THE CHENGTU CLAYS— DEPOSITS OF POSSIBLE LOESSIAL ORIGIN IN WESTERN AND NORTHWESTERN SZECHUAN BASIN*

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INTRODUCTION

Heim and Bowles (2)[1] have described the occurrence of loessial deposits in the mountain valleys and on the high plateaus northwest of Tachienlu, in the region commonly known as the Tibetan Borderland; but so far as we know, no-one has reported any loessial material within the Szechuan Basin proper. We are not yet prepared to report such deposits with complete assurance, but we have collected data which seem to us strongly indicative that they exist and that they are distributed intermittently over a wide area in the western and northwestern parts of the Basin.

During the autumn of 1935 we spent a few days studying these deposits together. Dye had previously observed them in a number of places over a period of many years, and had been puzzled as to the explanation of their probable origin. We therefore made a special effort to study them in the light of modern soil science with the hope of find-

* Received for publication in March 1936.

1 From the account of Bowles it seems that J. H. Edgar F.R.A.J., of the China Inland Mission has known of these deposits for many years and it was he who first called attention of scientists to them.

ing a satisfactory solution to the problem of their genesis. This paper is the result of our preliminary studies.[1]

The investigation was carried out concurrently with the study of the broader soil groups of the region between Chengtu and Mienyang. We wish to acknowledge the helpful cooperation and assistance of Dr. C. Y. Tschau and Mr. L. T. Chu of the Soils Division of the National Geological Survey of China, who accompanied us while most of the work was being done.

Physiographic Background

In the term "Szechuan Basin" we mean to include that great region of rolling hills and low mountain ranges which extends from near Wushan on the east, to Kuanhsien and Yachow on the west, and from the high mountains of the Kansu and Shensi borders of Szechuan on the north, to the mountain ranges which mark the borders of Hupeh, Kweichow and Yunnan on the south. The great heights of the Tibetan borderlands make a somewhat sharper line of demarkation of the limits of the Basin than the comparatively lower ranges which flank the other side. The structure of the Basin has already been described by many other writers and there is no object in going into lengthy reviews of these works. In a conversation, on one occasion, Dr. V. K. Ting described the Szechuan Basin as a synclinorium with broad synclines and short sharp anticlines superimposed on a great syncline. These anticlines and synclines extend in a roughly northeast-southwest direction, and toward the east, the remnants of the short, steep anticlines form low mountain ridges which tower above the rolling hill lands of the synclinal troughs and minor anticlines.

The famous Chengtu plain, which has also been described by many writers and lecturers, lies in western Szechuan Basin, between a low range of mountains, known as the Lungts'üan hills (龍泉驛山)

1 Following the suggestion of Prof. A. W. Grabau, we are proposing the name "Chengtu Clays" for these materials of probable wind-blown origin.

and the eastern edge of the Tibetan Borderlands. Dye has described this plain elsewhere (3), bringing out the fact that it is a complex, intermontane alluvial fan which is still in the process of aggradation. The southern part of the plain is being watered and built up by the distributaries of the Min River (岷江), while the northern part receives contributions of water and silt from several smaller rivers such as the Ts'ingshuiho (清水河), Pêyuho (白魚河) and Shihtingho (石亭河) which flow out from the western mountains.

In many places—more notably north, east and southeast of Chengtu city—the plain is interrupted by an older topography of undulations and low hills. The higher of these hills, such as those 15 or 20 li north of the capital city, are made up of reddish purple, tilted shales and sandstones of probable Cretaceous age, capped by a deposit of strongly water-worn quartzite cobble stones of much more recent deposition. These cobble-capped hills reach a height of 60 meters or more[1] above the general level of the plain (unfortunately no barometric readings were obtained for these hills), and are obviously remnants of a former peneplain, the geologic age of which can only be fixed by careful study. Flanking these hills on the north are lower, flat-topped hills which perhaps have a common altitude of 30 or 40 meters above the plain. The still lower hills and undulations seem to represent another peneplain stage which probably immediately preceded the present epoch of fan building.

Farther north—between Lochiang and Mienyanghsien cities, it is possible to trace 5 fairly distinct stages of peneplanation and terrace development—these stages being the most noticeable near the larger rivers, where terrace remnants give a clue to the physiographic history. In riding by motor car from Chengtu to Mienyang, these stages were observed and their relationships with the possible loess deposits were so striking that it was decided to make barometric determinations of the respective relative altitudes of the different terrace remnants and hilltops which represent the different stages. A profile of the road with repre-

1 Barbour estimates the height of these hills to be 30 to 60 meters above the Chengtu plain (Mem. Geol. Surv. China, Series A, No. 14, p. 38).

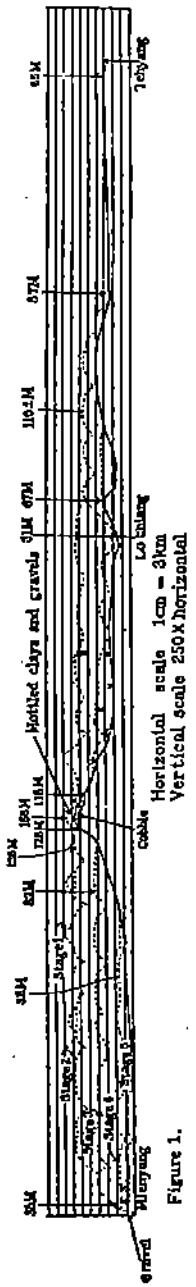

Figure 1.

Figure 1. The solid line is an approximate profile of the road between Mienyang and Tehyang. The total distance, including curves, is 67 Km. between these cities. The vertical scale is 250 times the horizontal scale. × marks indicate the known areas of probable loessial material. The numbers indicate the heights in meters of various places above Mienyang city. Dotted lines indicate the different physiographic stages of peneplanation and terrace building.

sentations of terrace and peneplain remnants is shown in Figure 1. It is unfortunate that we have barometer readings for only one direction along the road. We are thus unable to make corrections for local barometric variations which may have interfered with the accuracy of the work but these readings have been corrected for the barometer variations at Chengtu for the same day and are probably not far wrong. In spite of deficiencies we believe the results to be reasonably good, since the 5 stages of development were observed and recorded within two or three hours' time between Mienyang and the highest hills between that city and Lochiang.

In the profile (Fig. 1) the highest hills (Stage 1) represent the oldest peneplanation stage of the region examined. The only hill of this stage examined was capped by a cobble and clay deposit of a maximum thickness of 41 meters. The cobble horizon lay directly on eroded, nearly horizontally bedded, purplish red to reddish purple shales and sandstones. It has a variable thickness up to 15 or 20 meters and is overlain by 20 meters or more of yellow and red reticulately mottled clays with some layers of gravel (SeeFig. 2 B).

