OKLAHOMA
AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATION

C. P. BLACKWELL, *Director*

STILLWATER, OKLAHOMA

A Study of Methods for the Preparation of Permanent Soil Profiles

HORACE J. HARPER
Professor of Soils

Bulletin 201 (Technical Publication, Limited Edition) January, 1932

A STUDY OF METHODS FOR THE PREPARATION OF PERMANENT SOIL PROFILES

HORACE J. HARPER
Professor of Soils

A more careful investigation of the soil profile and factors which have been influential in its development is one phase of soil science which has not been emphasized by many educational institutions, probably because of a lack of suitable material which has been available for study.

One of the big problems which occurs in connection with the teaching of soils is the difficulty encountered in conveying to the student abstract information concerning variations which occur between different soil types. Loose samples of soil can be obtained from different soil horizons which can be analyzed to obtain information concerning their physical and chemical composition; however it is not easy to illustrate differences in soil structure and variations in the appearance of soil horizons unless unmolested cross sections of soil can be examined. Usually only a few soil types are available for study in any particular area; consequently the only practical way in which soils which have been formed under a wide range of climatic conditions can be studied would be to assemble typical profiles from different soil areas. This method of visual education has been used by departments of botany, geology, and other sciences for a long period of time.

One of the reasons why soil profiles have not been collected in greater numbers is due to the fact that no satisfactory method has been developed which is applicable to a wide range of soil conditions, although several different procedures have been suggested for taking and mounting soil profiles.

Review of the Literature

One of the first methods proposed for collecting soil profiles was devised and used by Glinka and other Russian soil investigators. A metal container similar to that shown in Fig. 3 is forced into a vertical section of soil until it is completely filled. After this has been accomplished, the container is removed by excavating on each side of it and beneath it so that the sample can be detached from the soil face leaving the metal box filled with soil. The chief objections to this type of a sample are that the weight of the profile makes it difficult to handle, and also that when a soil shrinks appreciably or if it is very sandy it will be loose in the container and cannot be transported conveniently without danger of destroying the characteristics of the soil as they appear in the field.

A method similar to that which has just been described has been used by the Bureau of Soils of the United States Department of Agriculture (1). The bureau has proposed the use of a wooden box 5 feet long, 8 inches wide, and 4 inches deep, which has only three sides and is lined with galvanized iron. This box is equipped with detachable cutting edges made of steel which are attached to each side of the box in order to cut through the soil when the box is forced into a vertical section of soil with a wood ram or by means of automobile jacks. The adjacent soil is cut away from the box after it is filled, and a cover is put on the box before it is moved from the place where the profile is secured. After the profile has been taken to the laboratory or museum, sphagnum moss is packed in the lower end

of the box beneath the soil. The moss is kept moist by means of a tube which is attached to a supply of water kept in a bottle near the soil sample. The water added to the moss moves upward into the soil by capillary attraction and keeps the profile in a moist condition. A glass cover is placed over the soil in order to protect it and reduce evaporation. There are several reasons why this method is not entirely satisfactory. The samples are heavy to handle; the cost of shipping them is considerable; and it would require extreme care in order to pack a soil profile so that the soil particles would not break apart if the sample were transported from one place to another.

A method used by Dr. Sigmund Pinkert, of the Royal Hungarian Geological Society, Budapest, Hungary, in mounting soil profiles exhibited at the First International Soil Congress held in Washington, D. C., in 1927, was not entirely satisfactory, according to Dr. C. F. Marbut, of the Bureau of Chemistry and Soils. The adhesive material which was used to fasten the soil profile to a suitable background dried and shrank after the profiles had been mounted for two or three years so that the soils were very much shattered and did not present a satisfactory picture of the actual soil characteristics as they existed in the field.

In order to reduce the large amount of work required in securing soil profiles, Chapman (3) has suggested a procedure which is very similar to that recommended by the Bureau of Soils except that a much smaller profile is obtained. In his method, a hole 9 inches in diameter and about 4 feet deep is dug with a post auger. One side of this hole is smoothed with a square-pointed spade and a galvanized iron trough 4 inches wide, 2 inches deep, and 40 inches long, similar to that shown in Fig. 3, is forced into the flat soil face by using a short automobile jack. The sample of soil is secured in the metal trough by digging away the soil on each side of the container until it can be lifted from the pit. Objections to this method of taking soil profiles are very similar to the objections previously given. Also, whether or not the soil profile is typical of the soil type cannot be determined until it has been removed from the ground. In some instances a 40-inch section may not be deep enough to include all of the physical features appearing in the different portions of a soil profile. When stony soils are encountered the method is of little value.

