Only a small number of plants are adapted to alkaline ground, and most of them have a very wide distribution, found on like localities and along the seashores of the northern hemisphere. I have not noted anything peculiar to Shansi among them.

Of course the most saliferous grounds are perfectly sterile. But according to the decreasing percentage of alkalines in the soil the plants are coming in. The most salt-hardy ones are *Salicornia* and *Suada*. Of other characteristic plants noticed in Shansi the following may be mentioned: *Atriplex roseum* and other species, *Kochia*, *Corispermum*, *Salsola*, *Chenopodium*, *Phragmites communis*, *Agrostis stolonifera*, *Scirpus maritimus* and other species, *Spharophysa salsola*, *Aster tripolium*, *Glanx maritima*, *Tamarix sinensis*, *Andropagon*, etc. In the salt waterpools are always *Ruppia* and *Zannichellia* to be found, and in less salsiferous ones *Ceratophyllum* (2 sp.) and *Potamogeton* (several species.)

(*To be continued*).

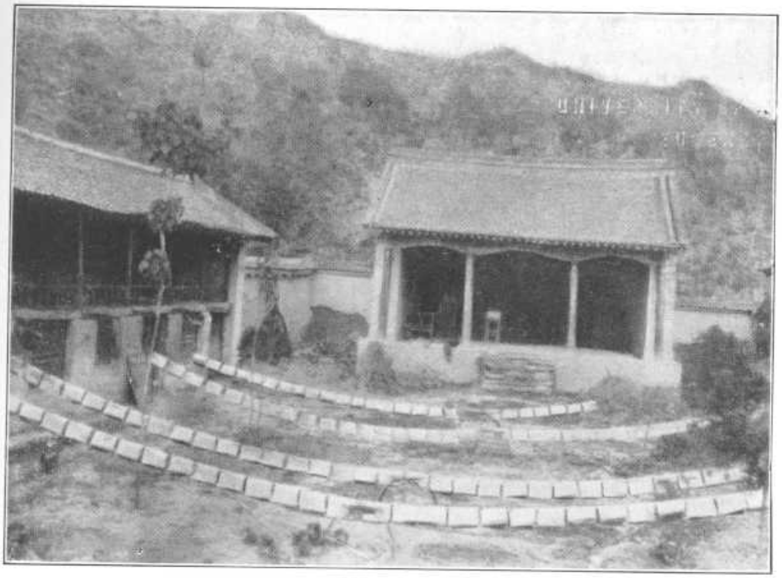
THE LOESS OF CHINA

BY

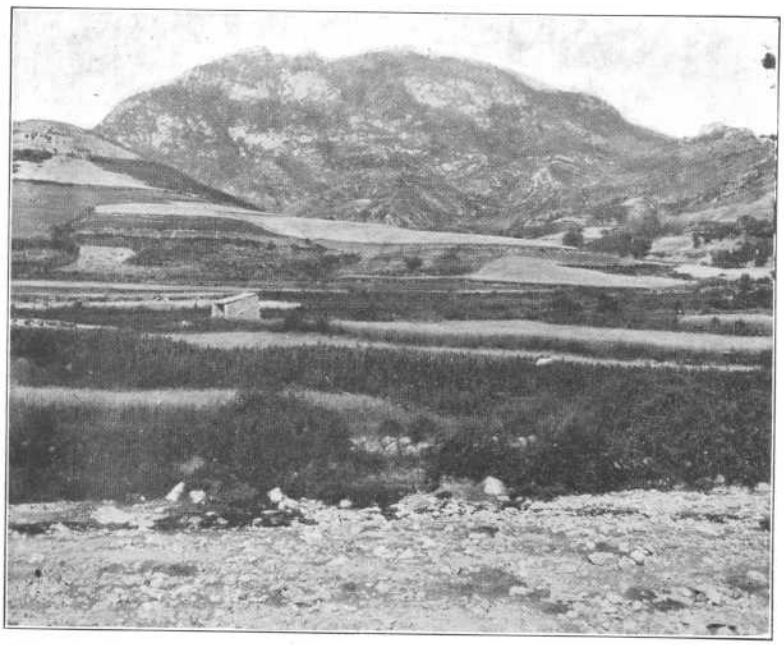
GEORGE B. BARBOUR.

Introduction.

Every traveller who returns from a first up-country tour in Chihli or Shansi has some comment to make upon the curious sights of the loess country, if not a photograph to show of picturesque canyons or quaint cave-dwellings. But despite frequent literary references to loess in China from before the days of its description by the explorer Baron v.



Drying Paper for the Collections. The Temple of Wu-li-tsun, July, 1924.



Pa-shui-kou Shan from the North. In the foreground are Fields with Oats and Hemp. September, 1924

Richthofen (10-56)* until to-day, any attempt to get at facts about its true nature and origin reveal how limited our actual knowledge is. For instance, careful enquiry has so far brought to light only three chemical analyses, none of these being in print. Descriptive notes, each usually from a different point of view, may be found scattered through articles or chapters by various authors.

Detailed descriptions of its occurrence are given in the researches of v. Richthofen and Willis. In recent years by far the most critical study has been that contributed by Dr. J. G. Andersson, Mining Advisor to the Chinese Government, based upon geological field work by Dr. Zdansky and himself. Dr. Andersson's conclusions are embodied in the Geological Survey's Memoir on the Cenozoic of North China. (1-121).

No attempt seems to have been made recently to bring together more than one aspect of our present knowledge. Such an attempt may now serve to unify the results so far gained, and act as a basis for later more complete scientific study. A summary of this kind does not aim at being exhaustive, and avoids more than passing reference to disputed points which are discussed elsewhere. At the same time, in this instance it is possible to add also certain field and laboratory observations recorded here for the first time. Prof. E. O. Wilson of Yenching University, Prof. T. New of Tsinghua College and Prof. W. C. Lowdermilk of the University of Nanking have placed at my disposal the results of research they have carried out, in each case making valuable contributions which fill important gaps in our previous knowledge. I am glad of this opportunity to express my appreciation of their generous co-operation.

Distribution of Loess in General.

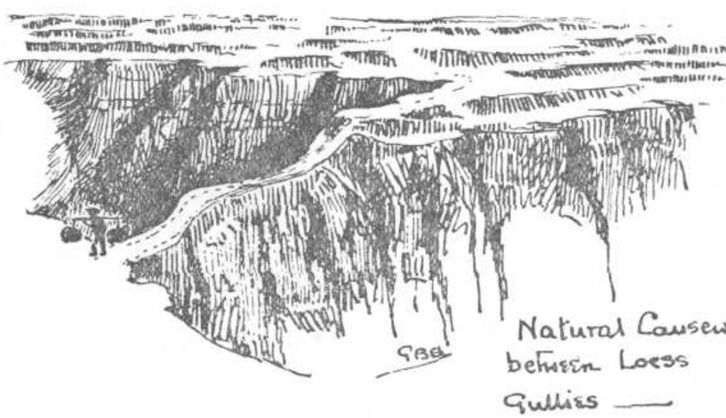
Loess is an important fine-grained loam formation, wide-spread in various parts of the Northern Hemisphere. Its uncompacted nature won the name " loess " in the German Rhineland, where it forms a soil of high fertility. It is widely developed in a farmland belt that stretches across North-east France and Belgium and extends irregularly into Poland, Czecho-Slovakai and Roumania. In the United States it covers large parts of Ohio, Indiana, Illinois, Iowa, Kansas and Nebraska, with a long southern projection through Missouri down the east bank of the Mississippi.

Even in Asia, China has no monopoly of the loess. According to v. Tillo (4-566) loess covers 511,150 square miles, or 3 per cent. of the continent. Assuming an average depth of 30 metres, Walther has calculated that this represents a volume of 40,000 cubic kilometres of material, almost all produced by rock-decay in arid regions (11-193). Sven Hedin and other travellers report it from places in the interior.

The Loess of China.

In China, loess is strongly developed throughout the basin of the Yellow River, and at other places in Chihli, Shansi, Shensi, Honan, Kansu

*Note—References, where not given as footnotes, are indicated by two numbers, the first that of the publication as listed in the Bibliography at the end of the paper, the second the page quoted in that volume.



and Shantung. Small accumulations are reported from Anhui, Kiangsu and elsewhere.