The color of this material is due to soil-forming processes which have been acting over a long period of time. This old soil belongs to a group which has been called "podzolized red earths" (7) in other parts of China; and perhaps part of it might be assigned to the "yellow earth" group of Europe and the United States. (This yellow earth is not to be confused with the "huang-tu" or North China loess, which is an altogether different thing).

There are relatively few of the highest hills of Stage 1 in the region, and we do not know whether the others are similarly capped with cobble and reticulate clays, but it is altogether reasonable to suppose that at least some of them have such caps.

Stage 2 is represented by a large number of more or less flat-topped ridges of very wide extent and must represent a very long period of erosion during which peneplain No. 1 was largely cut away. It will be readily seen from the profile that this second stage was at least partly developed on the older cobble layer but we do not know to what extent this is true. It is quite probable that sandstone shelves may mark some of the hilltops of this stage.

The hills of Stage 3 occur along the larger rivers and their tributaries and do not extend far back into the higher hills. Some of these terrace remnants are capped by cobbles and clay inherited from Stages 1 and 2, and some are rock terraces of sandstone, left behind when the rivers cut their way down into deeper strata.

Stages 4 and 5 are clear-cut river terraces but are also very restricted in area as in the case of Stage 3. Similarly with Stage 3, also, they are partly made up of inherited and reworked cobble deposits and partly of rock terraces. The latter are especially common in the Mienyang-Lochiang region because of the nearly horizontal position of the purplish red sandstone and shale bedrocks.

The river valleys near Mienyang are rather narrow, although, including the alluvial fans along their sides, they sometimes reach a width of more than a mile. The side streams bring in more material than the

rivers can remove and so the valleys are bordered by gently sloping fan deposits. There are narrow flood plains along the larger rivers which are occasionally flooded during heavy rains. In general, however, these rivers seem to be gradually entrenching themselves.

On the other hand, the Chengtu plain is being built up, at varying rates in different parts, rather than being cut down. Near Chengtu, Dye (3) estimates that the land surface has been built up at the rate of 6 inches (15 cm.) a century during the past 3,000 years, more or less. In the field we found indications that this rate of accumulation will probably not hold good for all the plain, but that the rate of alluviation varies considerably in different parts. There can be no doubt, however, that the plain is being built up an amazing rate of speed if we think in terms of geological time.

Even on a hasty journey through Szechuan it is easy to observe that a similar series of physiographic stages is traceable in nearly all parts of the Basin. From very imperfect observations along the motor road between Chungking and the Kweichow border, it would seem that still older peneplain remnants exist, and that more stages of physiographic development are represented than we have the time and the space to describe here. These conditions have been discussed in Barbour's Memoir (1).

The Deposits of Possible Loessial Origin (Chengtu Clays)

We have devoted several pages to the discussion of the physiographic background in order to make clear our reasons for believing that the deposits we wish to discuss are very probably of loessial (i.e. wind-blown dust) origin. We believe many of our readers will agree that such an explanation is the most reasonable one to fit the case; but we must caution ourselves and our readers that only a part of the field has been explored and that future investigations in other parts of the Basin may prove that some other explanation is more probably correct.

At the present time the Chengtu clays essentially comprise a subsoil of brownish yellow to grayish yellow sticky and plastic clay which

contains lime concretions of *"shachiang"*[1] and "loess puppet" types. The surface varies in color from dark or very dark brown on the unirrigated areas to yellow-brown on the eroded hillsides. The reaction of the surface soil varies from moderately acid to neutral, while that of the brownish yellow subsoil is usually neutral or only slightly acid. The lime concretions occur at the surface on eroded spots, but in only slightly disturbed areas are usually more than 3/4 meter from the surface. At Mienyang, on the river terrace (Stage 4), they occur throughout the deposit to a depth of 12 or 15 meters where there is contact with the old river cobble deposit (See Fig. 2-A).

These lime concretions apparently formed as the result of the working of soil forming processes in which lime was leached from near the surface and deposited in the subsoil. The confusing part about such an explanation is that it is not usual to find "pedocal" soils of this sort in a region of such a humid climate as that which prevails in these parts. This confusion disappears, however, when we carefully study the lime concretions and the soil surrounding them. We find that the soils, as we have already stated, are usually slightly acid, and all of the free lime which one normally finds distributed through the subsoil of a pedocal, has been leached away, and one can get effervescence with acid only in the concretions themselves—or sometimes in the cracks of the deeper subsoils. The pitted condition of many of the concretions shows that they are now in the process of being dissolved. In all probability they would have disappeared long ago were it not for the fact that the material around them is a heavy, sticky clay which becomes almost impermeable to water when it has once become thoroughly wet. This has protected the concretions from dissolution for a long period of time.

1 *"Shachiang"* is a term applied to lime concretions found in certain soils of northern Anhwei Province. These concretions are locally known by this name because of their resemblance to ginger roots. A literal translation of the word is "sand ginger". Shaw (5) used the term as a name for the soils in which these concretions are found, using the spelling "sajong". Our orthography conforms to the Wade system of romanization.

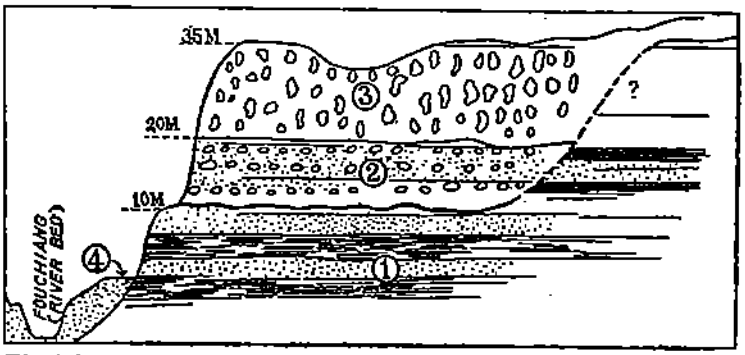

Fig. 2-A. Rough cross section of terrace at Mienyang, looking southward. 1 is nearly horizontal Cretaceous (?) purplish sandstones and shales. 2 Gravel and sand strata. 3 "Chengtu Clays", of probable loessial origin, and containing "loess puppet" lime concretions. No gravel. 4 Recent flood deposits of Fouchiang. Vertical scale much greater than horizontal. Heights given in meters above flood plain.

