Preparation of Wet Soil Profiles with Thai Adhesives.

BY

Magdaleno M. Cero

Department of Science, Ministry of Economic Affairs.

Reprinted from Thai Science Bulletin,
Vol. II, Nos. 3 & 4, October, 1940.
Bangkok, Thailand.

Preparation of Wet Soil Profiles with Thai Adhesives.

BY

Magdaleno M. Cero

Of the Division of Agricultural Science, Department of Science, Ministry of Economic Affairs, Bangkok, Thailand.

INTRODUCTION.

Taking soil samples from the field in monolith (one block) has been undertaken by many workers by various means and procedures. Soil sampling by monolith has also always been a problem because of the difficulty in making the samples firm and intact when taken from the original position and preserving the natural structure of the various depths of the profile. Diverse methods have already been applied by many soil investigators to upland or dry soils, but so far there has not been any method given definitely for the preparation of soil profile samples from wet soils. This paper is presented for the object of describing a method of preparing permanent soil profile samples from poorly drained regions with the use of a new sticking mixture. The materials used in this new sticking mixture are found very abundantly and can be secured very cheaply in Thailand. Its distinct advantage over other adhesives or cements is that it is capable of being used and is effective in soils which are extremely wet.

IMPORTANCE OF SOIL PROFILES.

The importance of soil profiles is not only recognized in the study of soil itself but is obvious also to other branches of sciences. For example in engineering, plans for the construction of roads, bridges, dams and wall retainers have often been drawn up with the knowledge of the soil profile of the particular locality where such constructions are to be undertaken.

The sampling of soil profiles in monolith block is especially of great aid in recent times when soil classification and mapping are being undertaken by many countries. There is not sufficient guarantee that the soils classified by one country would be given the same name, as adopted for the same soil type in another country, in as much as there is as yet no universal standard method of soil classification. Any man engaged in the classification of soils may forget his knowledge about certain soil types that had been already described and established, but one can save time and expense by having samples of soil profiles right in the laboratory for reference. Incidentally, using this method, there can be no possible departure or deviation in the classification, and any duplication in soil type nomenclature in future work is avoided.

The science of geology never denies the fact that the knowledge of the soil profile gives a clue to the ages of rocks under a certain set of climatic conditions. Other sciences such as botany also deal with the soil profile as demonstrating the anchorage of plant as well as providing a clear means of interpreting the intake of water and plant food elements from the soil. But most universities of the world do not possess soil profiles in their laboratories for demonstration purposes because taking a soil profile from the field and preserving its natural condition is not an easy task to accomplish.

Of course there are other benefits derived from samples of monolith soil profiles, such as studies of the chemical profile, the pH value and some studies on the extent of translocation of the clay fractions or the movement of various salts in either up or down processes.

According to Robinson, the earlier generations of soil investigators considered that the individual soil meant a sample of soil generally from the layer occupied by the roots of plants. But now we can only have an adequate conception of the soil from the study of the horizons down to the parent rock, and a complete picture of laboratory analysis can only be obtained when supplemented by the studies of the profile from the field. The soil profile gives a summation of all the processes of soil formation, including physical and chemical weathering and vertical translocation of soil constituents by water movement.

REVIEW OF LITERATURE.

The first sampling of soil profiles by monolith was undertaken by Glinka and other Russian soil investigators, who used wooden or metal containers. A similar method has been used by the Bureau of Soils of the United States Department of Agriculture (1927), by using a wooden box with 3 sides lined with galvanized iron sheet which is forced into the soil by means of an automobile jack or other similar device. The box was provided with steel on each side as cutting edges. When brought to the laboratory, sphagnum moss was placed at the bottom of the profile and kept moist by a device of water bottle. The box was then covered with glass to prevent evaporation. The objection in the method as used by the Russian soil investigators and by the Bureau of Soils of the United States Department of Agriculture is that the box is difficult to handle because a large bulk of soil is sampled and the material easily breaks during transportation on account of the enormous weight of the whole profile sample.

To minimize the excess weight included with the sample, Chapman (1928), utilizing the same method as those used by Glinka and the Bureau of Soils of the United States Department of Agriculture, applied a shallow metal trough of such dimensions as 2 inches deep by 4 inches by 40 inches against the prepared surface of the soil profile and cutting it away through the sides of the trough. The objection to this method is that the depth of the profile is very shallow and may not represent much of the characteristics of the profile.

The idea obtained from the criticisms against excess weight of soil brought along with the sample gives rise to thinner sampling of the soil profile which has to be mounted to some form of rigid container. But when thin soil is placed in the box, there is the probability that the sample cannot be placed in an upright position without the chances of breaking. This leads, therefore, to the use of adhesives and cements. Many soil investigators have tried to find out the best type of container and the best type of adhesive to suit the type of soils under different conditions.