It should be said at the outset that in the case of the Chinese loess, the term has been used to include other deposits, which, though somewhat similar in appearance, differ vastly both in age, composition, character and mode of origin from genuine loess. This confusion has given rise to the very exaggerated estimates of its thickness recorded by many observers. Von Richthofen gives figures of 500 and 600 and even 1,500 feet, and one reads travellers' references to "hundreds of feet of loess." But it is doubtful if there exist outside of Kansu deposits of much more than 200 feet thickness, the deeper deposits proving almost invariably to include the under-lying Hipparion clay, or more recent gravels, silt and "re-deposited loess." Andersson (1-123) gives 60 m. as the maximum thickness of true undoubted loess observed in any place.*

A second cause for such over-estimates is the failure to realize that loess was spread by wind over a valley-dissected land surface. Hence, though often found at considerable altitudes, it may have no greater vertical depth there than it does on the lower valley slopes, just as the back rows of an amphitheatre are under no obligation to be taller than those in the front seats.

The true Chinese loess is a yellow-grey poorly-consolidated loam deposit of the fineness of silt, which shows a characteristic absence of horizontal layer structure, being essentially non-stratified, and a tendency to split along roughly vertical joint-planes, so as to form perpendicular cliffs and walls. No attempt is made here to describe the remarkable erosion features, natural arches, crevasses, pinnacles, sinks, etc., common in loess regions. These are well described in such articles as those of Fuller (3-570) and Sowerby (2).

*In conversation Dr. Andersson has mentioned that recent careful observations in Kansu have showed that in one or two places this maximum ought to be increased by some 20 or more metres. Dr. George B. Cressey has measured cliffs over 300 feet high near Sui-te-chow on the west bank of the Yellow River in Shensi. Even greater thicknesses may exist in a few restricted localities.

The Collapse of Part of a Verticle Loess Wall undermined by recent river erosion.

Photo by J. E. Baker

A Village in the Loess, Shansi. The Scale is indicated by the animals in the foreground.

For the most part it is non-fossiliferous, the only animal remains found in any quantity being the shells of small non-marine snails (*Helix*, *Pupa*, etc.) But mammal bones are found in small numbers scattered over the wide area in which loess occurs. Dr. Andersson's list of those recorded by different observers includes elephant, hyena, hippopotamus, horse, stag, turtle and a vole-like rodent, commonly known as molerat *(Myospalax)* (1-127). A fossil of special interest is the ostrich egg (*Struthiolithus*), which seems to be fairly widely distributed.* One such was found at Ch'enchow by Mr. Max Engel of Peking, 25 feet below ground level when digging a well. Its length is 180 mm. The photograph which he kindly allowed me to take, shows clearly the calcareous incrustations often found attached to the surface of such fossil eggs. Though complete eggs are rare, broken bits are more frequently found; I have found fragments in eight localities within a radius of a few miles of Kalgan, which tallies with observations in other regions.

Chemical Analysis.

Failing to find any published quantitative description of the material which composes it, I examined typical specimens of loess from Chihli and Honan; the former was collected from a point ten miles south-west of Hsuan-hua, in Northern Chihli the latter was kindly furnished by Dr. W. H. Wong, Director of the Geological Survey. The latter material was very kindly analysed for me by Prof. E. O. Wilson in the Department of Chemistry, Yenching University. For comparison, the analysis given in his report is here set beside analyses of loess soils from the Rhine Valley, from Switzerland and three from America, showing the wide range of variation in composition of loess.†

	1	2	3	4	5	6
SiO_2	64.22	58.97	71.09	81.13	69.66	86.96
Al_2O_3	18.1 (with Fe_2O_3)	9.97	16.78 (with Fe_2O_3)	8.52	12.71	4.69
Fe_2O_3		4.25		2.92	4.89	2.86
CaO	6.31	11.31	1.81	.31	1.09	.71
MgO	2.09	2.04		.39	1.28	.43
Na_2O	0.22	0.84	.23	.52	1.17	1.07
K_2O	0.99	1.11	1.30	1.78	2.42	.91
TiO_2				.78	1.72	.69
P_2O_5			0.11	.08	.15	.07
N				.11	.23	.11
CO_2	4.1	11.08	.80			
MnO_2	tr.					
H_2O at 110°	.73					
Loss on ignition	1.81					

*See Andersson "On the occurrence of fossil Struthionidae in China" (1-53).

†Since this paper was prepared for the press, I have been so fortunate as to receive from Dr. W. H. Wong, Director of the Geological Survey, two further analysis of Chinese Loess examined by him. These analyses were presented by Dr. Wong at a recent scientific meeting in Nanking and will appear shortly in the Chinese journal "Science" (K'o Hsüeh).

1. Loess from Honan, analysed by Prof. E. O. Wilson.
2. Loess from Rhine-valley (Bischof, Chemical Geology).
3. Loess from Neubad, Switzerland (7-318).
4. Memphis silt loam, Miss. (Robinson, U.S.D.A. Bull. 551, 1917).
5. Loess soil, Cherokee, Kan. (Bennett, Soils and Agriculture, 1921).
6. "Silt loam," Weeping Water (Alway quoted 6-63).

It is clear from the range of composition shown by these samples from widely separated localities, that the reasons for the peculiar characteristics common to them all must have a physical, rather than a chemical, basis, and be a result of the size, shape, and relative position of the grains rather than the minerals that compose them.

MINERALOGICAL AND MECHANICAL ANALYSIS.

Viewed microscopically, loess presents the appearance of Fig 1 which is a *camera lucida* drawing of the grains of the Honan loess already referred to, enlarged 104 times.*

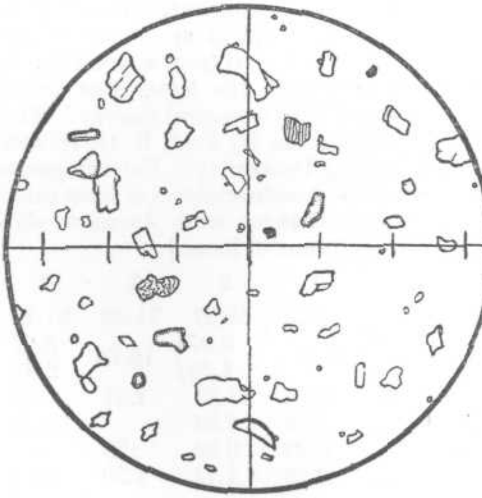
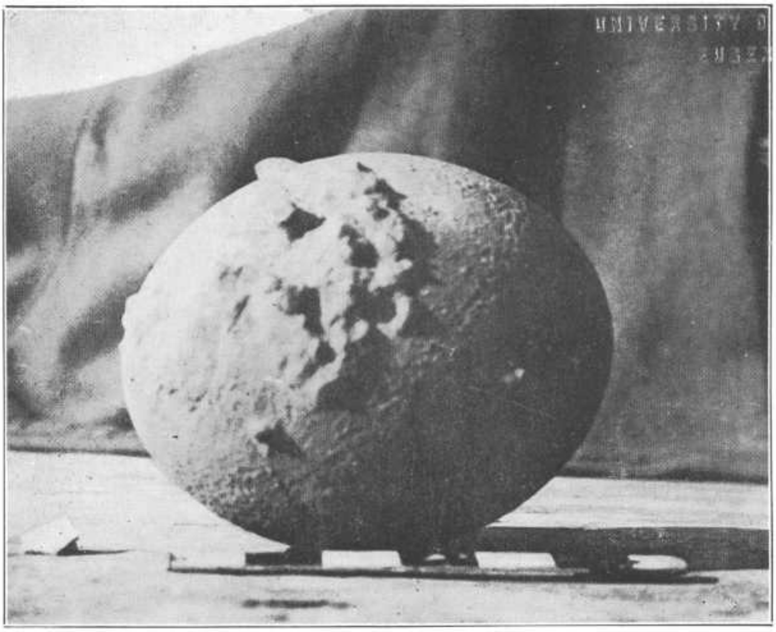


Fig. 1

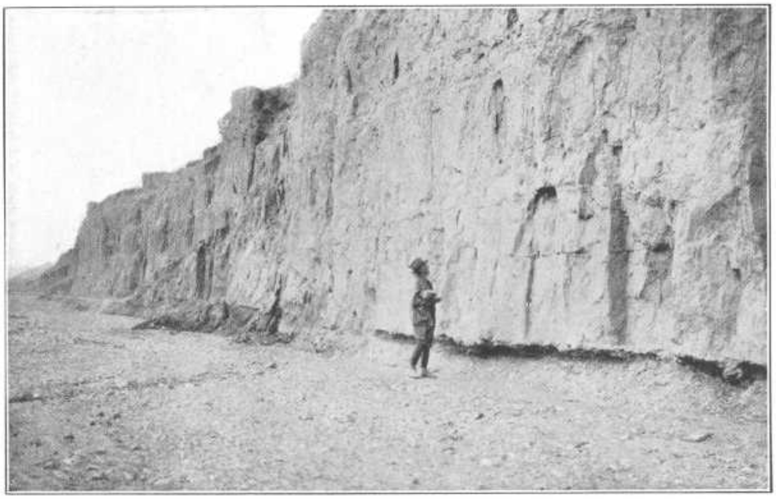
Grains of Loess from Honan (Magnified 104 times).
The Graduations on the Cross-wires indicate $\frac{1}{10}$ mm.