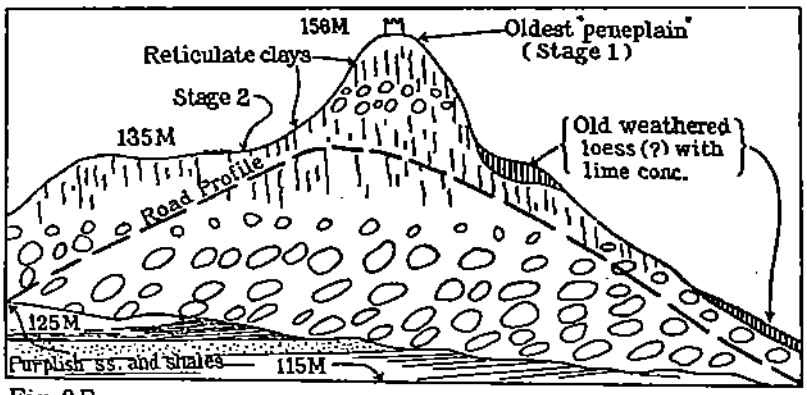

Fig. 2-B. Details of hilltop on the motor road 14½ miles southwest of Mienyang showing gravel and cobble beds and old reticulately mottled red and yellow clays with pockets of "Chengtu Clays". Cobble beds lie unconformably on purplish red sandstones and shales of probable late Cretaceous age. Vertical scale greatly exaggerated. Altitudes given are in reference to high water level in the Fouchiang at Mienyang.

It seems almost certain, then, that the lime concretions were formed under arid or semi-arid climatic conditions, when the rainfall was insufficient to cause the lime to be carried away in subsoil waters; but sufficient, only, to carry it into the subsoil where concretions were developed. Such large numbers of concretions as we find here, still remaining under climatic conditions unfavorable for their existence, seem to indicate that the parent material was, in all probability, quite calcareous; and probably also may not have been much different in composition from the calcareous loessial deposits of northwestern China. It is also within reason to suppose that the texture of the original deposit may have been "lighter", that is to say, it may have contained a higher proportion of silts and very fine sands which have since been weathered into clays. This could easily be true if we assume that many of the silt and sand particles comprised grains of feldspars, hornblends, etc., which would weather into clays. Such an assumption is reasonable in a region near the Tibetan borderland where fresh minerals are being rapidly exposed and powdered by erosion. On the other hand, the high lime content of the original material may have caused the coagulation of the colloidal clays with the consequent development of an only *apparent* light texture which is now so common in the loess deposits of the Northwest. Many soils of loessial origin in Honan, Shensi and Kansu have the appearance and "feel" of loams, silt loams and even sandy loams, when mechanical analyses prove that they actually belong to the silty clay or clay classes. When the excess of lime is leached away, such soils become sticky and heavy and lose their properties of friability.

The Chengtu clays, so far as we have observed them, nowhere show any evidence of stratification even in very deep horizons. It is true that they occasionally contain a few quartzite cobbles or pebbles, but *these occur only where they have been mixed into the material by the farmers.*

An argument against the yellowish concretionary "Chengtu Clays" being an old loess deposit is that they do not have a well defined columnar structure which is so commonly associated with loess. It has been the observation of the first author in many widely distributed regions, that

the true loess-column structure is nearly always associated with a porous and nearly always strongly calcareous material; and, furthermore, this structure is common in strongly calcareous materials which are entirely of alluvial origin of decidedly variable textures. When calcareous loessial deposits have long been leached under humid climatic conditions, they tend to lose their columnar form. Examples of such changes may readily be seen in the Siashu loams (Barbour's terminology) of Nanking (whether they are truely of loessial origin is still in question), and in the leached loessial deposits of the Mississippi Basin, U.S.A.[1]

The forgoing descriptions give, in a general way, the characteristics of the deposits. It is now of interest to note their distribution. Following the motor road north from Chengtu, the first deposits of this type may be noticed in a deep ditch 5 or 6 li north of the north gate of the city. The land here is undulating but is irrigated and devoted to rice. Recent deposits of alluvium cover the edges of the material and silt from irrigation water is building up the surface immediately above. Farther north,—about 15 li from the north gate of Chengtu, the land is more undulating and the proportion of loess-like deposit is greater. In some places there are very low outcrops of reddish purple

1 At this point it is certain that many geologists will raise objection on the ground that the Siashu materials (they are comprised more of clays than of loams, according to soil terminology) do have vertical cleavage. In the Memoirs on the iron deposits of the Yangtze Valley, Hsieh *et al* (4) have published a photograph of the Siashu materials as an illustration of their vertical cleavage. A close examination of this photograph shows that, while the cleavage is nearly vertical, there is a lack of a clear-cut development of true columns which are so characteristic of the N.W. China loess. The Siashu clays (loams, according to Barbour) do have a well-defined prismatic structure, especially where the colloidal content is high, and there may be some less leached horizons which have well developed columns. These facts, however, cannot be used as arguments against the loessial origin of the Siashu materials, since weathering in humid climates is likely to change their character. We are strongly inclined to believe the Siashu formation to be an old wind deposit and are thus able to agree with the majority of other investigators.

shale and sandstone which lie unconformably below it. The deposit varies greatly in thickness and pockets of it flank the lower slopes of Moupanshan, a remnant of cobble-capped old peneplain, 18 li north of the city. If the deposit formerly covered the entire area, much of it has been removed by erosion, and the hillsides are mostly the sites of outcrops of the purplish shales—already mentioned. Occasional pockets of rounded boulders and cobbles on the same slopes are inherited from the river deposits which were laid on the old peneplain and have now been largely eroded away. On the top of the old peneplain remnant (Moupanshan), there is a thin deposit of this same yellowish, concretionary loess-like material, which in places has been partly mixed with underlying gravel and cobbles by farming operations.

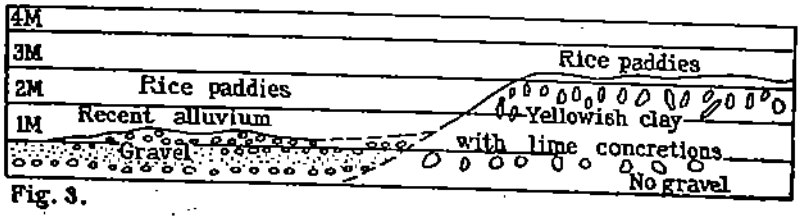

Fig. 3.

Figure 3. Road cut 6 li north of Tehyanghsien city, showing relationships between probable loess (yellowish clay) and alluvial deposits.

