Myospalax tingi was formally established) at location 13 in Chou-k'ou-tien. They suggested that since location 13 at Choukoutien had large number of Myospalax tingi but there was no ancient species of Nihowan stage, the age of the strata should be the Middle Pleistocene epoch and the stratigraphic position should be equivalent to the B bed of red earth designated by Teilhard de Chardin and Yang Chung-chien.

In 1934, based on the fact that the Shansi T'ai-ku red earth is in uncomformity over (erosion plane) the Nihowan T'ai-ku bed, P. Teilhard de Chardin and Pei Wen-chung determined that it was not appropriate to compare the B zone of red earth with Nihowan and they named the B zone of red earth as the Upper Sanmen system (it should be changed to the Upper Sanmen group now according to stratigraphic rules) and its age should be the Middle Pleistocene. The name of Upper Sanmen system (= red earth B zone) was thus formally established (this name had been used in papers by P. Teilhard de Chardin and Yang Chung-chien. The names of Sanmen upper system and Sanmen lower system suggested by Pien Mei-nien have seldom been used. These names should not be confused with the Upper Sanmen system).

In 1935 when studying Cenozoic geology of east Ch'in Ling, G. B. Barbour, P. Teilhard de Chardin and Pien Mei-nien[54] discovered that the red earth was well developed in the areas of Lo-yang, Kao-mei, Lu-shih and Che-ch'uan. They compared the red earth in those areas with that between Shansi and Shensi and designated its age as the Middle Pleistocene.

In 1940 in a paper entitled "The Question of Boundary Between Pliocene and Pleistocene in China" Yang Chung-chien[107] clearly pointed out that the Myospalax tingi-bearing bed was in unconformity over the strata bearing Nihowan fossils. At the same time, he also questioned

the reliability of identification of Myospalax tingi in the Nihowan bed.

In 1941, in a paleotological paper on the study of location 13 at Chou-k'ou-tien, Tailhard de Chardin and Yang Chung-chien designated Myospalax tingi which was named in 1934 as Myospalax epitingi. At the same time, they definitely believed that the age is Middle Pleistocene as proven by the indication of paragenesis of Choukoutien fauna such as Myospalax tingi and Sinomegaceros flabellatus.

In 1941 in a book entitled "Geology of East Asia and Origin of Human Being", P. Tailhard de Chardin designated the Myospalax tingi bed as from the age of Middle Pleistocene and he also explained that based on physiographic position of Myospalax tingi-bearing area in the central basin of Huang Ho he had changed his view regarding the correspondence of the Myospalax tingi bed and Nihowan stage. He then suggested that the Myospalax tingi bed should be later than Nihowan.

In 1942, in a book entitled Newly Discovered Pliocene and Lower Pleistocene Rodentia Animals in the North Part of China P. Teilhard de Chardin(77) systematically studied Myospalax fossils and made some additional observation on this question. He said: "in 1930 (Teilhard and Piveteau 1930) I had reported the discovery of Myospalax tingi in the Nihowan lake facies strata. I wish to make some additional observations here. At the time when the complexity of Myospalax family was not fully understood, the identification was based on the upper and lower jaw bones only. Therefore, the result of examination should be given more cautious consideration. Myospalax of "Wei-la-fang" stage of Nihowan definitely belongs to the "tingi group," but before a complete skull is found at this location more proofs are required to truly identify whether it is Myospalax tingi, Myospalax chaoyatseni or other species" (Teilhard,1942).

Meanwhile, in the systematic evolution table attached to the book, P. Tailhard de Chardin moved the age position of Myospalax tingi up from that of 1934 to the boundary of Early Pleistocene and Middle Pleistocene.

It can therefore be clearly noted that P. Teilhard de Chardin had taken the attitude of reconsideration on the identification of Myospalax tingi found in the Nihowan bed.

In 1942, in a book entitled Classification of China's Mammal Fossils P. Teilhard de Chardin and Lo Hsueh-pin listed Myospalax tingi as typical fossil of the Middle Pleistocene epoch.

In 1948 in a paper entitled "The Plio-Pleistocene Boundary in China" presented in the 18th International Geological Conference Yang Chung-chien(109) designated the Myospalax tingi bed as Middle Pleistocene.

From that time on there had been few reports on Myospalax fossils in loess. In 1958 a book entitled "China's Vertebrate Fossils Handbook (Mammals Portion)" by Chou Ming-chen et al lists the age of Myospalax tingi as from Early Pleistocene to Middle Pleistocene.

In 1959 Ting Meng-lin and other comrades discovered a loess bed bearing Nihowan animal fossils in a loess section (Wu-ch'eng loess) but Myospalax tingi was not found. Above the Wu-ch'eng loess separated by a not prominent denudation plane was a Li-shih loess bed (B zone of red earth) which contained Myospalax tingi, Myospalax chaoyatseni and Spirocerus peii. Moreover, Sinomegaceros flabellatus fossils were found in the position corresponding to this bed which is the Li-shih loess.

The significance of the section is that Nihowan fauna was found in the earth accumulations (a set of loess or red earth) which were overlaid with the Myospalax tingi-bearing bed. This environment is the same as that of the river and lake facies Nihowan bed in the areas of T'ai-ku and San-men where Myospalax tingi has not been found below the Li-shih loess (B zone of Red earth).

It can be noted from the above that why the age of Myospalax tingi-bearing bed /Li-shih loess (Liu, Chang 1961) = red earth B zone (Teilhard, Yang 1930) = Upper Senmen system (Teilhard, Pei 1934)/ was at first designated as the Nihowan stage of the Early Pleistocene epoch but was later changed to the Choukoutien stage of the Middle Pleistocene epoch. We can also understand why Myospalax tingi was first considered as typical fossil of Nihowan stage and such view is not so now. Thus, according to these records and studies in the past it is without question that the age of the stratum containing rich fossils of Myospalax tingi is the Middle Pleistocene epoch.