Working at 400 magnifications, it is not possible to make accurate quantitative observations on the very finest particles without first separating these from the coarser silt grains to which they cling. Hence, in the absence of apparatus for elutriation, the material of diameters below .005 mm. was disregarded; a major part of this is probably clay, with some limonite, but no attempt was made to determine physically

*Cf. also G. F. Merrill (7-317) Fig. 33 "Chinese Loess."



A Fossil Egg of the Giant Ostrich (*Struthiolithus*) from the Loess.



"Re-deposited" Loess, showing Gravel Layers.

what percentage of the total amount was fine enough to be so graded. Excluding these extremely fine particles, the average diameter of 758 grains in this sample was .0124 mm. Thus according to the U.S. Bureau of Soils classification, the bulk of the material falls within the limits of silt (.005—.05 mm.). The outstanding features are the angularity of the grains (which in many cases are pratically free from traces of rounding), and the surprisingly fresh condition of the mineral grains, many of which are still almost unattacked by weathering. The determination of the various minerals proved hard at first, as, owing to the extreme fineness of the particles (averaging, as noted above, less than 5 ten-thousandths of an inch in diameter), the ordinary methods of rock microscopy had to be replaced by special tests. By these means it was possible definitely to identify quartz, biotite, orthoclase and plagioclase felspar, hornblende, carbonate, kaolinite and apatite in approximately that order of abundance, together with some grains of one or two other minerals which, in the absence of means for making further more delicate tests, could not be determined with certainty. If allowance is made for the fineness of grain of clay, of which a relatively large percentage would fall below the minimum size determinable, the kaolinite might perhaps stand a little higher on the list in an analysis of the total material. To the naked eye this sample has a somewhat unusually high biotite content.

In connection with a more extended piece of research from a different point of view, Prof. W. C. Lowdermilk has analysed loess-soil material from Shensi in the Department of Forestry, University of Nanking. Professor Lowdermilk has most generously placed his preliminary results in my hands. The mechanical analyses were carried out using two samples from an uncrushed block of loess from Liu-lin on the Red Cross Road near the Yellow River.

Sample 1.

		%
(*a*) Percentage of sand and silt by settling	.. ..	80.01
Percentage of clay ..	.. ..	19.46
	Error	.55
		100.00

			%
(*b*) Sieve study.	Grains over 0.1 mm. diam.	.. ..	2.15
	Grains under 0.1 mm. diam.	.. ..	97.85
			100.00

(*c*) Micrometer study

Class	Average diam. of particle	%
Fine sand	0.13 mm.	1.59
Very fine sand	0.065 mm.	27.44
Silt	0.033 mm.	50.97
Clay	0.0035 mm.	20.00
	Error	.10
		100.00

Sample 2.

		%
(*a*)	Percentage of sand and silt by settling	81.70
	Percentage of clay	18.30
		100.00

(*b*) Micrometer Study

Class	Average diam. of particle	%
Fine sand	0.10 mm.	1.00
Very fine sand	0.063 mm.	25.00
Silt	0.030 mm.	54.00
Clay	0.004 mm.	20.00

Soil Characteristics of Loess.

Reasoning *a priori* from the mineralogical and chemical analyses above, it might be expected that loess would differ in several respects from normal river silts of corresponding texture. These latter, owing their fineness to prolonged wearing-down by stream action, and exposure to the attack of chemical weathering, tend to form products of relatively stable composition (especially silica, ferric hydroxide and clay), from which the more soluble elements have been removed. Such clayey soils let water permeate only with difficulty, are sticky and heavy to till, and may call for fertilization by the addition of those chemical elements desirable for plant growth, which have been gradually leached out by the solvent action of water. In these points Chinese loess shows a strong contrast. The analysis above is of special interest in showing how fresh and undecomposed much of the material of true loess may be, the minerals being those commonly found predominating in ordinary unweathered granite and allied rocks, and appearing actually almost less affected by alteration than the weathered surface of any average rock. It may be said here in anticipation that this seems to form additional evidence in favour of the now generally accepted belief that such loess is in the main, a windblown deposit formed under arid or steppe conditions.

Despite extended enquires, I failed to discover published records of any experiments carried out with a view to testing either the porosity of Chinese loess, its capillary capacity, hygroscopic or other co-efficients. Learning of this Prof. T. New of the Department of Agriculture, Tsinghua College, undertook a capillarity experiment and made daily observations over a period of four weeks of the rate of rise of water in a sample of somewhat impure loess soil taken from near the college. As will be seen from the record he has kindly furnished (see Note at end of paper), the results of his two experiments are strikingly consistent and of a high degree of accuracy, and they form an illuminating addition to our knowledge. In Fig. 2, I have expressed in graphic form Prof. New's observations and placed them beside similar data recalculated from Hilgard's researches* on certain California soils. It will be noted at once how closely the loess conforms to the broken-line curve representing the rise of water in Gila River alluvial soil, and how much more rapid it is than that of the Ventura silt soil (dotted).

*Hilgard, "Soils," New York, Macmillan, 1919, p. 202.

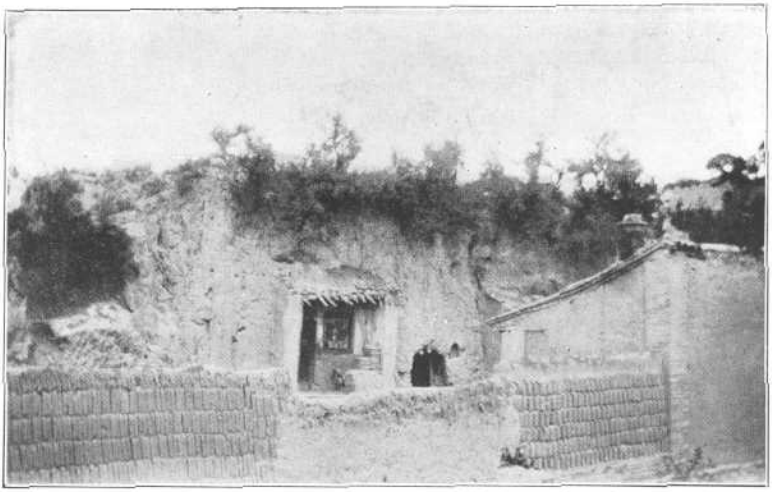
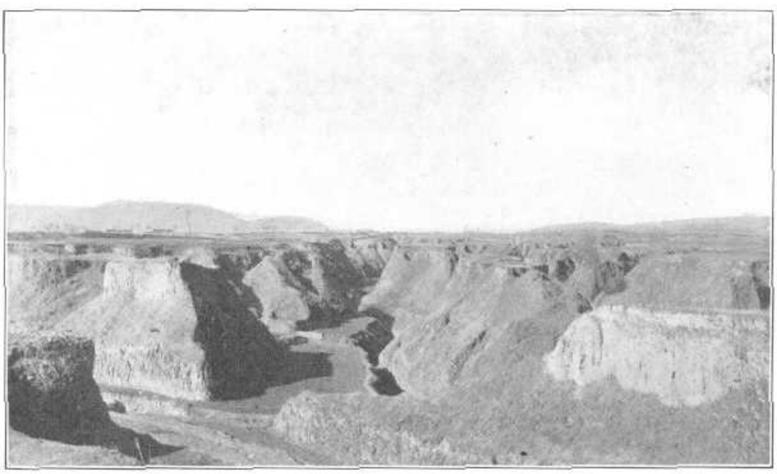


Photo by Miss Blanche Hodgson

A Cave Dwelling in a Loess Cliff.



A Dissected Loess Plain near Kuo Ts'un, Hsüan-hua Fu, North Chihli.