Conditions similar to those just described occur intermittently along the road between Chengtu and Lochiang, and especially notable deposits were observed just south of Liang-shan (town) (See Plate I-A and B) and again about 6 li north of Tehyanghsien city. At the last-named place the brownish yellow concretionary clay deposits occur in a low terrace-like position on a broad plain, and on the lower slope of the terrace the moderately recent gravel and silt deposits overlap these materials (See Fig. 3).[1]

1 Since the data just given were recorded, Dye has made a trip alone, recently, to the exposed old topography lying slightly above the aggrading alluvium of the Chengtu Plain. Plate I-A shows the village of Kao-tien-tzû (高店子), some six miles southeast of Chengtu City. This village is located on a ridge of this old

The road profile (Fig. 1) shows the approximate distribution of the supposed old loess deposits in relation to the physiography of the region. It will be noted that the deposits occur almost haphazardly from the river terraces, nearly to the tops of the highest hills. The thickest deposit we were able to measure occurs on the 35-meter terrace (Stage 4), directly south of Mienyang city. In this place the thickness is about 15 meters and the material is underlain by stratified gravel and cobble.

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topography. The photograph reveals the general peneplain level which is some 200 feet, possibly, above the small streams. On the hill tops are found river-worn cobbles and pebbles, many of which are 12 to 18 inches in diameter. These are inherited from the days of peneplanation and some are still found *in situ* on the tops of the knolls between the "loessial deposit" and the purple brown materials beneath. Workmen were breaking up quantities of these cobbles, collected from the beds of the *slow* streams, for surfacing the auto-road. The picture reveals reservoirs of "winter water" which permit of rice being planted in the spring before the seasonal rains.

The whole countryside appears to have been eroded to the configurations as revealed in the photograph. The purple brown material was then covered with a mantle of the loessial materials, some 10 feet in thickness. Since that time the (?) small streams have undercut some of the slopes very slightly, but enough to expose the purplish materials.

The lime concretions are almost everywhere in evidence. They are sometimes found in the *upper levels* of the original purplish material, but practically never in lower depths. These lime concretions are more readily seen in the yellowish covering.

In some ways it is more satisfactory to study the deposit of the yellowish material on these undulating hills than it is on the cleanly terraced hills out the north road from Chengtu City.

On many hill tops acres of surface are covered with the yellowish material without exposure of the old purplish materials. It would seem that the topographical contours have changed but little from those of the days immediately preceding the addition of the yellowish covering. To be sure, the covering has worn thin in places, so as to reveal the old surface.

Plate I-B, a photo of fresh graves, is informing. The camera plate holder is placed in the shallow trench where the

If the material occurred only in terrace positions and around the bases of hills, it would be fairly easy to conclude that it was deposited by rivers or lakes. Even with such an interpretation it would be difficult to explain the absolute lack of assortment or stratification. But, in fact, we find the deposit from very near flood plain levels almost to the tops of the highest hills, and from this fact, combined with other evidences already brought forward, it would seem that wind must, in all probability, have been the agent of deposition.

Dye has observed at least 4 dust storms at Chengtu during the last 25 years, during each of which the air became very dry and filled with yellowish dust. Such storms may last 3 or 4 days. During the same period of years there were many minor dust falls which caused red sunsets for several days on each occasion. These infrequent storms can have little effect on the nature of soils because of their minute deposits which would easily be leached of their lime in few months of

next coffin will be placed. The larger cobbles in the center and at the left are water-worn. They had been dug out of the shallow trench where they had lain at a depth of 14 inches. The red and yellow materials had generally mixed with the cobbles and pebbles at that level. Above there was a covering of 8 to 10 inches of the yellowish material. The concretions were interspersed all through this material and are still *in situ* at the sides of the trench. Two concretions, placed on a clod of the intermix of red and yellow splotched material, show their irregular shape. These are to be seen immediately to the left of the plate holder in the picture. The sods for shaping up the graves were skinned from the surface of the knoll. Those sods taken from the foreground and from the right of the picture are of the yellowish loessial materials, while the grave of which the corner is seen in the foreground is of reddish sods taken from the left of the picture—where the reddish-purple materials are exposed. The fine materials placed on the tops of the graves are of both kinds with concretions and a very few smaller river-worn pebbles. These were dug from the contact level. Practically all of the land surface that drains into the upper "winter water" reservoirs is of the yellowish probable loessial material (Chengtu Clay). This material seems to cover most of the low hills between Chengtu and the Lung-chien-i hills and is very useful for making reservoirs for storing water.

rainy weather; but they may represent vestiges of former greater and more significant dust storms.

The purplish red sandstones and shales of the region are more or less calcareous in many places and it might be argued that they comprise the parent material of the Chengtu Clay deposits. Such a theory seems untenable since we find a tremendous area of entirely different soils derived from these materials; and, still more important, since we find many places where there is a sharply unconformable contact between the two materials. Furthermore, the Chengtu Clays also occur, as we have already pointed out, lying on the cobble deposits of the old peneplain surfaces—above the purplish materials.

The accompanying map (Fig. 4) which, in addition to Szechuan, includes small areas in Shensi and Kansu, shows the known distribution of the probable loessial deposits of western and northwestern Szechuan Basin, and also indicates certain deposits in Shensi Province, south of the Tsinling range which are probably of the same origin. These deposits were reported by Mr. K. C. Hou (6) who made a hasty reconnaissance of some of the soils of southern Shensi. We believe it probable that these Shensi deposits form one of the connecting links between the loess of Northwestern China and the weathered loessial deposits of Szechuan Basin. Figure 5 is a map of the district around Lung-chien-i village. The Chengtu Clays form a blanket over the low hills, but do not extend very far into the higher hills at this place.