In order to explain this point,several other indications may be studied.

(1) In the stratum definitely identified as the Nihowan stage, no Myospalax tingi has been found since P. Teilhard de Chardin and J. Piveteau. In the sand gravel bed at Yu-she, P. Teilhard de Chardin(77) had recorded a Myospalax tingi but he was not sure of its position and suggested that it could be from the red earth. Considering that most Yu-she specimen described by P. Teilhard de Chardin were purchased, it is quite natural that the position given was unreliable. It should be specially pointed out that this question should also be given attention inthe loess region because in some areas the Myospalax tingi-bearing bed often formed steep cliff and there is possibility that fossils might have fallen down the slope. In such case, the fossils could not represent the typical fossils in the bed where they fell.

(2) The Nihowan fauna has been quite reliably found in the Sanmen group (in the San-men gorge area) which is corresponding to the

Nihowan stage, such as Eucladoceros boulei which contained Prosiphneus sp. but no Myospalax tingi(110). As far as evolution is concerned, Prosiphneus sp. was a race more ancient than Myospalax and its fossil has never been found in the Middle Pleistocene strata. There were reports of its discovery in the Early Pleistocene strata.

(3) Myospalax tingi has not been found in the Chin-lo group (?) at Chin-lo; but Prosiphneus intermedius and Myospalax omegodon have been found, which are both earlier than Myospalax tingi. The age of Chin-lo group (= red earth A zone?) is connected in A, B and C zones as divided by Teilhard and Yang. If the age in the three zones is moved up (B zone of red earth from Lower Pleistocene to Middle Pleistocene), then the A zone should be Lower Pleistocene which is probably corresponding to the Wu-ch'eng loess (see previous discussions).

(4) Myospalax epitingi found at location 13 in Chou-k'ou-tien was identified by its larger skull by Teilhard and Yang but they did not report other anatomical characteristics. From measurements made by Teilhard and Yang, it can be noted that they coincide with the skull measurements of Myospalax tingi fundamentally. According to present data, Myospalax epitingi should be considered as a sub-species of Myospalax tingi or even the same species (formal determination requires further study on specimen designated by Teilhard and Yang).

The identity of Myospalax epitingi and Myospalax tingi can be made more clearly by studying the statement made by Teilhard in 1941 on the examination of Nihowan Myospalax tingi and by the knowledge that other stratum that contained Myospalax is Middle Pleistocene and not older one and a large number of Sinomegaceros flabellatus and Myospalax tingi have been discovered in the Li-shih loess bed (identical to location 13 at Chou-k'ou-tien).

(5) Myospalax tingi is quite widely distributed in the Li-shih loess (B zone of red earth) in the central basin of Huang Ho. Fossils have been found in many locations. The position it was located is different from that in the Lower Pleistocene Wu-ch'eng loess which is mostly distributed in depressive areas; and it is found mostly at the bottom part of thick bed of loess. As noted from the fact that Myospalax tingi fossils are widely distributed and have been found in considerable number, they are unlikely from the Wu-ch'eng loess.

As far as condition of preservation is concerned, Myospalax tingi is often enclosed by calcareous substance and in nodule form. This is also different from the fact that in the Lower Pleistocene Wu-ch'eng loess calcareous substance often in bedded form.

Although the distribution and preservation of fossils are not the characteristics that could determine their age, these elements are helpful for determining various strata of loess in field work.

As noted from the history of research on the "Myospalax tingi bed" (Li-shih loess, B zone of red earth) and Myospalax tingi itself, there is no reliable report on the theory that Myospalax tingi lived during the Nihowan period, but there are large number of report indicating that Myospalax tingi was in paragenesis with Middle Pleistocene fauna.

According to observations on stratigraphic sections, the Myospalax tingi bed is always separated by a denudation plane from the Nihowan stratum below regardless whether it is on a set of overlapped loess deposit section or it is found between overlapped loess-like rocks and river and lake facies deposits.

P. Teilhard de Chardin and Yang Chung-chien had formally stated their views on the unreliability of the theory that Myospalax tingi occurred in the Nihowan bed, and they had formally moved the age of Myospalax tingi to the Middle Pleistocene epoch.

Now, is Myospalax tingi the typical fossil of the Nihowan stage? Although we can not discount the possibility that Myospalax tingi might have appeared during the Early Pleistocene epoch (particularly in the Wu-ch'eng loess), we still can not definitely consider it as the typical fossil of Early Pleistocene because it appeared in large number with Middle Pleistocene fauna and seldom or never appeared in the Nihowan stratum.

Therefore, before Myospalax tingi is definitely found to be in paragenesis with Nihowan fauna, even the question whether Myospalax tingi lived during Early Pleistocene epoch should be given careful consideration without mentioning it being the typical fossil of Nihowan period. Thus, the age of loess (Li-shih loess) which contains large number of Myospalax tingi should be the Middle Pleistocene epoch instead of Early Pleistocene is even more clearer.

(3) On the Question of Occurrence of Animals Such as Elephas and Coelodonta in Loess

Since Pleistocene epoch, the principal animal fossils in loess are those from Rodentia family. They represented an ecological environment of arid grassland. This is identical to the results from spore-pollen analysis[105] and sediments analysis of loess. But one report which attracted attention is that fossils of Elephas, Coelodonta and other animals adaptable to humid and hot climate [64] have been found in loess. This type of loess was mostly referred to the Malan loess in the past. In early period some had cast doubt on the theory of aeolian deposition of loess because of the discovery of fossils of animals of warm climate habit, and they believed that loess was formed by running water process[64]. If Malan loess does contain large number of animals with different habit from that of Rodentia such as Myospalax, such as Elephas and Coelodonta, then close consideration should be given

to the climatic condition during the formation of loess because even though mammals have greater adabtability to different climate, the character of fauna more or less reflects paleogeographical environment and climatic conditions. This is quite important to the study of the Quaternary period in China and therefore it naturally should be given particular attention.