The first adhesive material used in soil monolith sampling was presented by Dr. Sigmund Pinkert of the Royal Hungarian Geological Society at Budapest, and exhibited at the First International Soil Congress held in Washington, D. C. in 1927. There were certain objections to the adhesive material used because it shrank after 3 years and shattered the material in the profile.

Schlacht, as cited by Harper (1932), followed the method of Pinkert by using a special lacquer which is a condensation product of urea and formaldehyde, soluble in water, that will penetrate in the moist soil. When the lacquer has been applied to the smooth surface of the soil profile, a strip of celluloid is attached to the treated surface. When the cementing material dries, a layer of soil 1-3 mm. adheres to the celluloid. Then the soil with the celluloid back is attached and fastened to a flat board so as to expose the profile in a rigid position. But for good study this method is hardly recommendable, because with a 1-3 mm. layer of soil, structural formations cannot practically be shown.

Bushnell (1930), worked out a method using pad glue to hold soil particles in natural position upon a firm background. But in the same way as the method suggested by Schlacht, the soil layer is thin and lacks structural significance, and in sandy soils the sand particles do not adhere.

Collison and Harlan (1930) proposed two methods for collecting soil profiles for study. In the first method, they collected soil profiles in a galvanized iron box similar to Chapman's metal trough and the galvanized iron lined box of the Bureau of Soils of the United States Department of Agriculture, except that the box is provided with a special cover to protect and hold the soil sample in the box. The advantage of the additional glass cover is very little and does not really eliminate the objections against the original method. In the second procedure, they suggested taking cylindrical profiles similar to Bushnell. It is however possible that, with this second procedure, the structure of the soil is destroyed when the celluloid is being fitted to the surface of the profile.

A method of taking soil profiles has been worked out at the Illinois Agricultural Experiment Station similar to Chapman's but with a Nurex Tabbing Compound applied inside the trough, 5 inches wide, 1 inch deep, and 50 inches long. The objection to the use of a metal trough is that upon handling, the metal container easily twists which may shatter the fragile column of soil in the trough.

Then Russel, as cited by Harper (1932), of the Nebraska Agricultural Experiment Station has devised a steel tube, 3 inches square and 36 inches long, which is slightly reduced at one end with the edge sharpened so that penetration is easier. This tube is forced into the ground vertically through a specially constructed frame. This method can be used only with soils without stones to hinder the penetration of the tube.

Horace J. Harper (1932), of the Oklahoma Agricultural Experiment Station and Mechanical College, studied a number of methods for the preparation of permanent soil profiles. He found that a dilute lacquer solution containing one part of lacquer thinner was most satisfactory. In moist soil, he suggested the use of a metal trough and then transfer to a suitable container at the laboratory. For sandy soils, he suggested filling up of cavities created by removed stones and, in case the cavities are large, the depth of the box could be increased. The objection to this method is that, in sandy soils and soils that are dry with numerous natural cracks, the lacquer may penetrate to the exposed face of the profile. And when moist soil is sampled in a metal trough and then transferred to a suitable container in the laboratory, there is the probability of destroying the structure of the soil, if not a total breaking up of the whole soil mass.

Morwick (1932) used asphalt tar as a sticking material, but the use of asphalt is only practicable with samples of shallow depth because of the difficulty in keeping the asphalt tar melted both in the face of the soil profile and on the board.

Description of New Method.

MATERIALS USED IN THE PREPARATION.

1. Wooden box made from teak wood, 126 cm. long, 20 cm. wide, and 5 cm. deep, weighing approximately 4.5 kgms., having the following parts (see Plate I. Fig. 2):

Backboard—2.5 cm. thick, 18 cm. wide, and 126 cm. long.

Side boards (pair)—1 cm. thick, 7.5 cm. wide, and 126 cm. long.

End boards (pair)—1 cm. thick, 7.5 cm. wide, and 18 cm. long.

Among wooden materials found in the market, teak (*Tectona grandis*) seems to be the only wood best suited for the purpose of mounting soil profiles. Teak wood is comparatively light but very strong and durable, and unusually resistant to attack of insects and decay. In Thailand, teak is found very abundantly and is one of the country's chief exports. Other wooden materials may be used for boxes but they must possess sufficient lightness and durability especially to moisture. All the boards used must be properly seasoned to heat in order to prevent shrinkage subsequently.