Origin of the Materials

If these be wind deposits, what is the origin of the dusts of which they are comprised? Such a question cannot be answered with certainty, but it is possible to advance plausible theories. If the epochs of loessial accumulation were much dryer than the present—and this seems to be an almost foregone conclusion—then it is reasonable to suppose that at least semiarid conditions prevailed around the periphery of the zone of greatest dust accumulation. Northwestern and western Szechuan would fall in such a position. Under these conditions it is almost certain that the more violent and wide-spread of the dust storms of North China

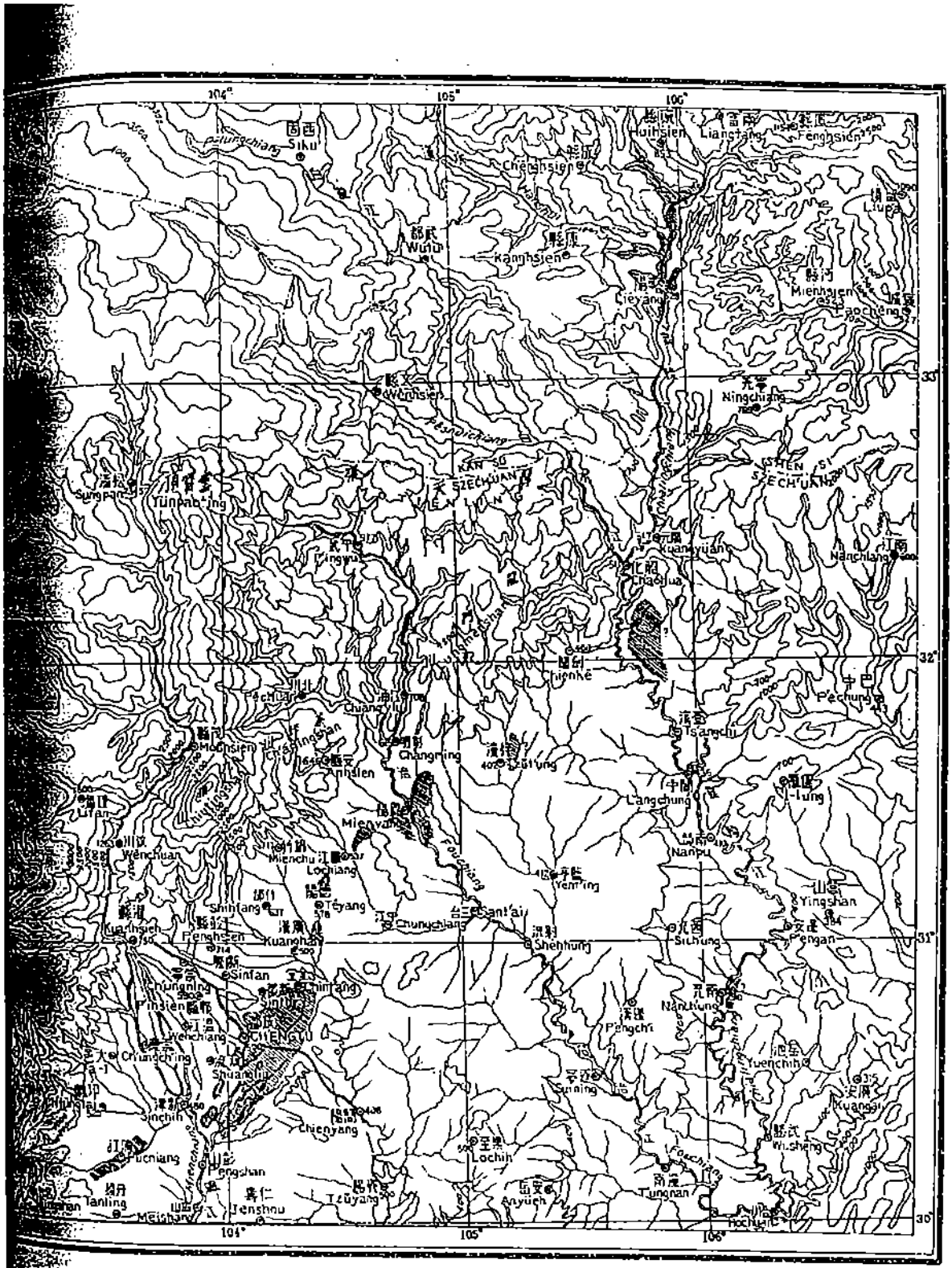


Figure 4. Map of parts of Szechuan, Kansu and Shensi. Hachured areas indicate the approximate known distribution of the "Chengtu clays". Areas of doubtful identity are indicated by question marks. The area shown in Shensi Province was mapped by K. C. Hou, who classified it as light brown loessial material. It seems to be transitional in physical character between the "Chengtu clays" and the slightly weathered loess of the Northwest.