Before making further study on the composition of animals in loess and their ecological conditions, the places of occurrence of these fossils, the relationship of stratigraphic positions and the characteristics of species must first be determined. In a paper entitled "Geographical Distribution of Quaternary Mammal Fauna in China," Pei Wen-chung(111) had mentioned the discovery of Elephas namadicus, Bos primigenius, Coelodonta antiqutatis and Elaphus canadensis in loess. Among the four kinds of animal fossils, the positions of occurrence of Elephas and Coelodonta have yet to be determined.

It has been discovered from available information that most positions of occurrence of Elephas and Coelodonta are unclear except those not found in loess but in sand gravel bed. An analysis of all records regarding this type of fossil in loess (from Wu-ch'eng loess to Malan loess) showed that the records can not answer this question.

J. G. Anderson had mentioned that it was possible that the perfect Coelodonta skull fossil(64) found in loess or secondary loess was purchased from a drug store in Ch'ao-yang and the location and position where it was found are not known.

P. Teilhard de Chardin and Yang Chung-chien had reported the discovery of fossil they were not sure whether it belonged to "Chu-ch'u" family or Hystrix sp. Its definite stratigraphic position and form of occurrence are also unknown and it is not known whether it came from loess or from the river and lake facies deposit banded in loess.

Elephas namadicus reported by A. T. Hopwood(112) came from Kung Hsien and Hsi-an in Honan, but its stratigraphic position is not known. Another Mammuthus primigenius fossil came from An-yang, Honan and its position is also unknown. A. T. Hopwood used to estimate the age of fossil according to the fossil itself and to compare the age with related geological unit; therefore the stratigraphic position where the fossil was found is unclear.

A piece of broken ivory has been found in P'ing-lu, Shansi. According to record of Yang Chung-chien(61) it was found in the upper bed of red earth. In recent years, a large number of Elephas fossils have been found in the yellow sand bed of Shen-hsien group or Sanmen group below the Li-shih loess (red earth) in the area of P'ing-lu in Shansi by various units. Since the fossils found at P'ing-lu are in small fragments, it is not sure that they probably came from the sand bed.

There was a report about ivory[56] in I-tu, Shantung. But it was reported by a missionary. Its source and position were doubtful because the upper part of that area is the Li-shih loess (red earth) and the lower part is sand bed. It is possible that the fossil came from the sand bed.

Skull fossil[56] of Bubalus brevicornis has been found in the Li-shih loess (in red earth) in Ch'ang-lo, Shantung. It was said that it came from the red earth but its position could not be determined. In the red earth below the Li-shih loess and on the weathered plane of limestone in the vicinity of Ch'i-ho-t'ou, Ch'i-yuan Hsien, Shantung, Wang K'o-lu had found tooth fossil probably from Bubalus sp. Therefore, it is possible that Bubalus sp. fossil from Shantung occurred in the diluvial and eluvial beds. But the point that should be noted is that this area is not only low in latitude (north latitude 36°10") but also near the coast. Its climatic condition should be different from that in the loess plateau region and the distribution of animals should also be different.

Meanwhile, skull[56] of Bubalus brevicornis has also been found in Miao-shan about 15 li from Shen-ch'ih Hsien, Honan. This stratigraphic position was at the lowest part of red earth, possibly the Wu-ch'eng loess.

P. Teilhard de Chardin and Yang Chung-chien[70] had reported unidentified Coelodonta family fossil at Huo-shan, Pao-te, Shansi. This fossil was collected from the lower part of red earth. Its age is Upper Pliocene or corresponding to the Wu-ch'eng loess (?). O. Zdansky[113] had reported the discovery of Chelonia and other fossils at Heng-ch'u, Shansi. Based on these fossils, J. G. Anderson had suggested that they were proof that loess was of aquatic origin. But their form of occurrence and position were unknown. Adansky thought the stratum was typical loess but other fossils indicated that the composition was quite complex (see Tables 12 and 13).

It can be noted from Tables 12 and 13 that very few fossils belonged to animals adaptable to humid climate (except Coelodonta antiqutatis and Elephas namadicus) and these few materials are mostly broken pieces and identification is difficult. More important is that the stratigraphic position and form of occurrence are not known (probably because only few pieces were discovered). For most fossils, it is not known whether they occurred in the primary loess (new and old) or in the sand gravel bed.

Meanwhile, some fossils such as Elephas and Coelodonta fossils which were believed to be discovered in loess deposit or sediments of loessic stage have been clearly recorded as being found in sand bed or sand gravel bed or alluvial lake deposit which are not loess. Therefore, the paleogeographical environment during the loess sedimentation period can not be explained by these fossils which are not the same type

found in loess.

There are very few Elephas and Coelodonta fossils found in the Malan loess (with definite position and form of occurrence). Why very few of these fossils have been discovered even in the older Li-shih loess?

The authors had discussed this question during the national stratigraphic conference of 1959. This question is related to the question of "phase" change during the loess sedimentation period in China and also has a certain relationship with the division of Quaternary strata in China.

In the more than fourty years since the beginning of 1920's, no large number of Elephas and Coelodonta or other water animals (including Mollusca) had been found in real loess (Malan loess, Li-shih loess). Conversely, large number of Myospalax and other Rodentia animal fossils and other grassland habit animal fossils had been found in loess.

In the Malan loess the fossils found are mostly Myospalax fontanieri, in Li-shih loess Myospalax tingi and Myospalax chaoyatseni and in Wu-ch'eng loess probably Myospalax omegodon and Prosiphneus intermedius. The occurrence of large number of these Rodentia fossils indicates that there was special fauna adaptable to the paleogeographical environment and climate during the loess sedimentation period. Up to today the distribution of Myospalax is still within the loess regions.