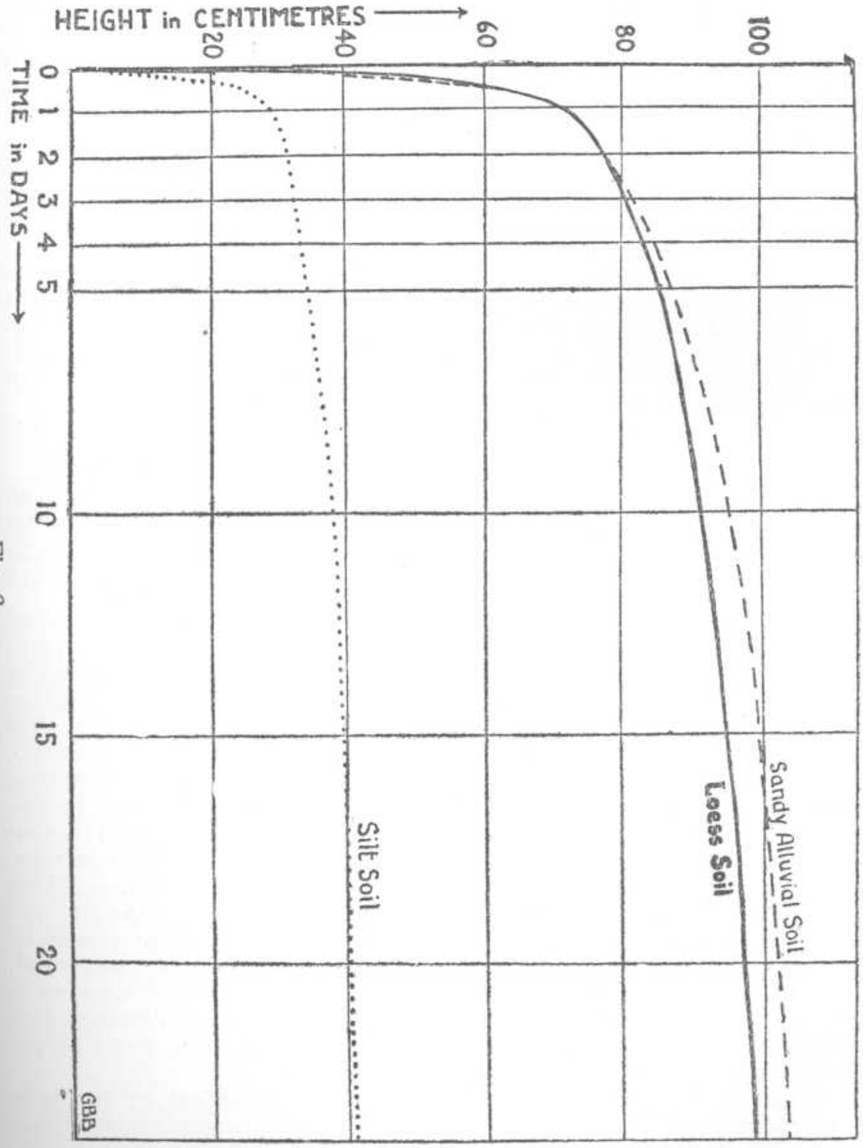


Fig. 2

If given adequate time to rise, of course, the general principle holds the same as that for fine glass tubes, namely that the finer the capillary spaces between the particles, the greater height to which water will ultimately rise. In practice, however, the presence of clay seems to modify not only this effect but also the rate at which moisture rises.

The Gila River soil is very markedly coarser than the Ventura, but Hilgard explains the slower rise in the latter as due to the fact that it has almost five times as much clay. Applying the same reasoning to Prof. New's results, we are doubtless correct in asserting, that we are dealing with a material of relatively low clay content for one of such fine grain—a conclusion borne out by microscopic analysis.

Professor New also carried out experiments to show the distribution of the capillary moisture in a column of loess soil. The detailed record of his quantitative observations in both sets of experiments will appear as a note at the end of this paper.

In connection with investigations along different lines Prof. W. C. Lowdermilk has recently determined the pore space in (*a*) "loess" and (*b*) "alluvial loess" as 47.84 per cent. and 45.33 per cent., respectively. During the course of the same research he calculated the water-holding capacity of a pulverized sample of loess from near Tungkwan, Shansi on the Yellow River.

Water-holding Capacity of Loess (Lowdermilk)

	%
Per cent. of water to saturate—based on dry weight ..	36.65
,, ,, ,, ,, ,, ,, ,, wet soil weight ..	26.82
,, ,, ,, retained after 1 day—on dry weight ..	33.93
,, ,, ,, ,, ,, 2 days ,, ,, ..	33.15

There is as yet a dearth of quantitative data as to the favourableness of loess as a soil. No information could be obtained as to the extent to which cropping of the soil in China through past years with the soya bean and other legumes, has enriched (or impoverished) it, especially in the matter of nitrogenous compounds, though there is no question that farmers have discovered experimentally, through centuries of practice, the penalties of non-rotation of crops; this knowledge and the universal practice of manure fertilization makes it hard to isolate the results due to any one factor. Certain generalizations, however, are possible, particularly where based upon experience of loess soils in other countries. Lyon and Buckman state, for instance, that under heavy cropping, where little organic or mineral matter is returned, loess soils need the addition of phosphoric acid and lime (6-63)—a deduction that might almost be made directly from an inspection of the analyses given above. In general, they say, whenever moisture relations are favourable loess is an exceedingly fertile soil. Since the Chinese loess often already carries a high lime-percentage and the practice of manuring is universal, water supply becomes the vital factor.

These theoretical conclusions seem to be borne out by the facts wherever observed in the field. During water-supply investigations along the foothill area west of the Peking-Hankow Railway in the Tingchow-Shuntehfu region, I noticed that, though the loess was porous enough to take up immense quantities of water,* the fineness of its grain

*Slichter notes that the pore space in fine alluvial clays may amount to 40 or even 60 per cent. of the total volume. (U.S.G.S. 19th Annual Report Part II 1899, quoted by Willis, p. 250) Cf. v. Rrichthofen.

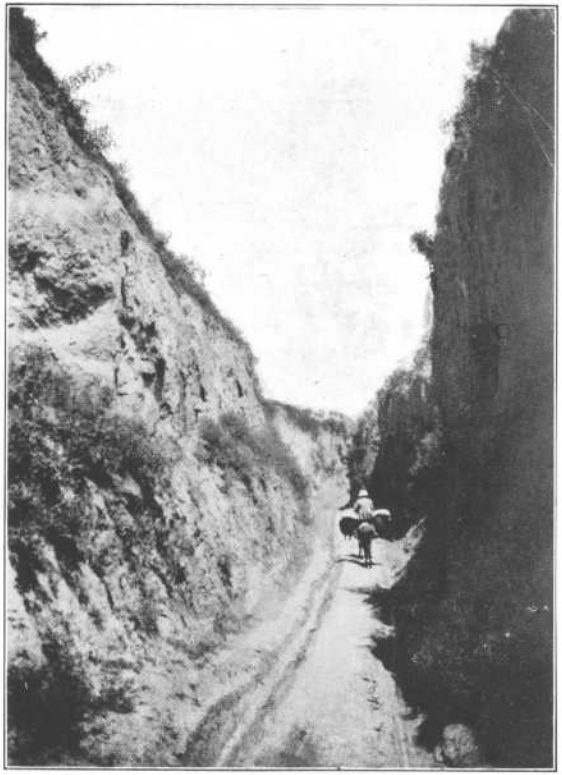
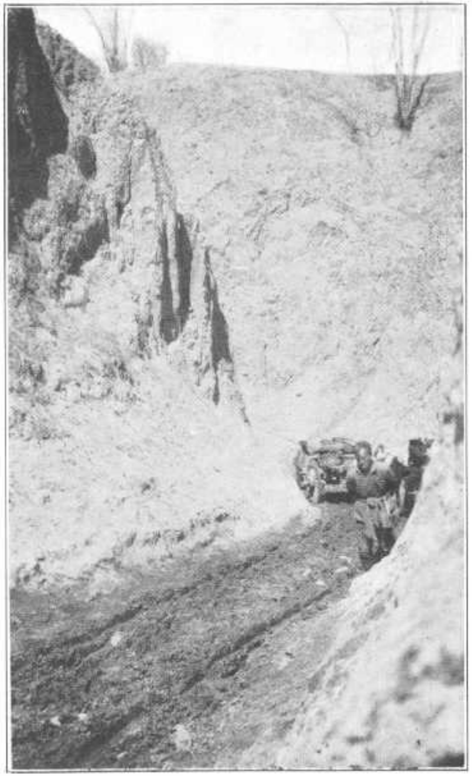


Photo by A. W. Hummel

A deep cut Road in the Loess Country.



A Road in a Loess Gully, P'u T'ao.

held the moisture by capillarity and prevented a rapid percolation of the ground water out from the walls into partially dug wells. (*See* Willis 12-250ff)

The fertility of the loess is due then, in part to its physical condition (which, combined with a clay content comparatively low for such a fine texture, creates a porous soil both light to till and easily penetrated by water), and in part to its relatively fresh chemical condition, especially as regards the presence of lime and other soluble mineral material available for plant nourishment.