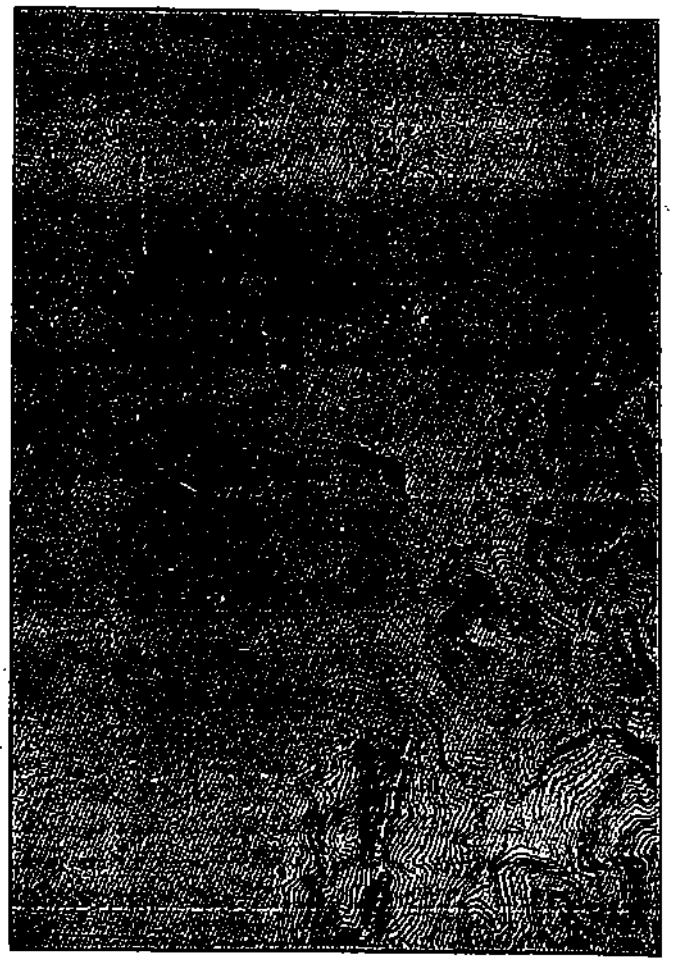
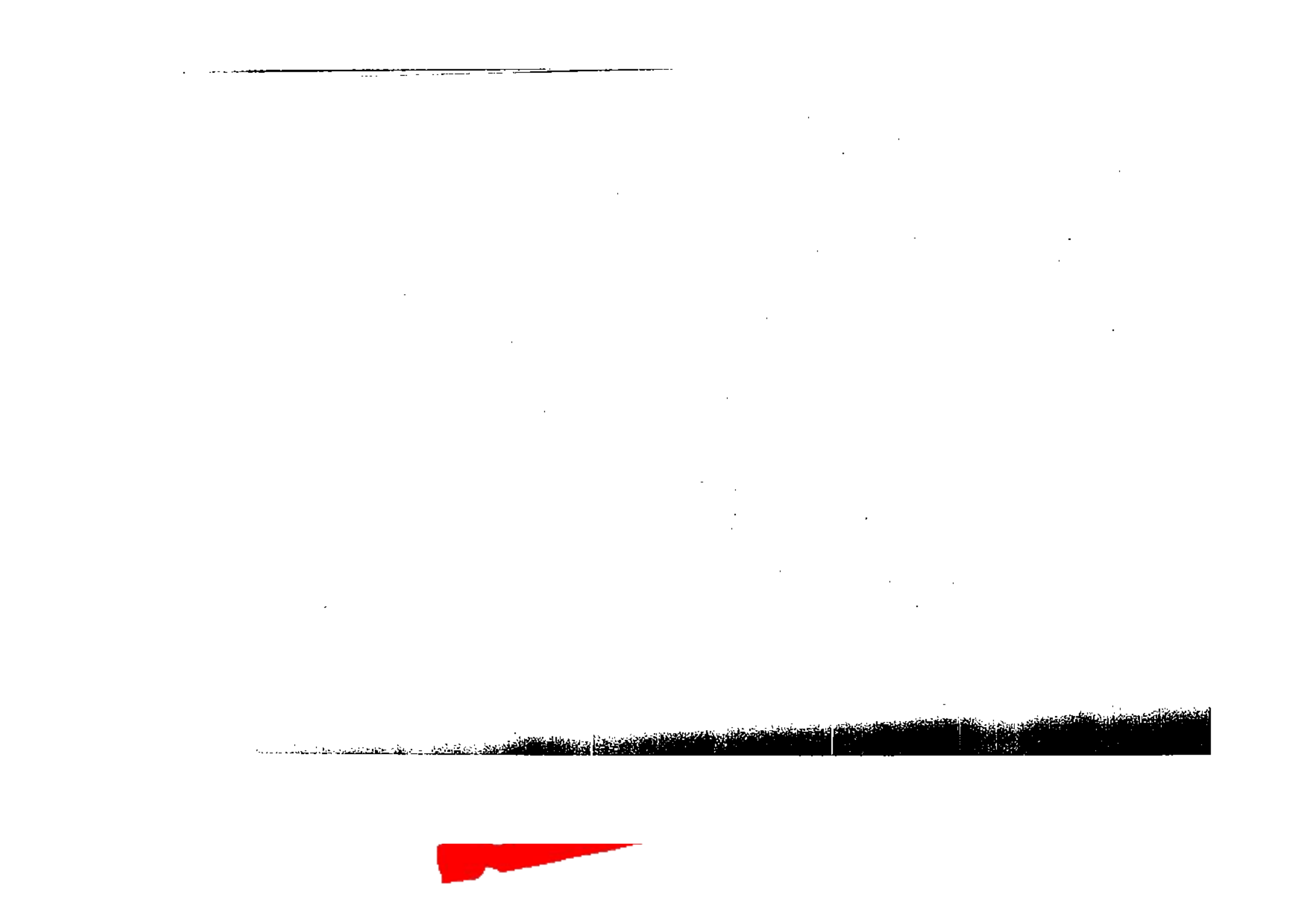


Figure 5. Topographic map of the district around Lung-chien-i village. The "Chengtu clays" form a blanket over the low hills. The impervious and sticky clays are admirably adapted for making storage ponds for irrigation water. A number of these ponds are indicated on the map.



and eastern Tibet would carry well over into the edge of the Basin, bringing with them significant quantities of dust. The present infrequent and more or less inconsequential dust falls are probably vestigial remnants of ancient and more violent storms.

In such a case we should expect the greater part of the dust to have come from what is now northwestern Szechuan and southeastern Chinghai and Kansu. Loess deposits are common in these regions and have been described by travelers (2).

One method of transportation of dust to a given locality is by a system of relays. Such a method is well illustrated in the loess deposits along the Yellow River in Honan. Presumably the dust of this region was originally blown out of the Mongolian and Ordos desert regions and the greater part deposited in Ninghsia, Shensi and Shansi. Step by step part of the dust moved southeastward toward Honan, resting for longer or shorter periods en route. In many cases the deposits of Ninghsia, Shensi and Shansi were eroded away by the rivers and spread out along the flood plains of their lower courses, only to be picked up again by the wind and blown to nearby hills and terraces. This process is still very active all through the loessial region and was observed by the first author (8), particularly along the Yellow River in northern Honan and along the Wei River in Shensi.

In the process of relaying the loessial material from its original source by the methods just outlined, there is a strong tendency for horizontal assortment to take place. The fine floury materials are most easily transported and of these, the ones with lowest specific gravity tend to be carried farthest, while heavier sand grains remain behind. The heavy sands will creep along the lower areas and move slowly, while the fine materials will be carried farther and higher by the winds. This is a principle already so well known as to scarcely warrant further discussion[1].

1 Dr. J. H. Jeffrey of the China Inland Mission at Mowkung reports (verbal information) that there are many more or less violent local dust storms in the various valleys of the Tibetan Borderlands

The many rivers coming down from the Tibetan borderlands of western Szechuan still bring with them large amounts of materials, part of which were originally of loessial origin. At present the alluvial fans are too wet throughout almost the entire year for the winds to pick up dust from them, but conditions were undoubtedly different during the periods of greatest dust movements in China, and these river flood plains may then have contributed an important share of the materials for the winds to move to their present position.[1]

Conclusion and Questions

We find it difficult to reach any other conclusion than that the deposits under discussion in this paper are of windblown loessial origin, and that they were made subsequent to the 4th stage of physiographic development illustrated in Figure 1, and prior to the recent fan-building of the Chengtu Plain.

Such a conclusion as the above necessarily leads to another one, i.e., that if the deposit is of wind-blown origin, then the climatic con-

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which seem to come from different points of the compass. They seem to bear no relation to the winds of the upper atmosphere which, by the direction of movement of the higher clouds seem to be almost constantly from S.W. to N.E. These local dust storms occur on the intermediate and lower slopes of the mountains within the narrow valleys, where a local arid climate prevails. Probably some of the dust of the infrequent dust storms on the Chengtu plain may come from this source but it is doubtful in the total quantity is significant during the present period.