2. Materials for sticking are composed of powdered dipterocarpus resin, dipterocarpus oil, and lime. The powdered resin and the oil are obtained generally from the sap of four species of tall trees known locally as *yang*, namely, *Dipterocarpus alatus*, Roxb., *Dipterocarpus turbinatus*, Gaertn., *Dipterocarpus pilosus*, Roxb., and *Dipterocarpus incanus*, Roxb. (see Plate II. Fig. 4).

a. Powdered Dipterocarpus resin. Dipterocarpus powdered resin is obtained from the pulverization of the dried resin which is commonly sold in the market in the form of chunks of various sizes. These chunks are results of the dried sap which oozed from the injured part of some branches or tree trunks. The continuous oozing out of the sap and following gradual drying leads to the formation of a large amount of excretion similar to the stalactites in caves, These dried resins are usually gathered after a storm or heavy wind which often breaks the "stalactites" down. This raw dried resin usually has two colors, one of light smoky yellow and the other of a transparent dark greyish brown color.

b. Dipterocarpus oil. The dipterocarpus oil is the undried sap from the above species of trees obtained by cutting a pocket at the base of the trunk; the juice is induced to come out through repeated burning of the cut portion. If viewed against light, the color of the oil in a beaker is lilac but, when viewed down, it is dark reddish grey to almost black. But in general appearance, it resembles crude fuel oil. The dipterocarpus oil has an average density of 0.92.

Preparation of the Sticking Mixture.

The powdered dipterocarpus resin is placed in a basin and the oil is added, a little at a time, with constant stirring until a mixture of a hard paste consistency is obtained. Then lime is added to the mixture and worked out thoroughly. At this stage of the mixing, it is almost imperative to use the hands in rolling and folding the hardening mixture. The addition of lime should cease when the sticking mixture assumes a state similar in character to just above that of the sticky point in clay loam soils.

The proportion of powdered resin, resin oil, and lime in the mixture, according to the materials used, is 15 grams powdered dipterocarpus resin, 7 cc. dipterocarpus oil, and 4 grams of lime. This proportion could be multiplied by any number depending upon the total bulk of mixture to be desired. However, variations from the above ratio may happen according to the density of the oil and the purity of the lime which is used as a dehydrating agent. But generally, the sticking mixture hardens sufficiently in two hours after its preparation. Because the sticking mixture dries naturally fast, it is almost always advisable to prepare it when the digging of the sample pit and the fitting of the board to the face of the soil profile is almost complete.

For very wet soils, a slow hardening mixture is desirable because it is soft and yields easily to the readjustment of the soil, in the sample box. On the other hand, a quick hardening mixture is adapted to soils that are only slightly moist or dry and whose shape does not alter any more after sampling.

The implements used in the sampling operation, as shown in Plate I, fig. 3, are crow-bar, hoe, post digger, spade, and bucket.

Procedure Used in the Collection of the Profiles.

The first consideration in every sampling procedure is the selection of the site typifying the soils of the locality. A pit 50 cm. wide and 100 cm. long was dug vertically down to a depth of 126 centimeters. The excavated soil was placed on the long sides of the sample pit while one of the short sides was designated as the side from which the sample was to be taken. When the excavation was completed, the pit appeared in cross section as in fig. 1, where *a*, represents the side to be sampled and *b*, a bowl-shaped dug-out at the bottom of the pit. Water is allowed to accumulate in *b* and then bucketed out from time to time. This is important as there should be no standing water in the sample pit during the whole sampling operation. The back board of the box was very closely fitted to the surface of the soil profile to be sampled.

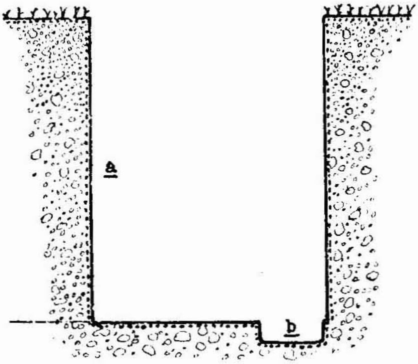

Fig. 1. Showing X-section of a sample pit.

The board, after being fitted to the soil, was taken out and the freshly prepared sticking mixture was thoroughly and uniformly smeared to the board while, at the same time, the dipterocarpus oil was smeared unto the fitted surface of the soil. When the soil was very wet, one application of the oil was sufficient to fill the larger pores without water. Having smeared the board thoroughly with the sticking mixture, it was again fitted to the soil and gently tapped from the back. The board was held on top by hands and at the bottom by sinking a crow bar or sharpened wood in a slanting position which pressed the board closer to the soil and gave freedom of space for the workman to excavate the soil from the sides of the box.