This is a striking contrast to the occurrence of fauna adaptable to hot and humid climate in the river and lake facies strata such as Nihowan, Ting-ts'un, Ho-ho and Sa-la-wu-su strata. In topographically complex regions, it was natural for the co-existence of animals of different habits in the ancient time. But in the loess plateau region the topographical features are generally identical except certain mountainland areas. Therefore, the question of occurrence in certain strata is very important in the study of stratigraphic division, paleogeography and paleoclimatology.

(4) The Relationship Between Loess Facies and River-Lake Facies Deposits in Northern Part of China

Very few fossils of Elephas and Coelodonta (except Coelodonta antiqutatis and Mammuthus primigenius) and other vertebrate fossils have been found in loess but they have been found in large number in the river-lake facies strata, why? Was it because of climatic fluctuation or because loess and river-lake facies deposits were in different geographical and ecological regions or whether because of both? This question of significance is worth study.

Many positions containing rich Elephas, Coelodonta and other

fossils have been found in the loess region but these fossils were all found in the river alluvial or lake facies deposits of different periods. The Early Pleistocene deposit of Nihowan stage is distributed in Ni-ho-wan, San-men gorge, T'ai-ku, Yu-she, Shou-yang and Lin-i. Various river and lake facies strata of Choukoutien stage are found in Shen Hsien and Ho-ho. The Late Pleistocene river and lake facies deposits of loess stage or Malan stage are found in Sa-la-wu-su, Chien Hsien, Ting-ts'un, Ch'ing-yang and Huai Hsien.

In these areas, the river-lake facies strata underly below the loess formation of different ages.

What is the relationship between the position of these fossils and loess (including red earth)?

Whether these deposits and loess deposits are in the sedimentary relationship of same age but different facies? Or they were deposits of different time and under different climatic conditions? Different persons have different views on this question.

To solve this question is the fundamental task in the study of the Quaternary strata in the northern part of China. It can be solved through the study of fossils or characteristics of fauna contained in these deposits and their process of evolution and also the study of the properties of these two kinds of deposit and their stratigraphic contact relations in field geological work. Of course, these two types of study must finally be consolidated in order to solve this question better. In other word, the question of stratigraphic division is to be solved through the study of both climatic fluctuation and animal evolution (at the same time, the neotectonic movement and geological development history must not be neglected).

In the past some scholars considered loess of different periods (including red earth) and its corresponding (roughly) river and lake facies deposits as same time but different facies deposits. For instance, P. Teilhard de Chardin[7] in a book entitled "Geology of East Asia and Origin of Human Being" had explained this view in 1941. He suggested that in various stages during the Quaternary period in China there were two sets of different types of accumulations - "loess-like" and "river-lake facies." But it seemed that he based on the belief that the climatic fluctuation was not vigorous during the Quaternary period to consider these two types of deposits and did not think that they had something to do with the notable change of climatic conditions at that time. Therefore, he merely made his observation on the angle of difference in facies.

When discussing this question, it should be explained that the phase change of different sediments is an undeniable development and needs not be explained further. In a period when certain climatic conditions prevailed, there were definitely many kinds of genetic type

of deposits which form a series of combined bodies with regional characteristics. Therefore, the subject to be discussed is not the existence or non-existence of phase change but whether the concept of phase change suggested by P. Teilhard de Chardin meets the actual condition of field section. P. Teilhard de Chardinhad mentioned the cyclic nature of China's Quaternary strata and he suggested that the loess-like deposit of each cycle represents eluvial facies and river-lake facies accumulations represent basin accumulation facies. As far as sedimentation is concerned, the two have a relationship of transitional transverse facies. They were formed during the same time. Through actual field observation, we believed that many phenomena observed can not be solved or very few of them can be explained. Moreover, such misunderstanding was responsible for causing inappropriate explanation of field geological sections and resulting in the overlook of stratigraphic units that should be identified.