Both of these characteristics could naturally be explained as resulting directly from an aeolian mode of accumulation, since the mineral decomposition occurring during transport by wind is almost negligible in comparison with that due to prolonged water-action. But before discussing the origin and age of the Chinese loess, it is advisable to refer again to deposits of loess in other parts of the world, and to those other formations in China whose similarity has led to their being mistaken for it.

(*To be continued*).

SCIENTIFIC NOTES AND REVIEWS

WHITE ANTS OR TERMITES IN SHANGHAI: In the June (1925) issue of this Journal we reported that the late Mr. F. B. Pitcairn had sent us some specimens of white ants, or termites, which Dr. P. Silvestri had identified as *Coptotermes farmosanus*. We made the statement then that as far as was known this was the only species to be found in the Shanghai district. Since then we have receivep specimens from Mr. L. W. C. Lorden, of the Customs Service, of another species of termite, smaller than the foregoing and of a dark colour. Dr. P. Silvestri, to whom we submitted them, identified them as belonging to the genus *Reticulitermes* and, he thought, but was not sure, to the species *flavipes*, which is a Japanese form. It might, on the other hand, represent *R. fukienensis*, described by Professor S. F. Light from Fukien. The genus *Reticulitermes* is palæarctic in its distribution, one species occurring in the south of France, Central Italy and Spain, several species being known from North America, New York being the most northerly range, two occurring in Japan, and one in South-east China.

VIBURNUMS IN WESTERN GARDENS: In a delightful article in the July 4th issue of *Country Life*, Mr. E. H. Wilson, of the Arnold Arboretum, Cambridge, Massachusetts, discusses the relative values as decorative garden shrubs of the various kinds of viburnums known to nurserymen in England and America. Besides the indigenous forms there are numerous species that have been introduced from China, Japan, Korea or the Himalayas, and of these certain species stand out as suitable for gardens in Europe and America. Probably the greatest favourite of all is *Viburnum tomentosum*, a hardy Oriental species with dark-green, prominently veined leaves. It is " a large shrub with tiers of wide-spreading horizontal branches, on the upper side of which the flat flower-clusters are thickly placed, each cluster surrounded by a ring of snow-white ray flowers."

of plants. It was interesting to find the west Chinese *Codonopsis tibetica*, a peculiar kind of bluebell, with a few large, greyish deep-blue bells, and the evil smell of a fox's den.

On some of the rocky hillsides one could trace the vestige of a coniferous belt. There were more or less single specimens of two kinds of spruce and one pine (*Pinus Armandii*). Also there was an interesting shrub, *Myripnois dioica*, sometimes growing in thickets up to 3 m. high.

I cannot leave Shui Wang P'ing without telling about the lily meadows at about 1,600 m altitude. I have hardly ever seen such a wonderful sight. A gentle slope of several acres, crowded with all kinds of flowers and herbaceous vegetation, and rising above all other things hundreds of beautiful lilies with one or two flowers together, 3 to 4 inches long, creamy white, with some purple brown colouring outside at the base. These lilies filled the air with fragrance.

The flora in this part of Shansi is of a little different character from that which we met with at Mien Shan and Pa Shui Kou. There the vegetation was made up entirely of elements belonging to the North Chinese flora (Siberian-Manchurian). Here the touch of Central and West Chinese (and Himalayan) is noticeable. And the number of leafy trees and shrubs has increased very much; for instance, oaks. In Pa Shui Kou Shan I found one kind only, in Mien Shan two, here not less than six.

But this is not the place to go into details. As soon as I have examined my collections and named the species, I shall publish the results, including a list of the plants. All in all, I collected in Shansi, last summer, 1,150 different species of higher plants.

THE LOESS OF CHINA

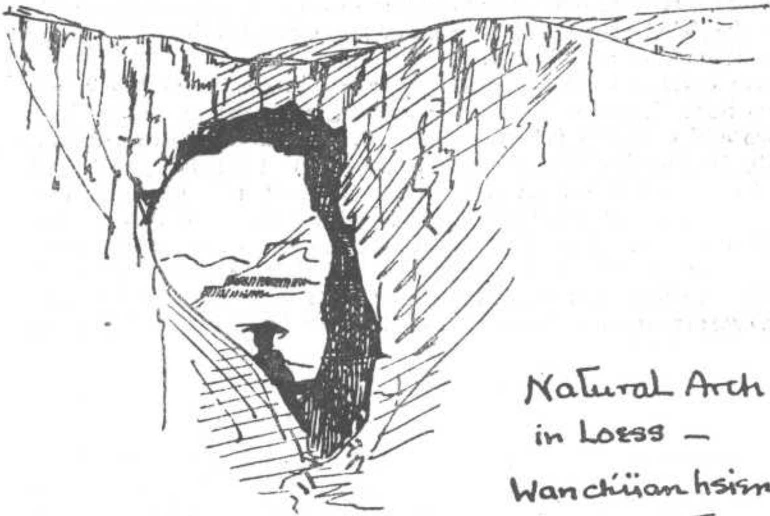
BY

GEORGE B. BARBOUR.

(Continued from page 463).

Loess of Europe and North America.

In most respects the descriptions of Chinese loess could be applied equally to that of Europe and America. The same features call for special explanation—the fine texture and angularity of the particles, and the vertical cleavage responsible for the perpendicular cliffs and canyon-walls. But in these countries there is in many localities distinct



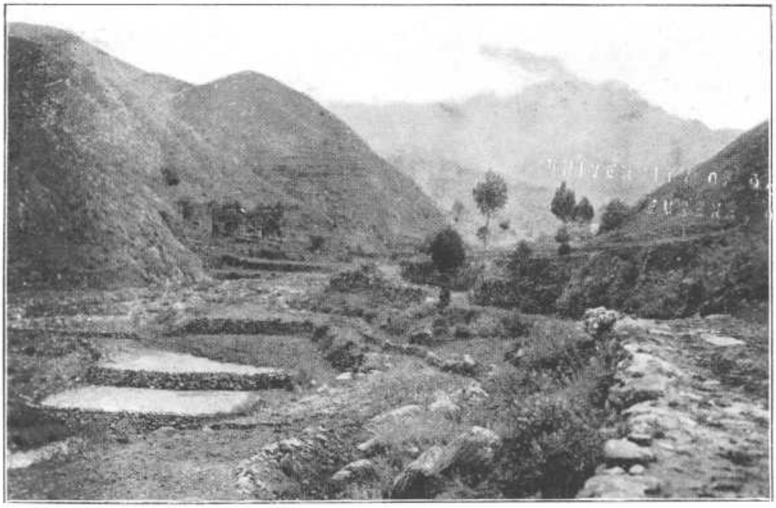
Natural Arch in Loess — Wanch'üan hsien

horizontal bedding, suggesting water-action. A rough stratification is found also in the loess-carrying deposits which over-lie the genuine loess in China, but these formations belong to a period of time, distinct and definitely later than the loess, which is not the case with the European and American stratified loess.

In these countries it was recognized at an early date that loess had a complex origin different from that of the fine-grained silts made by river erosion. Of the other natural forces capable of producing quantities of "rock flour" of such fineness, explosive eruptions yielding vast amounts of volcanic dust may be ruled out at once; the distribution, age, chemical and physical analysis and habit of loess are against such an origin. On the other hand glacial boulder-clay invariably contains a large amount of powdered rock material that has been crushed into minute sharp-cornered fragments; in Switzerland to-day the water of many Alpine streams is made whitish by the presence of much rock-powder, so fine as to be wholly impalpable. But this water-borne "rock-flour" is normally deposited in layers on lake-bottoms or sewpt down to the sea. An equally fine powdery dust fills the air in desert sandstorms.*

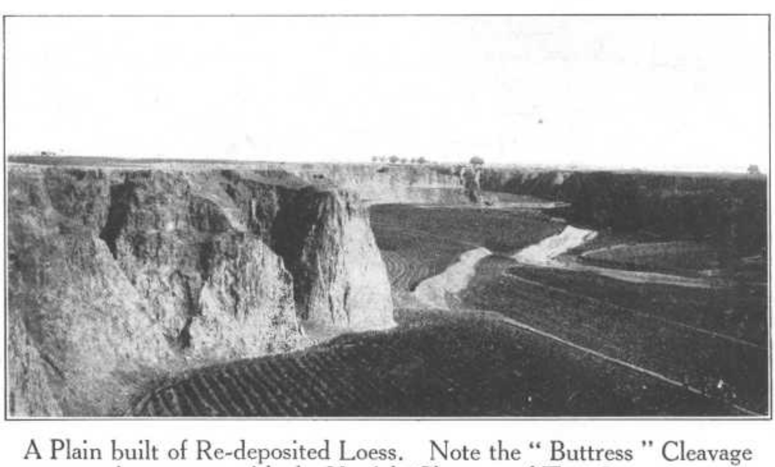
It is significant that the European and American loess belts lie along the line marking the glacier-front of the Great Ice Age, or in adjoining areas into which it might have been carried by streams or wind. The vertical cleavage and general absence of stratification in loess has led to the belief that in Europe and America wind played a major part in distributing the rock-dust originally powdered by the grinding action of

*(Walther Denudation in der Wuste Leipzig, (p. 566 and 581).