The soil along the outside of the board was slowly cut away in order to fit the sides of the box, which was done either by carefully nailing small 1-inch nails or by the use of screws. The use of screws was found preferable to nails because the possibility of the soil being knocked off or loosened during the process of nailing was prevented. When all the sides of the box were fitted, the soil along the vertical sides was carefully dug out and worked in diagonally towards the middle until the excavation from each side nearly met. When the soil was either sandy or too moist, great care was observed during this part of the operation. In both cases, when digging from each side almost met each other, from top to bottom, the box and attached soil should not be given the slightest move, for any shock given to the box may cause the collapse of the whole column of soil inside. When roots were absent or the profile was devoid of stones, the soil in the box was cut away from the main soil by passing a thin knife from top to bottom and at the same time pressing the box firmly to the soil as much as the knife can be allowed to be pressed down. In this manner the danger of collapsing in the process of separation of the sample was minimized. In this method of sampling, it was found convenient to include excess soils with the box, as much as 1 to 2 inches thick only. When an unnecessarily large amount of soil is cut away with the sample, it often leads to collapse of the soil from the box especially in very wet and sandy soils.

The withdrawal of the sample from the main soil requires a sudden fast pull away and bringing the box into a slanting position as quickly as possible. By this manipulation, the possible collapse of the soil sample was generally prevented. Whenever an unavoidable collapse occurred, a refitting of the board had to be made and the sticking mixture was wiped out and smeared with fresh mixture.

When the ground water table was within one meter, as was usually the case in most of the sampling, it was necessary to complete the operation immediately in order to escape any difficulty arising from the constant flow of water into the pit. This was particularly guarded against in the case of sandy soils where, when the water was allowed to accumulate in the sample pit, the sides soon crumble away, entailing extra labor in the digging the soil and refitting of the board. The water in the sample pit was bucketed out to keep the bottom of the pit sufficiently free from water during the process of fitting until the sample had been taken away.

Handling of Profiles.

After the profile sample was taken from the pit it was laid flat on the ground at once. This was observed especially among soils that were either loose or saturated with water. The extra soils were removed to prevent excess weight. The samples were in a horizontal position all the time, when in a moist state, and during transport from the field to the laboratory. In the laboratory, the samples were placed in the shade in order to dry them gradually. When the samples were thoroughly dry, they were trimmed in level with the box and then brought to a vertical position and placed in piles in racks. Some of the samples which were placed on exhibit were provided with glass covers to protect them from dust and also from the hands of curious spectators. And when these samples were stored for further reference, they were wrapped in cellophane to protect them principally from boring wasps and ground ants as well as from dust.

Discussion.

In the preparation of a permanent soil profile, there are two important considerations, namely, the container and the sticking material. The container, to be ideal, must be rigid but at the same time light enough for convenience in handling and transportation. In this investigation, the container is described in the materials used and complies with the distinction of being light and rigid. The sticking mixture as a part in the preparation of a permanent soil profile sample is probably the most important because it is from the effective hold of the sticking mixture on which the permanency of preservation of the sample depends. With the knowledge acquired from various investigations conducted along this line, so far, there seems to be no material better than the sticking material used in this investigation with regard to ease of handling and its effectiveness when used with any kind of soil, either dry or wet to a degree of being saturated with water.

The soil after sampling soon adheres to the box by means of the soft sticking mixture although not probably throughout the whole soil column; but when the sample is laid flat on the bottom of the box, a sort of automatic readjustment takes place. The weight of the soil exerts pressure upon the bottom of the box and upon the sticking mixture. The soil, being soft in the moist state, fills itself in the spaces where there was no contact between the soil and the board, while at the same time the sticking mixture which is also still soft, creeps to find in the soil masses where there was no sticking mixture at all. In this case, therefore, even when there was no complete contact between the sticking mixture and the soil during the process of fitting, there would be an eventual fitting up as soon as the soil is laid flat on a horizontal position. There would not be any possibility of air being trapped between the soil and the box because the weight of the soil would exert a constant pressure, strong enough to liberate the air through the spaces between the soil particles. The sticking mixture, therefore, becomes completely effective because the adhesive mixture remains soft for some time and permits the most soil to set wholly on the bottom of the box and allows the mixture to creep into the minute spaces of the soil.

The use of the new sticking mixture is easy. No extra apparatus are required when the sticking mixture is smeared to the board or when the oil is applied to the fitted surface of the profile. A piece of stick could be used to aid both operations but the use of bare hands[1] is quicker and more effective. This sticking material has practically the same effective hold to the soil as the asphalt tar but the result is better because of its capability to creep into the minute crevices of the soil mass. It is used without the aid of heat, yet it dries very fast depending upon the quantity of lime added.