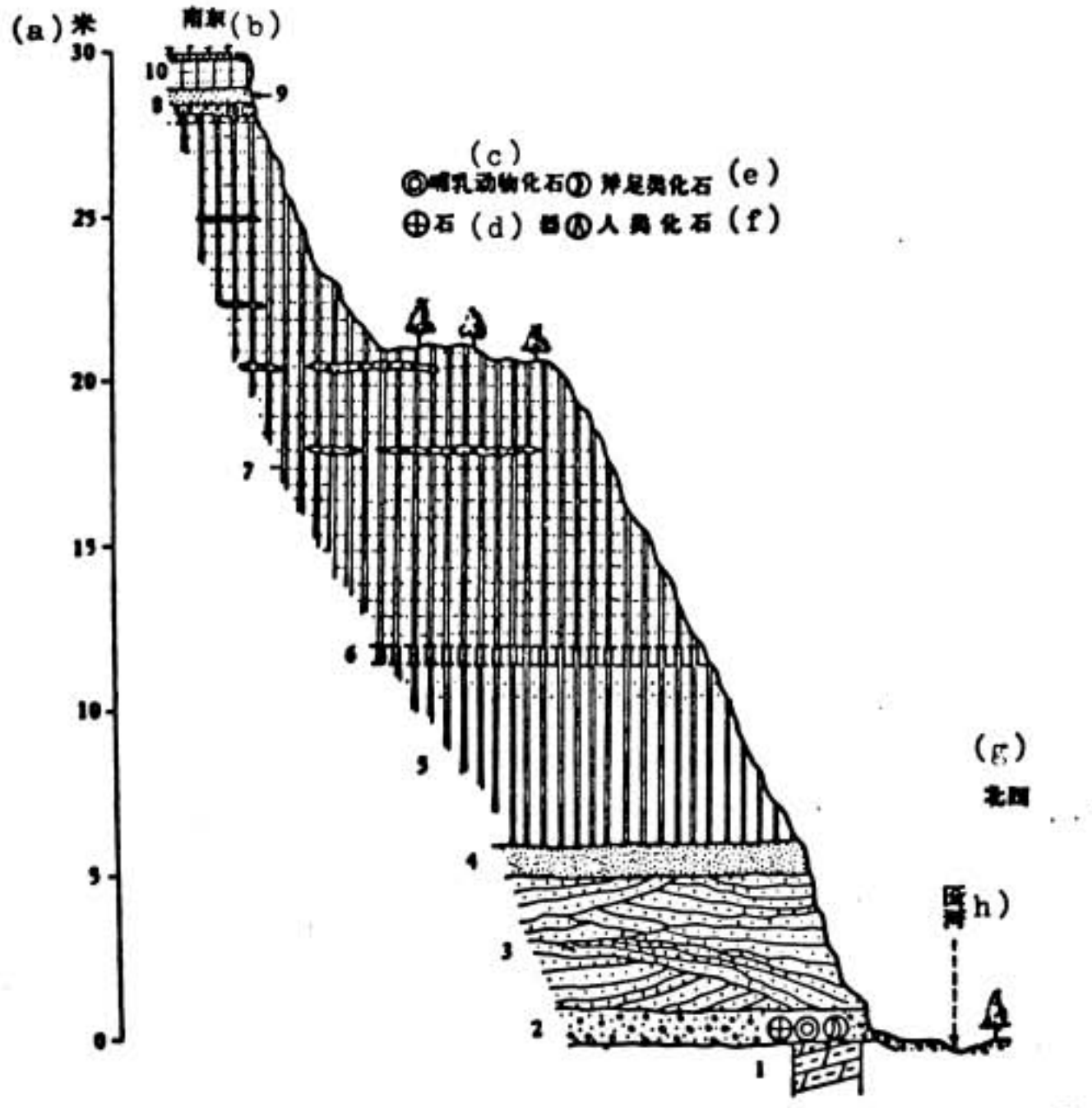
Except making a certain number of diagrams, P. Tailhard de Chardin did not show any concrete section to prove his assumption. However, his sample sections explain the diversion of these two sects of deposits (such as Sa-la-wu-su section, T'ai-ku section, Huo-shan Section, southeast Shansi section). For instance, he often pointed the sections to prove the overlapping of deposits of same time but different facies (such as Yu-fang-t'ou section) but when the form of section corresponded or was similar to his phase change, he had to use the discovered fossils to acertain they were deposits of different period (such as T'ai-ku section).

The Quaternary sections studied in the past and recent can not explain the phase change. On many sections, loess and river-lake facies deposits of different periods appeared alternatively. But because fossils in loess are generally discovered in very small number, there is still lack of more detailed analysis on fauna in loess (loess of various periods, corresponding to the red earth and Malan loess in the earth-like accumulations referred to by P. Teilhard de Chardin and Yang Chung-chien) and river-lake facies deposits, except approximate division of Lower, Middle and Upper Pleistocene and no further. Although there is at present no other method that can be used to more correctly solve this problem on the basis of knowledge on strata, certain other viewd may be expressed on this problem through the acquiring of knowledge of composition of stratigraphic sections, origin and type of materials and contact relations. The author had discussed some sections in 1959 when presenting this problem and will not repeat here again. Recently, Chia Lan-po(114) studied a section at Ho-ho, Pin-ch'eng, Shensi. According to his study, the Ho-ho Pleistocene section can not be divided into the following four formations (Fig. 67):

D. Red earth formation ..... 60 meters thick
C. Fine sand bed ..... 1 meter thick
B. Cross sand bed ..... 4 meters thick
A. Yellow gravel bed, its bottom is in unconformable contact

with the Lower Pleistocene light brownish marlaceous clay. It is about 1 meter thick, containing Stegodon cf. orientalis Owen, Stegodon zdanskyi Hopwood, Euryceros pachyosteus and Bubalus sp. and stone wares.

Fig. 67 Kehejian 6050 and 6060 Geological Sections (According to Chia Lan-po)



Key: 1. Light brownish marlaceous clay, generally dipping 5°-10° toward south, depth unknown; 2. Yellowish gravel bed in which Stegodon zdanskyi and Euryceros pachyosteus fossils and stone wares have been found; number designation for location: 6054; 3. Light brownish crossed fine sand bed; 4. Grayish yellow fine sand bed; 5. Red earth bed, clayey with vertical joints, the lower part is cemented harder than the upper part, the upper part contains more sand, bedding clearer; 6. Brown fossil soil bed; 7. Slightly reddish powdery sand-bearing soil bed, lower part contains less sand than the upper part, slightly clayey, with vertical joints, banded with lenses of

of sand and gravel; 8. Sand gravel bed from which lower jaw bone of "new man" and stonewares have been found; number of designation of location: 6060; 9. Grayish yellow powdery sand bed; 10. Sandy loess. a) Meter b) Southeast c) Mammals fossils d) Stonewares e) "Fu-chu-lei" fossils f) Human fossils g) Northwest h) Ho-ho

Based on fossils, Chia Lan-po and others thought that A - C sand gravel beds correspond to the early deposits of Middle Pleistocene location 13, Chou-k'ou-tien). Regarding the 60 meters thick red earth accumulation, Mr. Chia sand: "It should belong to the red earth (Li-shih loess) system according to its lithological characters." Base on the succesion of loess formations in Shansi and Shensi, we believe that this 60 meters thick accumulation is corresponding to the Li-shih loess. On the relations between the red earth and sand gravel alluvial deposits, Mr. Chia(114) sand this red earth sometimes covers over bedded fine and coarse sand bed, such as at location 6062 (11, Fig. 5) at Nan-kou, Chien-k'ou, locations 6054 and 6060 at Kehejian (5 and 6, Fig. 2) and location 6059 (10, Fig. 5) at Kehejian; sometines it covers over the crossed sand bed such as at location 6051 at Hsi-yang (9, Fig. 5), location 6059 at Kehejian (7, Fig. 5) and location 6052 at Hou-chien-ho, Tu-t'ou (2, Fig. 5) and sometimes covers over marlaceous or argillaceous clay such as at location 6061 (8, Fig. 5), location 6056 at Hsien-shui-kou, Tu-t'ou (3, Fig. 5) and location 6055 at Tu-t'ou (1, Fig. 5); sometimes it covers over the Nihowan sandstone such as at location 6053W at Hsi-hou-tu (5, Fig. 5). Regardless of the difference in the basal rock formation, the properties of red earth are generally the same (Chia Lan-po et al, 1962).