The Entrance to the Shiu-wang-ping Mountains from the West, July, 1924.

A Village in the Loess, Nan Tien-men, Chahar.



A Plain built of Re-deposited Loess. Note the " Buttress " Cleavage in contrast with the Verticle Cleavage of True Loess.

glaciers. However, it is equally certain that at times rain and stream-action were an important factors in spreading the loess over the country. The wind-blown deposits would naturally form during the arid periods that came after the more humid glacial times. Osborn therefore places the date of Western loess accumulation during the inter-glacial stages following the second and third great advances of the Ice-sheet, and still more after the final retreat of the ice.

LOESS LIKE FORMATIONS IN CHINA.

A. Deposits older than the loess

1. *Hipparion Beds.*

Previous to the careful work of Andersson and Zdansky, the upper and lower limits of the loess had not been recognized. Hence the distinction between it and the more reddish clay underlying it in many localities passed unnoticed by v. Richthofen and by many others since. In fact the great explorer notes, as typical of the loess, the presence of large lime concretions which in point of fact are much more characteristic of the red clay. Sowerby (2-116) in the report of the Clark Expedition of 1908-9,* recognizes the red clay as a distinct unit (sh'ao t'u), but having no fossil evidence on which to separate it, classed it, as did Bailey Willis, with the loess. Perhaps this in part accounts for the extreme thickness he attributes to the loess.†

On the north margin of the loess basin the name is perhaps misleading, as here the " red clay " is not a true clay and is often only reddish brown in comparison with the yellow-grey of loess. In the centre of the area it is more true to its name. It has the appearance of a residual soil resulting from the decomposition of rocks *in situ*. Moreover, Andersson has noted that its distribution is practically limited to the old limestone lands. This has led him to suggest that, though the bulk of the loess came as dust blown from the desert in the manner suggested by v. Richthofen, much of it may have been material formed locally, and only resorted or slightly shifted by the wind.

Locally the red clay shows a poorly developed stratification marked by gravel beds, may reach a thickness of 200 feet, and in several localities, which are thought to have been oases, has yielded rich collections of animal remains. According to Drs. Wiman and Zdansky the animal types of this Hipparion fauna ‡ indicate the existence of steppe conditions in China at the close of Miocene, and the beginning of Pliocene times.

*Through Shên Kan, by R. S. Clark and A. de C. Sowerby; Fisher Union.

†The loess covers the whole of the sedimentary rock to an average depth of 1,000 ft. . . . . south of the Ordos Desert the depth increases to 2,000 ft. (2-128).

‡Andersson—109 gives a provisional list of the animals found by Zdansky in one locality, which includes among others, deer, antelope, boar, fox, hyena, sabre-toothed tiger, elephant, mastodon and turtle, together with *Hipparion richthofeni*, *Aceratherium*, *Stegodon* and the ostrich-like bird referred to already.

As Andersson points out, however, (1-107) there exists in many places no sharp line of demarcation between the loess and the red clay. Instead, locally a gradual transition occurs through layers showing characteristics intermediate between them. It is, however, a distinct and older formation.

In other places Zdansky describes the loess as making sharp contact with the Hipparion beds below. In the district East of Wan Ch'uan, near the Mongolian border, I have observed shallow deposits of typical yellow loess occupying gullies cut in an underlying reddish clay-loam formation, that has all the appearance of such a resorted residual deposit. In this are large carbonate "loess-püppchen" often over a foot in length.

Père Teilhard de Chardin has mentioned in conversation that a similar concretion-bearing red clay underlies the loess in many parts of the Eastern Gobi Desert, recently visited by Père Licent and himself. At the same time he pointed out that, as far as his observations went, gravel beds were frequently found at the base of the loess, and he expressed the opinion that in certain restricted areas fluviatile conditions may have existed after the greater part of the land surface was already ruled by aridity. In any case it is not surprising that on a continental area sharp contrasts of conditions should exist locally even during arid times.

2. *Kansu Continental Deposits.*

Recent observations made independently by Dr. Andersson and by Dr. George B. Cressey of Shanghai College, point to the existence in many parts of Kansu of heavy beds of red sands and gravels overlying the Hipparion clay, and therefore, presumably, of Pliocene age. They look like the deposits of a great delta or alluvial system, and from their description may well represent the products of the period of greater moisture that came between the time of the red clay and the days of the loess.

3. *San Men Beds.*

In a number of localities sand and gravel beds may be seen at the base of the loess. The moister conditions suggested by these seem to have been widespread over North China. Dr. V. K. Ting first described a series of such beds from the San Men rapids of the Yellow River (1-118). These underlie the loess and carry large freshwater bivalves (*Quadrula*), which Dr. Dall of the Smithsonian Institute of Washington regards as probably early Pleistocene in age.

When the caissons for the new bridge opposite the Governor's yamen in Tientsin were being lowered, shells of similar large freshwater molluscs were found at a depth of 81 feet below ground-level. Through the courtesy of Mr. P. L. Yang of the Chihli River Conservancy Board, I was given facilities for examining on the spot the material brought up from the various levels while the caisson was going down. Besides the *Quadrula* there were a great number of very small gastropods, some less than 1-16th of an inch in diameter. A careful log was kept by the engineer in charge of the work, Mr. Malin, which will be published when the fossil material has been studied by Dr. Grabau, Chief Palæontologist to the Geological Survey.

4. *The Sangkanho Beds.*

In 1923 a farmer brought me part of a silicified rhinoceros femur and several other petrified bone fragments, all of which were said to have come from the same locality near Ho Chih Liao in the Sang-kan Ho Valley. Later similar silicified mammal bones were kindly shown me at Kalgan by Père Vincent of the Mission Apostolique. The reverend Father has made a series of scientific contributions in several branches of natural history, and in conversation was able to confirm from personal observation the theory current locally among the villagers that the present course of the Sang-kan Ho west of Ni-ho-wan cuts through a lake deposit of olden days; this perhaps influenced the theory of the American geologist Pumpelly (9) regarding the past changes in the course of the Yellow River. I made a brief reconnaisance of the area during the summer of 1924.*

Forty miles south-west of Hsuan-hua in the valley of the Sang-kan River there is a magnificent development of terraces cut in two superimposed series of non-marine beds. The lower series are green and brown in colour and carry large bivalves, one type like the *Quadrula* of San Men, the other much more fragile and without the florid bosses which ornament the coarser type. The beds also have gypsum and plant remains and abundant small gastropods like those at Tientsin. The upper beds are uniform brown colour and lie on an erosion surface of the lower series. Locally they seem to pass up into a dark brown loess-like deposit without marked stratification. Silicified mammal bones and bits of *Struthiolithus* were found in this upper series. The problems raised by these beds are so vital as to call for careful study.†

During the spring of 1925, Père Licent and I were able to visit the area and found many deposits of silicified mammal bones. Père Licent has since returned to the locality and secured a large collection of fossil material. The fauna represented when studied will fix the age of the beds. It is either late Pliocene or early Pleistocene. It appears in the main similar to that reported by Andersson from the Chou-kou-tien caves in Manchuria, which are regarded as belonging to the earlier period.

More recently I have found freshwater beds with abundant molluscs along the railway east of Huai-lai. The species are just enough unlike those found in the Nihowan beds to suggest a different, perhaps slightly older horizon. Several fragmentary mammal bones were recovered.

Freshwater beds with fossils of the San Men type have been found by members of the Geological Survey near Pao-ting Fu; Dr. Andersson has mentioned finding them south of Pao-ting Fu and they will certainly be reported from many other spots. They imply fairly widespread conditions of greater moisture before the onset of the aridity.

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*See Geol. Soc. China, Bull. Vol. 3, No. 2, Peking, 1924, p. 167

†Subsequent to my reconnaisance, Père Licent himself visited the district: his observations have just appeared as Publication No. 4 of the Musee Hoang Ho Pai Ho.