The dipterocarpus oil, after passing through the minute pores of the soil, serves as " roots " of the sticking mixture and holds the soil firmly to the board, when dry. Where the ground water table is below the depth of sampling, this method even works more satisfactorily because the resin oil and the sticking mixture can penetrate deeper into the soil and attach the soil more strongly to the board than when the soil is moist.

In dry soils, the board with the sticking mixture, after being placed against the soil, can be left to stay untouched for 20 minutes to allow the sticking mixture to harden sufficiently. When the board is allowed to stay overnight, the sticking mixture becomes perfectly hard the next day. In this case, the box and soil were found to be very easy to detach from the main soil, the chances of collapse as in the case of wet soils having been eliminated.

DESCRIPTION OF SOME SOIL PROFILES.

For lack of color differentiation of the profiles shown in Plate I. Fig. 2, the following descriptions supplement this presentation and give the geologic and economic background of these profiles. Soil profiles Nos. 1, 2, 3, and 4 were obtained from Amphur Ban Pong (อำเภอ บ้านโป่ง) regions, Changwad Kanchanaburi, (จังหวัด กาญจนบุรี) during the height of the flood in 1938.

---

[1] The hands are oiled with the dipterocarpus oil to prevent the mixture from sticking to the hands.

Soil profiles Nos. 5 and 6 were obtained from Amphur Ta Mai, Changwad Chantaburi, (อำเภอท่าใหม่ จังหวัดจันทบุรี) where the soils are better drained and dry during most part of the year.

Soil profile No. 1. Taken about 5 m. north-east of a point 19.3 km. from Nakorn Patom (นครปฐม) along the Nakorn Patom-Ban Pong (นครปฐม-บ้านโป่ง) road. Ban Pong itself is 20.4 km. from Nakorn Patom. The general topography of the land is flat and low but the place from which the profile was taken was slightly elevated with a fair amount of drainage. The small strips of depression near by are waterlogged.

The surface soil is dark brown loam; slightly granular and the structure broken down by cultivation to a depth of 20 centimetres. A transition of 4 cm. below it, is slightly dark greyish brown and of the same texture. The subsoil beginning from 24 cm. down to 70 cm. greyish brown heavy loam to very light clay loam. The substratum begins from about 80 cm. below the surface of the ground. It is characterized by few small dark brown mottlings interspersed in its generally light greyish brown color. The texture is heavy loam with a rather loose consistency. During most part of the year, this portion of the profile is within the reach of the ground water level.

The texture of the whole excavated profile is generally light and the only very noticeable variation along the vertical section is the color, probably due to the organic matter which gives a darker color to the surface soil and which grades into a lighter to medium greyish brown in the second horizon, with almost none of its effect in the substratum. Another quite noticeable difference in the profile is the probable translocation of the fine aggregates and clays into the subsoil which makes it slightly heavier in texture than the surface soil or the substratum.

Because of the generally light character of the whole soil profile, the retention of water is practically small so that although the ground water table is about 80 cm. below the surface of the ground, there seems to be no effect produced by a condition of poor soil drainage on the crops grown.

The crops best suited for this type of soil are bananas and coconuts and sugar cane when there is ample fertility present, and when planted at the proper season.

Soil profile No. 2. Located 100 m. north-east at a point 17.2 km. of the Nakorn Patom-Ban Pong road (นครปฐม-บ้านโป่ง). The topography of the surrounding vicinity, from which the sample was taken, is generally flat with only a few slightly elevated portions. The sample site was situated on a slightly elevated topography where the land was dry and fairly drained on the surface portion.

The surface soil is dark greyish brown, very fine loam to a depth of 30 cm., structureless and firm with a gradual transition of 8 centimeters. The subsoil which is also structureless, begins from a depth of 38 cm. down to 95 cm., a light brown to buff of fine sandy loam texture with slighly loose consistency. The texture below 1 m. is loamy sand, more or less buff in color with few glistening particles of quartz. At the time of sampling, this portion of the profile was wet, the ground water level was about 80 cm. deep.

The place of sampling, a slightly elevated portion, must have heen a part of the old flood plain of the Kanchanaburi River in its earlier stage of development. At that time, there was actually no deep channel for a permanent and stable course of the river water. As a result, all the lower regions of Kanchanaburi are, until the present time, more or less alluvial in nature and the soils resulting from such formation are almost in all cases light in texture. This characteristic alluvial formation is very clearly shown in this profile. A large amount of materials carried down with the water and deposited on the whole flooded region is more or less uniform in depth, but as the flood water began to recede or reshaped its course, then the amount of water decreased in the regions around Ban Pong. In the later stage of the flood, the river water might probably have separated into small distributaries forming small channels all over the flooded region, as shown by the present land surface of Amphur Ban Pong (อำเภอบ้านโป่ง), which is composed of small ridges of uplands which are dry, and expanses of depressions which are poorly drained and sometimes swampy.