These detailed studies by Chia and associations are very important in the following senses:

(1) Proving the existence of Middle Pleistocene river alluvial facies Shen Hsien group with more complete fossil evidence. The age is the early period of Middle Pleistocene epoch.

(2) Proving that there is a 60 meters red earth (Li-shih loess) over this formation.

(3) Proving that the red earth is in unconformable contact with Middle Pleistocene early alluvial facies Shen Hsien gray sand gravel bed below.

This naturally indicates that there were two sets of deposits during the Middle Pleistocene time, the upper one being the loess facies and the lower one being the river facies. The unconformity between them indicates that they were not phase change but two deposits.

The condition of such section is identical to the Shen Hsien group and the Li-shih loess over it found by the authors(115) in 1957 at Yao-tou-kou in the vicinity of Hui-hsing Chen, Shen Hsien, Honan.

This proves that its distribution is quite wide, its position is steady and it is not a river deposit formed by individual running water action of temporary nature. Although no reliable fossil has been found in the Li-shih loess (red earth) at Shen Hsien and Ho-ho and therefore its geological age and its difference from the underlying sand gravel bed can not be judged, the fact that the Li-shih loess (red earth) has a tremendous thickness and the occurrence of many formations of buried soil in it convinced us that this 60 meters thick deposit can not be completely considered as within the Early and Middle Pleistocene (corresponding to location 13, Chou-k'ou-tien) sand gravel bed deposit. Moreover, according to sectional data given by Chia Lan-po et al, the stratum above the red earth is the newer deposit containing the fossils of human being.

This section can also prove that in the loess region, the Middle Pleistocene loess and alluvial deposit overlap one another.

Such type of two facies deposits have also been found in the Late Pleistocene strata. For example, the section stretching from Sa-la-wu-su to Shui-tung-kou discovered by P. Teilhard de Chardin and associates and the Chien Hsien section studied by the authors are typical of such deposits. At these two sections, the Late Pleistocene loess (Malan loess) and the alluvial or lake deposit below form the divided section.

Regarding the Lower Pleistocene loess (Wu-ch'eng loess) and the river-lake facies deposit below, there is no section indicating their division. However, many Nihowan strata have old loess (red earth) accumulation above them. Whether part of them can be divided and designated the Lower Pleistocene is still unknown.

On the section[19] at Ho-feng, Chin-lo, Shansi, whether the "Chin-lo system" which is composed of river alluvial sand gravel below the red earth is a typical alluvial deposit below the Lower Pleistocene loess is an interesting question. According to fossils found at Ho-fêng, Chin-lo, this is possible.

The section at Ting-ts'un, Shansi, is an interesting one. It is now understood that this river facies deposit whose position has been designated as the uppermost Middle Pleistocene or lowermost Upper Pleistocene has a loess soil containing brown earth type buried soil bed above it is older than the Malan loess. The age relationship between this set of deposit at Ting-ts'un and a set of deposit at Ho-ho is still not known. It is possible that it represents the deposit formed a fluctuated humid climatic condition in the late period of Middle Pleistocene epoch.

It should be mentioned here the basal gravel of loess mentioned in papers published in the past. Part of the basal gravel is probably newer and is the basal gravel of secondary loess accumulation; and part

of it probably represents the alluvial deposit of humid climatic facies formed before the deposition of loess. The sections mentioned by Teilhard and Yang in the past are worth further study.

The study of physiographic period is quite closely related to the Quaternary strata research. One section is presented here to indicate erosion during different physiographic periods. If the erosion represents one humid period, then various different loess accumulations which represent several cycles can be compared with the section just mentioned (Fig. 41).

In the loess region where river-lake facies deposit is lacking, such erosion is represented by several large denudation planes (Fig. 44).

The above mentioned geological section and sections containing fossils discovered in the past several years indicate that they are more complex than the river-lake facies deposits accumulated in the basins during the Early, Middle and Late Pleistocene periods and the accumulations on the mountain slopes. Particularly since the red earth bed is considered loess accumulations of different periods and a product of special climatic conditions (this kind of deposit can be used as an index to distinguish the conditions for the formation of Quaternary deposits), it became clear that further division is required for the Quaternary strata (deposits) in North China.

Neverthless, it can be noted from the above discussion that very few animals adaptable to humid climate were found in loess but larger number of them have been found in river and lake facies deposits. Moreover, it seems that the fauna in these two kinds of deposits can be separated. Therefore, it can be noted from the animal fossils the cyclic nature of climatic fluctuation during various Quaternary periods. Following are several indications:

(1) The loess deposit in the geological section is lying unconformably over the river and lake facies deposit;
(2) From Early Pleistocene and Late Pleistocene the loess and river-lake facies deposit occurred in several cycles successively;
(3) The existence of denudation planes in loess deposits of different periods and several erosion physiographic periods and their corresponding relations with river-lake facies;
(4) The difference of animal fossils in loess and river-lake facies deposit.

The succession of Quaternary strata in the northern part of China as indicated by the cycle of climatic fluctuation is shown in Fig. 4.