B. Formations younger than the loess

1. *Re-deposited Loess.*

In many places, especially on the lower slopes of the hills, the loess is overlaid by series of sand and gravel beds with layers of loess. For the most part this formation is poor in fossils, but bones of bighorn sheep, oxen and deer are occasionally found in the gravels. I have found remains of both the latter two animals in gully banks in and near the Hanoorpa Pass from Kalgan to Mongolia. The definitely stratified nature of this formation shows that torrent action was the chief determining factor in its deposition, though wind may have played a minor part in the case of the layers of loess. The individual lenses of loess are never more than a few feet in thickness but the aggregate thickness of the sediments may reach at least fifty feet. The material occurs typically as a valley or torrential deposit, and, where seen in contact with the true loess, is invariably found to over-lie it, or to occupy gullies cut through it. Dr. Andersson has applied the name " Re-deposited Loess" to this formation. The animal remains and the character of the material making the beds point to a date distinctly more recent than that of true loess, and indicate also a great change of climate from that ruling during the earlier steppe epoch.

2. *Alluvium.*

Still more recently the rivers of the present cycle of erosion have deposited gravel and alluvium on the broad flood plains or in narrow valleys.

THE AGE OF THE LOESS.

The age of the loess may be determined in two ways. Firstly, by comparison of those few types of animals whose remains have been found embedded in it with fauna of other regions that have been studied, taken in conjunction with our knowledge of the climatic conditions ruling in Eastern Asia and other parts of the globe at different stages during the last half million years. Secondly, by bracketing its age between the dates of older and younger beds which are found respectively to underlie and overlie the genuine loess.

With regard to the latter line of reasoning, the loess must be more recent than the Hipparion beds which mark the close of Miocene and opening Pliocene times. Dall's determination of the San Men fossils would narrow the lower limit to later than early Pleistocene. It is possible that the upper series of Sang-kan Ho beds will still further reduce the bracket, especially if they can be correlated with the beds observed at the base of the loess by Fathers Licent and Teihard de Chardin in the Ordos region, who discovered at this horizon palæolithic stone implements strongly recalling the Moustierian stage of human culture* The

* " If found in Europe, such implements would be taken to indicate that the overlying deposits were as young or younger than the inter-glacial period between the Third and last (Wurmian) great advance of the Ice Sheet ; following Osborn's estimate that would fall well within the last 75,000 years. At present, however, no such exact correlation with China is possible."

upper limit is set by the fossils found in the gravel of the re-deposited loess. Of these it can only be said that they are comparatively recent, but are in some cases distinct types from the species living to-day.

Judging from the data offered by the loess itself, it must be admitted that no more exact date can be given. Andersson concludes that the fauna is " decidedly Pleistocene in type, and assuming that Dall is right in dating the mussels of the sub-loess San Men beds as early Pleistocene, it will follow that the loess is of Middle Pleistocene age. It would then be the arid equivalent of the Pleistocene Ice Age " (*loc. cit.*).

From what has been said it will be clear that the loess is certainly as young as the date given by Andersson, and that it probably corresponds in time to the later stages of the Pleistocene Ice Age, but formed under arid conditions.

Origin and mode of accumulation of Loess.

The present position of many loess deposits, perched high up on the slopes of mountains, the uniformly fine grain, the absence of evidence of water-action and the known arid conditions of the time, all point strongly to wind as the great agent responsible for the accumulation of the Asiatic loess. This was recognized by v. Richthofen in 1877. The fact that the geological study of erosion has for the most part been carried out in lands of moist climate, has tended to give too little weight to the work of the wind in drier regions, whether cold or hot. The very fact that wide areas of such rock deserts as the Gobi have to-day no covering of sand, implies that the eroded material of past ages has already been carried off as dust clear out beyond the margins of the desert, to sink and collect wherever moister conditions, the shelter of mountain ridges, or the protection of vegetation, can hold it. How far to such desert-borne material must be added the decay-products of rock decomposition in the locality can only be a matter of conjecture.

Schlosser, referring to Dr. Andersson's observations on this very point, quotes the latter's remark that " he had now seen real loess, at least in larger masses on the Mongolian Plateau." Schlosser agrees that the absence of loess may be due to its removal by northerly winds as fast as it was produced by rock decay. Once across the Chinese border, however, the mountains protect it from the extreme effects of the violent winds. Schlosser* believes that the chief material which yields the loess by decomposition is the Hipparion clay, which may thus grade up into the loess locally, as happens with the Miocene " Flinz " near Munich, where the transition is so gradual as to defy demarcation of the two formations.

The scouring out of immense quantities of fine dust from deserts has probably been a much more common occurrence than we are apt to think. It has doubtless affected vast stretches of Central Asia and Africa and other areas which in former days had more arid climates. Much of the adobe soil of S. W. North America has the same origin. Keyes†

*Max Schlosser, G. S. C. Palaeontologica Sinica, Ser. C., Vol. I Fas. 1 " Tertiary Vertebrates from Mongolia " p. 104 (seen in proof through the courtesy of the Director, Geological Survey).

†Pan-American Geologist, XLII 3, 1924, p. 225.

thinks this factor has been seriously under-estimated in the case of the deserts of the Western United States, and the deposits of the Middle Western plains.

When the dry steppe conditions gave place to moister times, dust was lifted more seldom and carried for shorter distances. Its surface was periodically planed off by the wash of heavy rains, which also helped to distribute it further. During this later time of the piling up of "re-deposited loess," it is likely that the new supply from the desert was small, the bulk of the loess being shifted only a short distance and then "re-deposited."

The Vertical Cleavage of Loess.

One of the still unsolved puzzles is the explanation of the cleavage responsible for the vertical walls of the canyons and cliffs which form such a feature of loess districts. Many are dissatisfied with the theory of v. Richthofen that this is due to the lines of weakness produced by plant roots.

It is true that to-day in almost any loess gully plant roots or their remains, often encased in a tube-like sheath of carbonate or other cement, may be seen piercing to several feet below the surface. A photograph taken near Kuo Ts'un (Huan-hua) shows such a root exposed by a collapsing cliff to a vertical depth of 13 feet without reaching the tip.

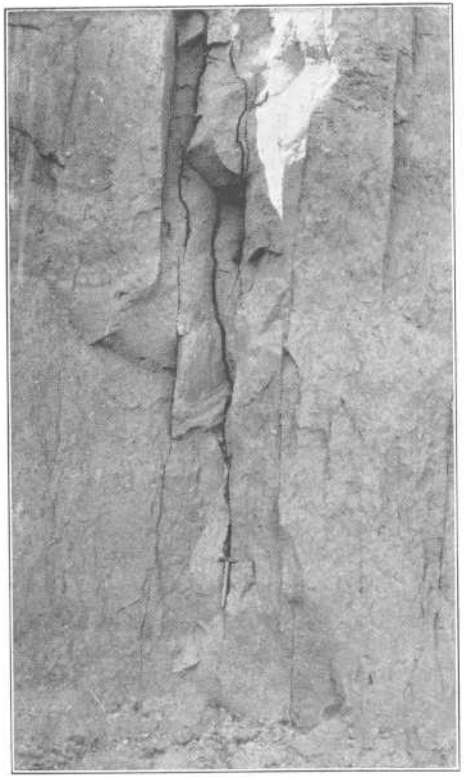
Among the objections raised to the "rootlet theory" are the facts that it is curious that plants, which could thrive prolifically under such a variety of climatic conditions fairly recently, have no real living counterpart to-day. Such root tubes equally might be the result and not the cause of vertical weakness.

As an alternative Willis (12-253) suggests the following explanation. Owing to the lightness of the grains, the dust on first falling was very loosely packed. Under the weight of further deposits on top and alternate drying and soaking by surface water sinking into the ground, the material settled slowly and became compressed vertically, though no corresponding lateral force existed to lessen the distance between grains on the same horizontal plane. Moreover, the closer the grains the stronger the bond between them made by the weak cementing action of salt-charged percolating waters. Hence the direction of least resistance, which moving air and water would tend to follow, would be the up and down direction in which the material now splits to-day.

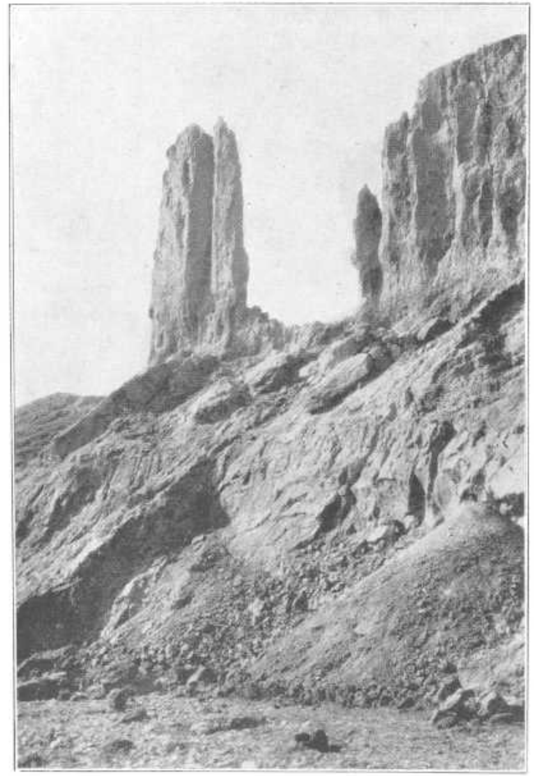
"Huang T'u" and "Loess."