Soil profile No. 3. The sample was taken 250 m. north to northwest of the point 4.2 km. near the irrigation gate crossing the Ban Pong-Kanchanaburi (บ้านโป่ง-กาญจนบุรี) road. The topography is very gently sloping away from the bank of the river. Drainage is at most only fair.

The surface soil is light buff to light greyish buff very fine sandy loam to a fine loam. The whole surface soil is distinctly alluvial resting on an older residual formation at 53 cm. below the surface of the ground. The color is fairly uniform with a slightly loose consistency and devoid of any structural formation. The second layer is dark greyish brown, light clay loam, which gradually grades into its substratum from 108 cm. to 114 centimeters. The substratum is a light greyish brown heavy loam with a slightly loose consistency and slightly mottled with brown coloration in the form of irregular spots.

How long the formation of the alluvial over-laid surface soil has taken place is unknown. Only one thing is certain, that the kind of alluvial material is uniform in color and texture in its whole range of surface soil section. It may be possible that this amount of material has been deposited in one single flood. That this assumption is apparently true is shown by the uniformity of the deposited material. When the alluvial material is assumed to have been laid in more than one flood occurrence, then, with the difference in velocity of the current, the amount and kind of materials would have been shown in the surface soil profile. But as actually shown in the sample, the materials in the whole surface soil are of a uniform character both in color and texture. It is therefore probable that the whole alluvial surface soil had been laid in one single flood. Subsequent floods must have occurred, but they never had any material effect upon the amount of alluvial deposit already formed.

The capacity of the surface soil for water is very low and most of the percolated water goes down at a comparatively rapid rate into the heavier residual subsoil. At the time of sampling, the upper portion of the subsoil was found to contain the most amount of water in the whole profile. The land represented by this sample possesses good fertility due probably to the recently formed alluvial material. Because of the light character of the surface soil, its cultivation is comparatively easy. Vegetables were found to grow well on this type, but in this region bananas have been the dominant crop raised by the farmers with good profit.

Soil profile No. 4. Located 50 m. east of a point 2.6 km. north of Ban Pong railway station (สถานีบ้านโป่ง) along the Ban Pong-Kanchanaburi road. The topography is flat and low with very poor drainage conditions.

The surface soil is a dark greyish brown, light loam with single-grained or massive structure, firm, and brittle in consistency to a depth of 14 centimeters. The subsoil is slightly granular, greyish brown with a few dark brown mottlings, down to a depth of about 1 m. below the surface of the ground. The substratum, which is loose and slightly granular, is light greyish brown, light clay loam. During most part of the year, this portion of the profile is within the reach of the ground water table. At the time of sampling, water was generally high in all the low places especially in the rice fields. In this locality, the soil has been probably formed in place, as there has been a gradual development of the soil profile especially in color formation, that is, from a dark greyish brown, fairly drained surface soil to a light greyish brown subaqueous substratum.

This type of soil is low and flat and is subject to flood during times of extremely heavy rainfall. So that for optimum utilization, it can be cultivated only for some staple crops such as legumes, corn and some vegetables, which can be planted part of the year when there is not much excess moisture in the soil. Its extent is rather limited, situated mostly along the marginals of the lowland rice soils. Because of its proximity to these lowland rice fields, the soil is almost always moist throughout the year. But the light character of the surtace soil eliminates the possibility of having too much moisture in the soil to be detrimental to cultivated staple crops.

Soil profile No. 5. Located 10 m. outside the middle portion of the south-western boundary of the Pepper Station of the Thai Department of Agriculture and Fisheries at Amphur Ta Mai, Changwad Chandhaburi (อำเภอท่าใหม่ จังหวัดจันทบุรี). The topography is very gently sloping with good drainage.

The surface soil is light brownish red heavy loam, slightly loose in consistency and with very fine granules. The surface soil grades very gradually into a brownish red clay loam subsoil which is very granular, ranging in size of granules of from 1 to 3 millimeters. The subsoil extends the whole range from 25 cm. down below the depth of sampling without any change in color, structure, and texture.

This sample represents the typical level or gently sloping, brownish red soils of Chandhaburi. The examination of the water wells in this same type revealed that the depth of the subsoil extends from 6 to 8 m. below the surface of the ground, gradually grading into a greyish brown slightly mottled and moist substratum, which is underlain by a gray, partly cemented well-weathered andesitic rock at a depth of 14 m. from the surface.