(5) The Comparison of Loess Strata

The loess strata distributed in various regions have already

been discussed in previous sections. Preliminary comparisons have been made stratigraphically on loess in the Northeast, North China, Northwest regions and in the central basin of Huang Ho. The loess deposit has two typical types: one is the overlap of loess strata themselves with prominent or unclear denudation planes as represented by the central basin of Huang Ho; another is the crossed occurrence of loess and river-lake facies deposit (Fig. 68) which is well developed in the river valley and basin regions in the east. Of course, in such region due to severe erosion and denudation the strata are not as perfectly overlapping as those in the west of Luliang Shan.

In the Fen river valley region, loess and alluvial deposit form one set of deposit (such as Ho-ho, San-men gorge and Ting-ts'un sections This is most prominent at the Ta-ho river valley area. This form of deposit can also be found in some local areas in some tributary areas. In some low areas thicker loess (such as the San-men gorge section) can be found. In the areas of Sa-la-wu-su and Chien Hsien, Shensi, loess forms fossil river bed overlying with generally thin layer of loess. This type of deposit also includes the so-called basal gravel bed (including red earth with basal gravel section). In certain river valley areas (such as the southeast Shansi basin), areas along the river valley basins and river valley region of Huang Ho, several different terraces represent erosion periods (at the right side of Fig. 68).

The vertebrate fossils found in loess of different periods have been discussed in previous sections, we will not repeat here. The typical mammal fossils found in loess of different periods are shown in Table 10.

Because there have been more stratigraphic studies in the central basin of Huang Ho and North China regions, particularly works by Yang Chung-chien on loess in the central basin of Huang Ho and Shantung area (including red earth), some fossil data can be used for comparison.

The entire loess strata from north Shensi toward the east have a tendency of thinning gradually as indicated by typical sections at Lo-ch'uan, Wu-ch'eng, Ho-ho, Ting-ts'un and southeast Shansi (Figs. 37, 38, 39).

The stratigraphic development in the area north of east end of the Chin Ling range in the Honan region is basically similar to that in Shansi. For example, based on recorded vertebrate fossils found the loess soil in the areas of Hsin-an and Shen-ch'ih has position corresponding to the Malan loess and also has positions corresponding to the Li-shih loess and Wu-ch'eng loess.

As to the distribution of loess strata in the region south of east Chin Ling, according to previous reports(54) the loess soil corresponding to Li-shih - Wu-ch'eng loess is quite widely distributed but

the Malan loess is in lesser distribution.

Yang Chung-chien(56) had found Ovis shantungensis in the red earth bed at the bottom of loess in Shantung. This fossil is also found in the Nihowan stratum and is an animal fossil of "Wei-la-fang" stage. Therefore, Shantung loess can probably be compared with the Wu-ch'eng loess. The red earth in the area of Ch'ang-lo has fossils of Bubalus brevicornis, Sinomegaceros sp. and Pseudaxis grayi (Sinomegaceros sp. was originally named Pseudaxis magnus by O. Zdansky). This part of loess can probably be compared with the Li-shih loess. It also contains Myospalax tingi (I-tu, Shantung).

The Malan loess at the uppermost section is more easily be compared with that in other areas in North China and the loess plateau region because their form of occurrence and lithological characters are similar.

Although loess is not very thick in Shantung and it is not widely distributed, its time of deposition extended possibly from Q_1 to Q_3. Its lithological characters can also be compared with those in other areas.

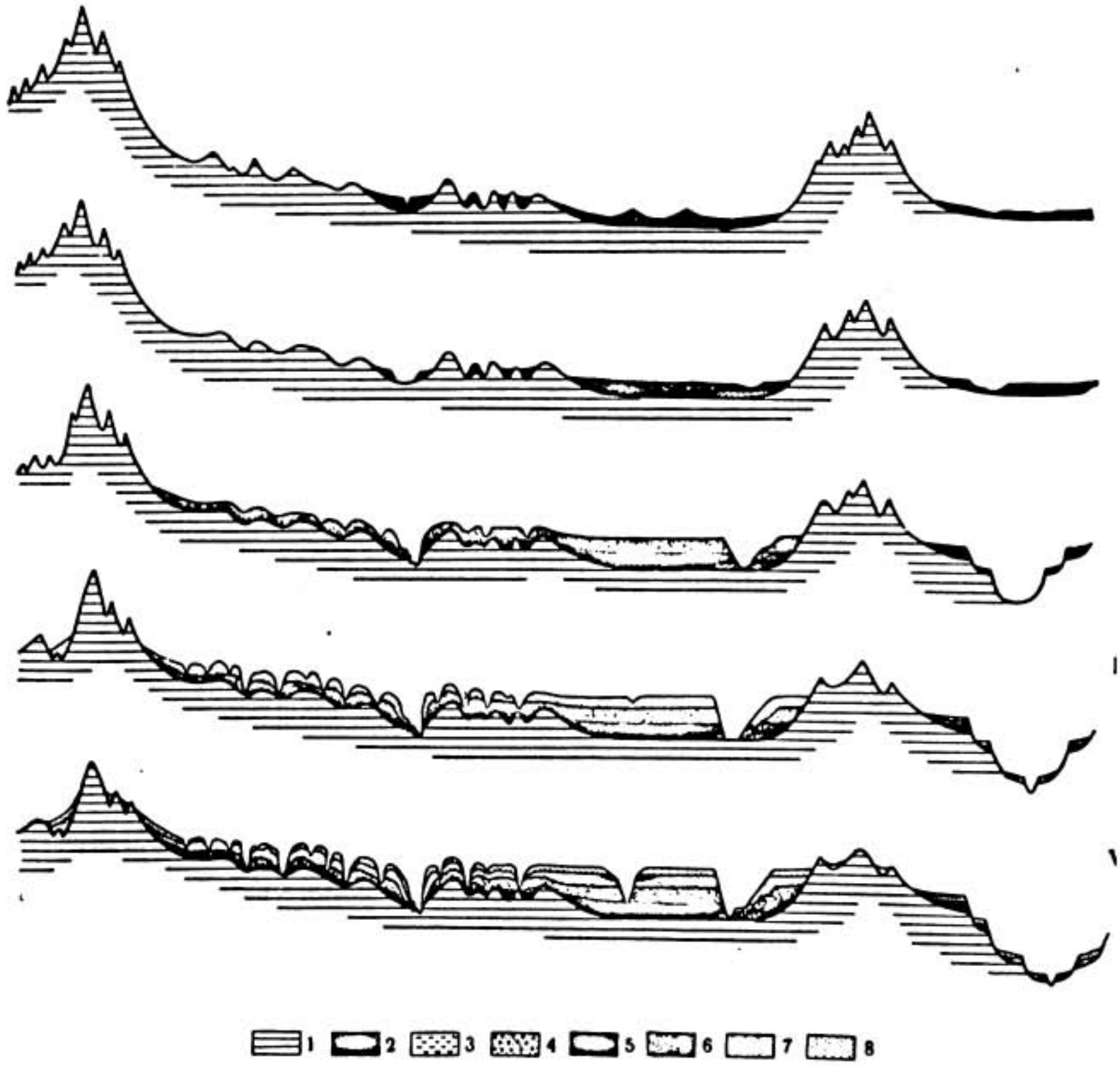
In the North China plain region, comparison can not be made at present because most strata are buried. The geomorphological position of loess and its stratigraphic development at the eastern foothills of T'ai-hsing Shan and around the southern slope of Yenshan are basically similar to those in the Shantung area.