1 Recently, L. T. Chu reported verbally that the Chengtu clay occurs not only as a blanket over most of the low hills between the Lung-chien-i hills, as has already been observed by Dye, but he also found strips of it on the 35-meter terraces of the rivers eastward as far as Nanchung, about one hundred miles east of Chengtu. As more and more evidence comes in it seems that this material occurs largely on the eastward sides of the larger rivers and flood plains and that much of it may be locally blown dust, picked up from the river flood plains by westerly or northwesterly winds. At the present time strong winds are exceedingly rare, and so the Chengtu Clay may possibly be considered as fossil evidence of a former dry and windy climate in the region.

ditions must have been much dryer at the time of deposition than they are at present—the present humid climate being radically different from the one which then prevailed.

We should like to be able to correlate the age of these deposits with the better known loessial series of northern China, but our data are scarcely sufficient for that purpose, nor is either of us sufficiently conversant with the different subdivisions of the loessial deposits and their interrelations to make any very definite statements along this line. It is quite conceivable that more detailed study may reveal more than one epoch of deposition. The deposit of the material on the 35-meter terrace at Mienyang would indicate a fairly recent age, say, corresponding to the *Malan* stage. But even here our evidence is insufficient. We need fossils and more detailed physiographic material before drawing conclusions too freely.

Upon consulting Figure 1, it is evident that, if the material in question is of windblown origin, it must represent a long period of drought between a former humid climatic condition and the present moist climate. The reticulately mottled yellow and red clays of the very old topography evidently were well developed before the deposition of the loessial material. Their development was checked during the dry period but is now resumed. Evidence of this may be seen in the gradual leaching of the loessial (?) deposits and in the more rapid development of strongly acid soils on materials which are less resistant to soil forming processes, than these sticky yellow-brown concretionary clays. Specifically we refer to more or less reticulately mottled acid soils derived from the sandstones and loamstones of Cretaceous age in various parts of the Basin. Such soils may be found on gently sloping hills where erosion has been slow and soil forming processes have been active a long time.

One of the most intriguing questions that follows in the wake of the probable existence of loessial material in this region is the influence it may have on ancient man. Did man live in the Szechuan Basin at the time these deposits were accumulating? What was his mode of life and

means of subsistence? Did these early men prefer dry climate and stepp life to that of the forests? Had man learned to cultivate the soil at thi early date? These and many more questions force themselves upon us, and in all probability, many of them can never be answered; but with careful studies of the deposits and of fossils and archæological relic possibly included in them, it may be possible to open a new and entrancin field of investigation.

References

(1) Barbour, G. B., 1935: Mem. Geol. Surv. China. Series A No. 14. Peiping.

(2) Bowles, G. T., 1933: A Prelim. Rep't. of the Archæological Investigations of the Sino-Tibetan Border of Szechuan. Bul. Geol. Soc. China. Vol. 13, No. 1. Peiping.

(3) Dye, D. S., 1929: Szechuan's Chengtu County Irrigation Project. Lingnan Sc. Jour., Vol. 8.

(4) Hsieh, C. Y., et al. 1935. Mem. Geol. Surv. China, Series A, No. 13.

(5) Shaw, C. F., 1930: The Soils of China. Soil Bul. No. 1. Nat. Geol. Surv. of China, Peiping.

(6) Thorp, J. & Hou, K. C., 1935: Soils of Northern and Northwestern China. Soil Bul. No. 12. Nat. Geol. Surv. of China. Peiping.

(7) Thorp, J., 1935: Geographic Distribution of the Soils of China. Bul. Geol. Soc. China. Vol. 14, No. 2.

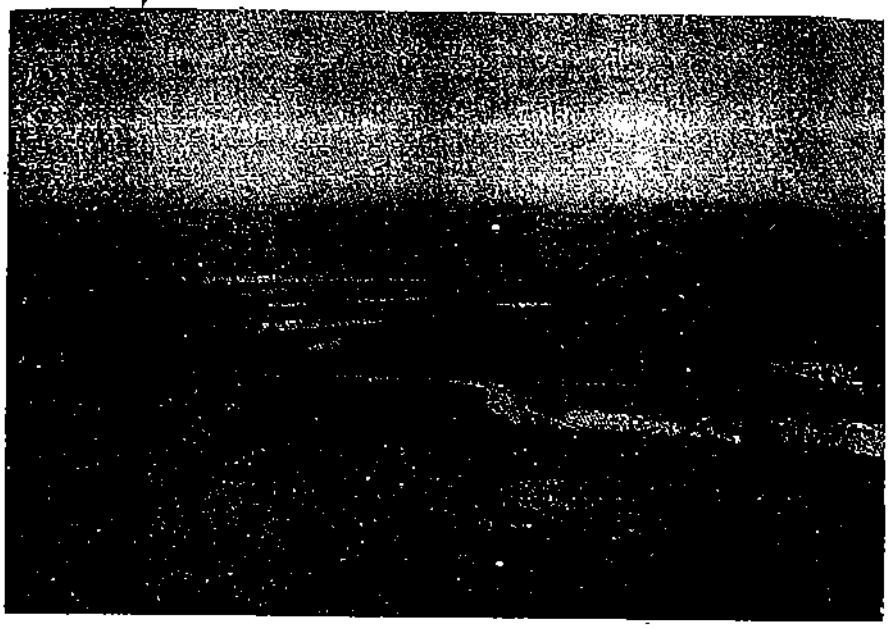
(8) Thorp, J., 1935: Soil Profile Studies as an Aid to Understanding Recent Geology. Bul. Geol. Soc. China. Vol. 14, No. 3. Peiping.

Explanation of Plate I

PLATE I

A. Kaotientzŭ (高店子) village, about 6 miles southeast of Chengtu, situated on a low hill of the strongly undulating "old topography". Hilltops, representing an old peneplain surface, average about 200 feet above the small streams. Underlying materials are mostly purplish red Cretaceous sandstones and shales, with a scattering of rounded cobbles and gravel inherited from the old peneplain. The whole area is capped by a more or less continuous blanket of "Chengtu clays" of probable loessial origin which varies from less than a meter to 3 or 4 meters thick. Irrigation ponds are constructed in the impervious "Chengtu clays". Photo by D. S. Dye.