The red soils of Chandhaburi, which are equivalent to the "terra rosa" of the Mediterranean, have great capacity for water and are very deeply weathered. According to preliminary mechanical analysis, the amount of clay present is as high as 60 per cent. But although it contains a high percentage of clay, the soil is very easy to handle and cultivate. The granular structure is excellent and therefore allows water to penetrate down very readily. This character coupled with its very deep extent is quite detrimental to the conservation of plant food in the feeding zones of most cultivated plants, for, if percolation is great, then the rate of leaching of plant nutrients is also great. It is partly for this reason that the red soils of Chandhaburi, which are thoroughly weathered, are very poor in plant food. The farmers in this locality can only maintain and grow crops through a very liberal application of organic fertilizers as well as the use of burned soil to increase the fertility of the land.

Soil profile No. 6. Located in the north-eastern part of the village of Nong Kar (หนอง กา), Amphur Ta Mai, Changwad Chandhaburi, (อำเภอ ท่าใหม่ จังหวัด จันทบุรี). The topography is flat, and drainage fair.

The surface soil, which is dense, dark gray loam, extends to a depth of 20 cm. under natural condition with small trees as the vegetative cover. In cultivated grounds, the surface soil is light greyish brown or sometimes light brownish gray. The subsoil, which extends from a depth of 20 cm. down to 50 cm. below the surface of the ground, is light greyish brown sandy clay loam, very firm and compact. The change in color from the surface soil to the subsoil is very gradual; the subsoil, on account of its texture being the same as the substratum, might be called a transition into the more pronounced substratum, which is very slightly reddish brown sandy loam to gravelly loam extending beyond 1.25 metre. The substratum is more compact and denser than the subsoil.

The soil represented by this profile seems to have originated from a quartzitic sandstone rich in iron and seems to be the prevailing soil in the lowlands around the hills of brownish red soils. New excavations from wells of 6 m. deep indicated that the soil in the lower part of the profile was purplish brown, very fine sand.

In the Chandhaburi region, this type of soil is considered the poorest soil agriculturally. The reasons why the people of this locality have assumed it to be a poor soil are due probably to the fact that the soil, being very shallow and underlain by a compact sand subsoil, is difficult to cultivate. The insufficient amount of moisture is another factor which lowers its usefulness to agriculture. The insufficiency of moisture is due to the compactness and sandy nature of the substratum which prevents capillarity during the dry season. And because of the compactness of the subsoil and subsoil and substratum, excess rain water stands on the surface of the soil which may be detrimental to crops when found at this state for an extended duration. When rain stops, standing water soon evaporates leaving the zones, in which plants may acquire water, dry. In other words, the peculiar characteristic of this soil lies in its compactness, sandy nature, and very small clay content.

SUMMARY AND CONCLUSION.

1. A new preparation of permanent soil profiles from wet soils with Thai adhesives was found very satisfactory. The method can be applied to dry soils with even more gratifying result.

2. Dried resin, resin oil, and lime which are used as a sticking mixture are easy to handle and to prepare. These materials are found abundantly in Thailand and are cheaper than any other adhesives or cements, and more effective in extremely wet soils.

3. Directions for preparing the sticking mixture and the excavation of the sample pit in poorly drained soils are given in detail.

4. The use of light wooden receptacles, resistant to moisture and decay as teak, for mounting soil profiles was found very convenient in the process of sampling, handling during transportation, and in the exhibits.

5. A description of some profile samples refers to samples obtained by this method from the poorly drained areas of Amphur Ban Pong, Changwad Kanchanaburi, and from the well drained soils of Amphur Ta Mai Changwad Chandhaburi.

LITERATURE CITED.

1. *Anonymous.* 1927. A better way of soil sampling. U. S. D. A. Official Record 6 : 3.
2. *Bushnell, T. M.* 1930. The Purdue technique for taking and mounting monolithic soil profile samples. Soil Sci. *29* : 395-397.
3. *Chapman, J. E.* 1928. Monolithic soil profiles. Science. *68* : 299.
4. *Collison, R. C., and Harlan, J. D.* 1930. Preparation of soil profiles for exhibition and soil study. New York State Agricultural Experiment Station Technical Bulletin. No. 173.

5. *Harper, H. J.* 1932. A study of methods for the preparation of permanent soil profiles. Technical Bulletin. No. 201.
6. *Morwick, F. F.* 1932. Preservation of soil monoliths. Scientific Agriculture. *13* : 1-6.
7. *Picharn, Phya Vanpruk.* 1923. List of common trees, shrubs, etc. in Thailand. 1st ed., iii+278. Bangkok : Bangkok Times Press.
8. *Robinson, G. W.* 1935. Soils, their origin, constitution and classification. 2nd ed., xvii+442, 17 illus. 5 pts. London : Thomas Murphey & Co.

Fig. 2. Soil profiles in wooden boxes, 1.26 m. long, 20 cm. wide, 5 cm. deep, and showing natural cracks.