The loess soil is more widely distributed in certain intermontane basins north of Yenshan and in certain transitional areas to the north toward the Mongolian plateau. Its thickness is also greater. The fossils found in the past in these areas were mostly from the Malan loess. Very few of them were found in loess of older periods.

In the northeast region, no Middle Pleistocene and Lower Pleistocene fossils had been found in loess. Whether this stratum is corresponding to the Li-shih loess which contains buried soil in the loess plateau region or Wu-ch'eng loess is not sure. Like in North China, most Middle Pleistocene and Upper Pleistocene strata in the Northeast are buried at the lower part of basins and are not exposed above ground. Only in the Sung-liao dividing ridge region and few areas along the mountain edges the strata correspond to the Middle Pleistocene but there lacks fossil evidence. Studies by Japanese at Ku-hsiang-t'un in Harbin suggested that there are Middle Pleistocene strata. But it has been indicated recently that that was an error in the examination of fossils.

These faunas can be considered as fossils of "rainy period facies," and are different from those found in loess. But the discovery of these fossils was very useful for the determination of the geological age of Malan loess above.

Fig. 68 Sections Showing the Process of Deposition of Loess of Different Ages in China



Key: 1. Bed rock; 2) Hipparion red earth (Early Pliocene); 3. Clay, sand, gravel (Early Pleistocene Nihowan deposit); 4. Sand, gravel; 5. Wu-ch'eng loess (Early Pleistocene); 6. Lower part of Li-shih loess (Middle Pleistocene, early period); 7. Upper part of Li-shih loess (late period of Middle Pleistocene); 8) Malan loess (Late Pleistocene). I - Paleotopography at the end of Pliocene epoch II - Paleotopography at the end of Early Pleistocene epoch III - Paleotopography at the end of early period of Middle Pleistocene epoch IV - Paleotopography at the end of late period of Middle Pleistocene epoch V - Paleotopography at the end of Upper Pleistocene epoch

P. Teilhard de Chardin had mentioned that the faunas in loess (now considered as of the Late Pleistocene time) are different to the south and north of north latitude 42° (Yenshan is the dividing line). To the south of this line the fossils are mainly Dicerorhinos kirkbergensis=merki and Elephas namadicus. To the north the principal fossils are Coelodonta antiguitatis and Mammuthus primigenius. Recently, in studying fossils found in Yu-shu in the Northeast, Chou Ming-chen(40) also mentioned that the fauna of Upper Pleistocene in the Northeast consists of mainly Mammuthus primigenius-Coelodonta atiguitatis fauna.

It should be noted that in Europe Coelodonta atiguitatis and Mammuthus primigenius have also been mentioned as animals of loess grassland in addition to certain animals of Rodentia genus.

The fauna of the loess stage in the Northeast was similar to that of loess period (Upper Pleistocene) in Europe. But loess is less developed in the Northeast than in the loess plateau. It is probable that the loess distribution and properties in the Northeast region are more identical with those in Europe and had more closely relations with the ice age. This also illustrates that as far as distribution and properties are concerned, loess in the loess plateau had different sedimentary environment from that of European loess. According to recent knowledge, the distribution of Coelodonta atiguitatis fossils is quite common in the central basin of Huang Ho such as at Ting-ts'un and Sa-la-wu-su and even reaching Ch'ing-yang and A-pa. Its distribution is more complex than previously imagined.

Fewer vertebrate fossils have been found in loess in the Northwest region west of the Ho-hsi Corridor. Greater comparison is therefore more difficult to be made on strata according to paleontological features. In the eastern area of Tsinghai, the succession of loess strata is fundamentally identical with that in the loess plateau (see Fig. 69). Further westward to Sinkiang, the thickness of loess is the same as that in the Northeast region and it thins gradually. Some authors such as H. De Terra(92) compared it with the Malan loess in North China on the basis of lithological characters and geomorphological position. But whether there is older loess below it is still unknown due to lake of fossil evidence. There is possibility that the thickness of loess increases in the southwestern part of Sinkiang as a result of wind blow from the west. As to whether the genesis of loess in this area is more complex than that in other areas, the answer is more on affirmative side. Thus, the comparison of its strata is also more difficult.

(6) On the Comparison of Loess and Other Quaternary Strata and Physiographic Period

The study of physiographic period in North China has a quite long history. This research effort has an important significance in

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