B. New graves at Kaotientzŭ, excavated in "Chengtu clays" where they come into contact with the Cretaceous rocks. Lime concretions are scattered through the soil near the plate-holder. The cobble stones were lying directly on the Cretaceous materials and had been covered by the loess-like material (Chengtu clay). Some lime concretions formed among the cobbles as a result of the leaching of the overlying blanket of material. These concretions are now being gradually dissolved. For further details, see the footnote on page 235. Photo by D. S. Dye.



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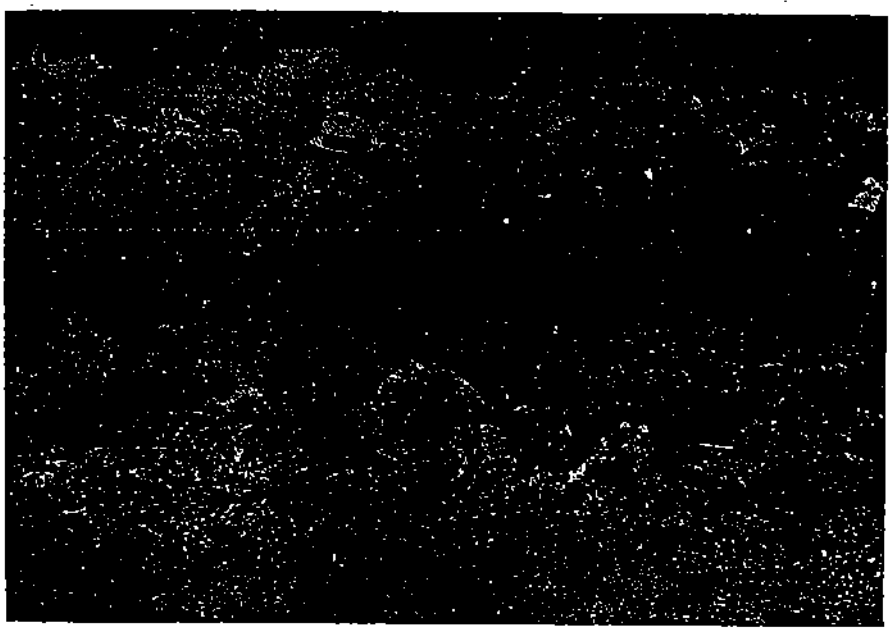


B

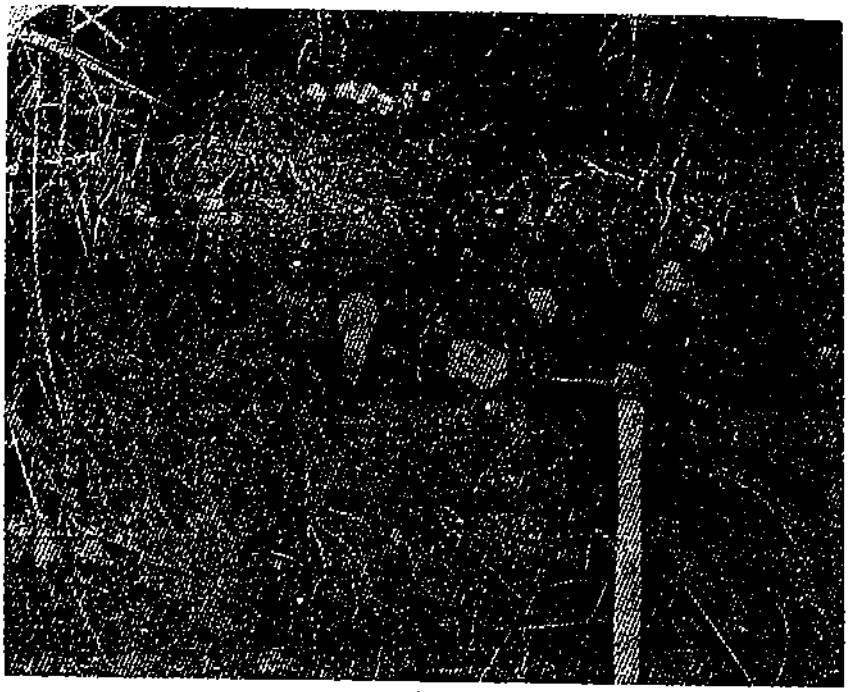
Explanation of

Plate II

PLATE II

II-A. Lime concretions in "Chengtu clays" near Lienshan, south of Têyang. Note the small pits on the concretions, indicating that they are in the process of being leached away. The pick handle is a little more than 40 cm. long. Photo No. 161-7, by J. Thorp.

II-B. Cloddy structure of "Chengtu clays". The upper horizons tend toward prismatic structure. Note the pitted white lime concretions. Photo 161-8, by J. Thorp.



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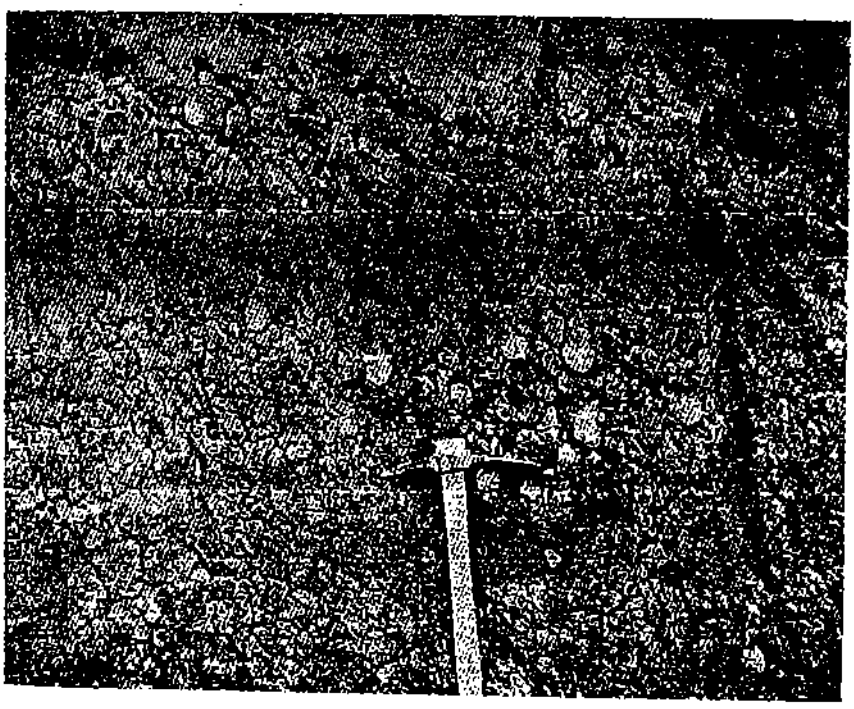

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