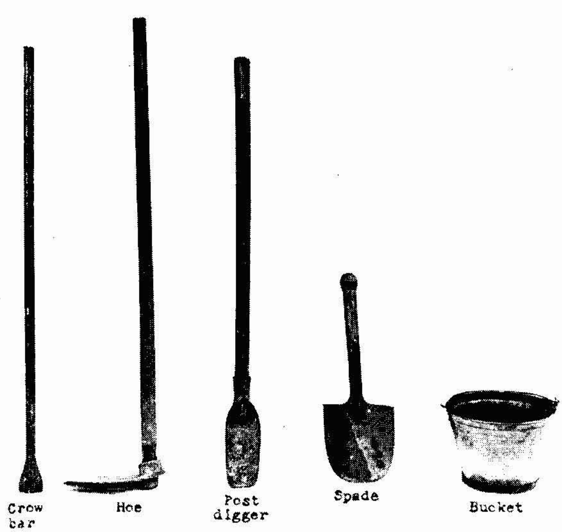

Fig. 3. Implements used in sampling.
(*Photos by Industrial Chemistry Division, Dept. of Sci.*)

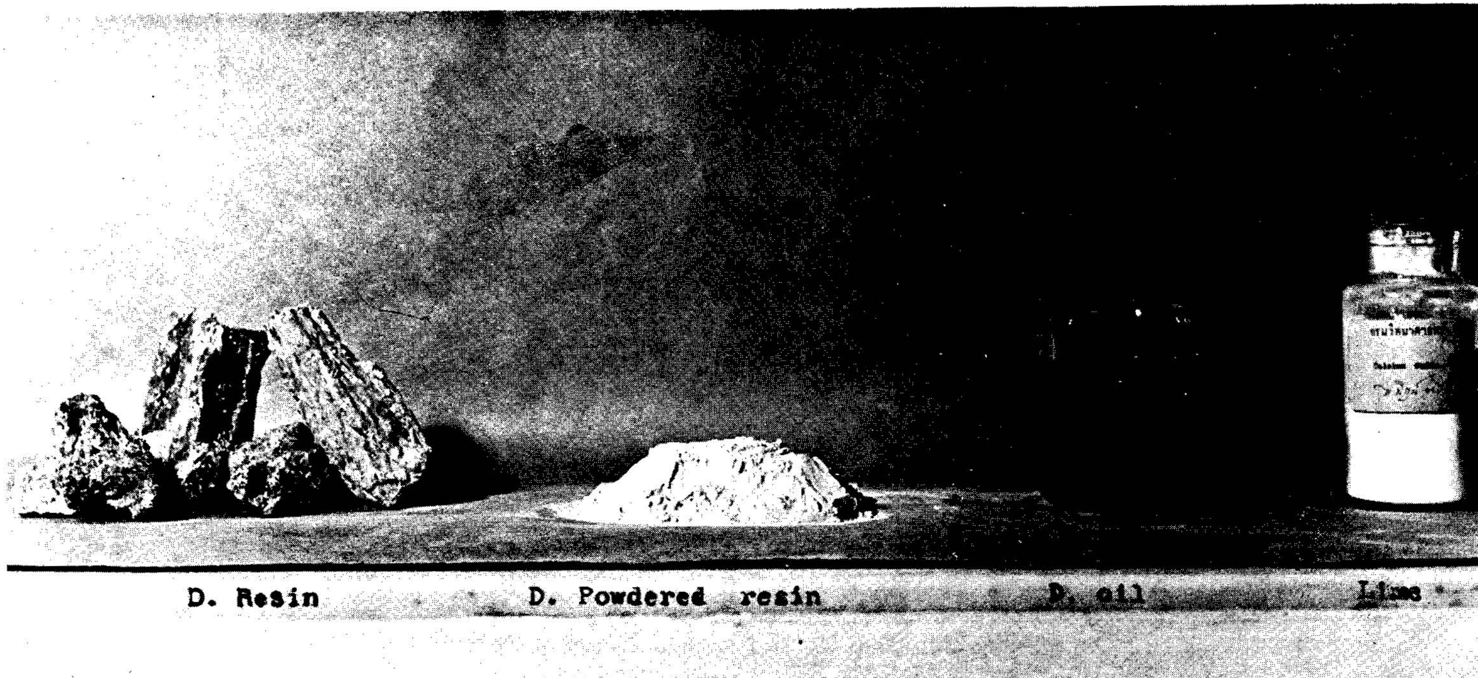

Fig. 4. Ingredients of the Sticking Mixture.
(*Photo by Industrial Chemistry Division, Dept. of Sci.*).