Willis in his Researches gives the formation name "huang t'u" to the entire series which is now recognized as including the red clay, the true loess, and the gravels with re-deposited loess. This is also the broader sense in which the word "loess" is constantly used to-day.* It is true that such observers may fully recognize the inclusion under this term of deposits of both stratified and unstratified material and Willis, for example, states that the age "ranges from late Phliocene or early Plestocene to the present, it (the huang-t'u) having been continuously in process of deposition throughout the Quaternary and possibly since a

*e.g. Sowerby (2-116).



Face of Loess Cliff, showing Vertical Cleavage and Plant Roots extending down from the Ground Surface (4 feet above top of picture) to the Hammer. The haft of the Hammer is 10 inches in length.



A Loess Pinnacle at Shang Sha Kou.

pre-quaternary date." But it has been shown that not only do the deposits span a longer interval of time than is here suggested, but there were gaps and periods of sharply contrasted climatic changes included within its limits. There is often little to be gained by trying to restrict the use of a scientific term that has been accepted popularly in a wider sense. On the other hand loess and its origin is of general interest and yet has aroused much discussion that would have been seen to be beside the point had the theorists realized they were talking of a thing that was not one, but many! Moreover, in this case even the broad range of variation covered by the word as used in Europe and America is exceeded if we use it to include deposits definitely distinct from true loess in composition, texture, habit, age, origin and fossil content.

By recognizing these perfectly observable differences there is reason to hope that we may in the near future solve the remainder of the puzzles presented by the loess in China.

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Note.—This list is in no sense exhaustive, since descriptive passages are to be found in almost every book of travel. The references noted below make either original scientific contributions or summarize conveniently the results of the research of others.

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Professor T. New's Experiments

Certain conclusions stated in the above paper were based on the results of experiments carried out by Prof. T. New in the Department of Agriculture, Tsinghua College. The exact data given below he has very kindly offerred for publication.

The sample taken was of re-deposited loess soil collected near Tsinghua. When air-dry, it was seen to be composed of nearly uniform reddish brown loess material, with a few grey-brown clots scattered through it; the latter appear from microscopic study to contain a somewhat greater proportion of clay and (?) decomposed organic matter. The soil is therefore not strictly geologically pure loess, but corresponds closely to the type of loess-soil usually under consideration in agricultural problems in China.

Experiment 1.—*Rise of Capillary Moisture in Loess Soil*

This experiment followed the standard procedure, Prof. New measuring the height of rise of moisture in air-dry loess standing in two 2-inch tubes, the bases of which were in water. The doubtful readings ("?") on Dec. 26-28, occur where a joint in the tube-sections obscured the top-level of the moisture column. The curve in Fig. 2 (see page 461) was obtained from the average of these two experiments.

Date 1924	Hour	Rise of Capillary Water in Centimetres		
		A	B	Average
Nov. 21	8 a.m.	0	0	0
	11 a.m.	39.0	39.0	39.0
	2 p.m.	50.5	49.0	49.75
	5 p.m.	—	54.5	—
	8 p.m.	61.2	59.0	60.1
Nov. 22	6 a.m.	68.2	67.2	67.7
	6 p.m.	72.8	73.5	73.15
„ 23	12 m.	76.3	78.5	77.4
„ 24	„	79.4	81.8	80.6
„ 25	„	81.5	84.6	83.05
„ 26	„	83.5	?	?
„ 27	„	?	88.0	?
„ 28	„	?	89.4	?
„ 29	„	87.8	90.5	89.15
„ 30	„	88.5	91.8	90.15
Dec. 1	„	89.4	92.7	91.05
„ 2	„	90.5	93.6	92.05
„ 3	„	91.4	94.4	92.6
„ 4	„	92.0	94.9	93.45
„ 5	„	92.8	95.6	94.2
„ 6	„	93.5	96.3	94.9
„ 7	„	94.1	96.8	95.45
„ 8	„	94.5	97.0	95.75
„ 9	„	95.0	97.4	96.2
„ 10	„	95.5	97.9	96.7
„ 11	„	96.0	98.3	97.15
„ 12	„	96.4	98.7	97.55
„ 13	„	96.8	99.1	97.95
„ 14	„	97.2	99.5	98.35
„ 15	„	97.7	99.8	98.75
„ 16	„	98.0	100.00	99.00
„ 17	„	98.2	100.2	99.20

EXPERIMENT 2.—*Distribution of Capillary Moisture in Column of Loess Soil.*

In this experiment Prof. New used previously weighed tube-sections 15.5 centimetres long filled with air-dry loess. These sections were again weighed when set one over the other to form a column through which moisture was allowed to rise by capillary action. By weighing subsequently the amount of water held in each section was measured and reduced to a percentage. In Fig. 2. I have recalculated these results from Prof. New's data and plotted them against similar observations made by Buckingham on clay, sandy-loam, and sand soils, respectively (U.S. Bur. Soils, Bull. 38, 1907).

Set 1.

Tube No.	1	2	3	4	5	6	7	
A Begin	800.0	761.2	746.4	762.0	714.6	702.1	642.0	wt. pan and soil
B End	647.5	617.7	616.7	650.0	630.4	640.6	601.7	wt. pan and soil
C diff.	152.5	143.8	130.4	112.0	84.6	51.5	40.3	water held
D	245.3	231.5	250.0	263.3	244.2	254.3	240.5	wt. of pan only
E=B-C	402.2	365.9	366.0	396.7	385.8	396.3	361.2	wt. of soil only
F=C/E	37.92	39.30	35.62	28.23	21.92	12.99	11.15	percent of water

Set 2.

Tube No.	1	2	3	4	5	6	7	
A Begin.	653.8	680.0	634.7	628.6	611.9	562.7	567.0	wt. pan and soil
B End	507.7	520.3	501.0	515.0	525.1	501.2	522.2	wt. pan and soil
C diff.	146.1	159.7	133.7	110.6	86.8	61.5	45.8	water held
D	124.8	122.2	122.3	122.8	131.7	123.4	128.0	wt. of pan only
E=B-D	382.9	398.1	378.7	392.2	393.4	377.8	384.2	wt. of soil only
F=C/E	38.15	40.11	35.30	28.19	22.06	16.27	11.92	percent of water

Average of two experiments

	1	2	3	4	5	6	7	
	38.04	39.70	35.46	28.71	21.99	14.63	11.53	percent of water held.

Note.—The percentage of water held is based upon air-dry soil instead of water-free soil as usually done.

ANALYSIS OF LOESS MADE BY THE GEOLOGICAL SURVEY OF CHINA

The following two additional analyses have been most kindly furnished by Dr. W. H. Wong, Director of the Geological Survey, and are particularly interesting as supplementing the data already published ; the surprising similarity of composition of samples from widely separated localities is also worth noting.

	Loess from Wei-ning, Kansu	Loess from Tai-yuan, Shansi
SiO_2	59.30	61.23
Al_2O_3	11.45	11.35
Fe_2O_3	2.32	3.50
FeO	1.55	1.20
TiO_2	*0.60*	*0.70*
P_2O_5	0.20	0.18
$CaCO_3$	14.90	13.40
$MgCO_3$	4.58	3.95
Na_2O	1.80	1.65
K_2O	2.17	2.10
SO_3	0.20	0.20
H_2O	0.96	0.64

These analyses should be compared with those given on page 457.

SCIENTIFIC NOTES AND REVIEWS

THE FLOWERING OF THE CENTURY PLANT : The following letter upon *the flowering of the well-known Century Plant (Agave americana) has been received* from Dresden, and we feel sure that it will prove of interest to many of our readers :

SIR,—Will you permit me to make a few remarks respecting the Century Plant mentioned in Mr. Porterfield's interesting and instructive article on *Bambusa* in your March issue.

The name Century Plant was given to the *Agave americana* by mistake. So far from flowering only after 100 years, it reaches the flowering stage in Mexico after about five years ; near Malaga it requires six ; and on the Italian Rivera about 15 years. Tolens-Laubach attributes the delay to reduced assimilation caused by suboptimal insulation.

In Fiala's description of the Coins and Medals of the Guelphish Land, Prag, 1907/8, there is given the description of a medal struck in commenoration of the