Schlacht (5) has proposed a method for securing soil profiles which involves the use of a special lacquer which is a condensation product of urea and formaldehyde. This lacquer is soluble in water and will penetrate a moist soil. After the lacquer has been applied to a smooth vertical section of soil a long narrow strip of celluloid is attached to the treated area. As soon as the cementing material is dry a layer of soil about one to three millimeters thick can be removed. The celluloid strip to which the layer of soil is attached is then fastened to the bottom of a shallow box with the urea-formaldehyde lacquer in order to hold the profile in a rigid position. Such a method for collecting soil profiles has an advantage over previous methods from the standpoint of the light weight of the profile secured. A good idea of the colors of the different soil horizons can be obtained from this type of a profile, but a study of differences in soil structure cannot be made when such a thin layer of soil is secured because one or two inches of soil and occasionally thicker layers may be required to show some structural differences.

Bushnell (2) has worked out a good method for taking and mounting soil profiles in which pad glue is used to hold the soil particles in their

natural position and attach them to a firm background. Good profiles can be secured on many types of soil with this method; however there are many conditions where pad glue does not give satisfactory results. In sandy soils where the particles do not adhere, the procedure cannot be recommended. In case of soils which break into small granules on drying, and in stony soils, good profiles are difficult to secure.

Collison and Harlan (4) have proposed two different methods for collecting soil profiles for study. In the first method the soil profile is collected in a galvanized iron box in a manner very similar to that procedure proposed by Chapman (3) and the Bureau of Soils (1) except that a special cover has been designed to protect the soil sample and hold it in the box. Very little advantage can be gained by using this method in preference to those which have already been suggested. In a second method directions are given for taking cylindrical profiles which are similar to a procedure suggested by Bushnell (2). It is entirely possible that the natural soil condition could be exhibited by this type of a profile unless the structure of the soil was destroyed in smoothing up the surface of the profile in order to cover it with a celluloid cylinder to protect it from dust and from the possibility of crumbling when certain soils or soil horizons are encountered which are granular in nature.

At the Illinois Agricultural Experiment Station, soil profiles have been mounted in a metal tray 5 inches wide, 1 inch deep, and 50 inches long. Nurex Tabbing Compound is applied to the inside of the tray before it is forced into the soil in order to hold the soil in the tray after the sample has been dried in the laboratory. The chief objection to a metal tray is that it is not rigid and when handled will twist slightly, this movement tending to loosen the soil sample so that it will fall apart unless carefully handled. The method is not satisfactory for stony or sandy soils.

Russell of the Nebraska Agricultural Experiment Station has devised a steel tube which is 3 inches square and 36 inches long and is slightly reduced at one end. The edges of the reduced end are sharpened so that the tube can be forced into the soil more easily. A special frame is constructed so that the tube can be forced perpendicularly into the soil by means of a heavy automobile jack. The steel tube is removed by excavating on one side of the tube with a large auger. Under favorable conditions a very good core of soil can be secured; however there are many soil conditions where such a method could not be used successfully.

STUDY OF EXPERIMENTAL METHODS

As a result of a considerable amount of detailed investigation in regard to methods which have been proposed for mounting soil profiles, no method was found which was satisfactory for all soil conditions; consequently an attempt was made to find a method which could be successfully used in collecting soil profiles under any condition of soil which might be encountered. A large number of different types of materials have been studied in order to find some procedure, if possible, which could be recommended for use in taking soil profiles so that the soil would present a natural appearance and would withstand a considerable amount of rough treatment without disintegrating after it had been mounted on a suitable background.

A list of materials which have been used in connection with this study is as follows:

Common Materials

1. Asphalt, M. P. 340° F.
2. Carnauba Wax
3. Coal Tar Pitch, M. P. 143° F. to 148° F.
4. Dextrin
5. Furniture glue
6. Gilsonite, M. P. 275° F.
7. Japan Wax
8. Lacquer (brushing)
9. Lacquer (spraying)
10. Linoleum Cement
11. Linoleum Paste
12. Montan Wax
13. Naudella Wax
14. Ozokerite
15. Pad Glue
16. Paraffin Wax
17. Plaster of Paris
18. Rosin
19. Rosin - Venice Turpentine mixture
20. Starch Paste
21. Shellac
22. Varnish
23. Yellow Ceresin Wax

Special Cements and Adhesives

NO.	MATERIAL	COMPANY
1	Acid Proof Cement	Quigley Furnace Specialties Co., Inc., New York, New York
2	Colvulc Plastic Rubber	Colvulc Rubber Company, Norfolk Downs, Massachusetts
3	Duco Cement No. 5458	E. I. DuPont de Nemours & Company, Wilmington, Delaware
4	Findley's Hot Cement No. 83, 84, 85, 86A, and 87.	The F. G. Findley Company, Milwaukee, Wisconsin
5	Korite No. 1, M. P. 175° to 185°F.	Standard Oil Company, St. Louis, Missouri
6	Korite No. 3, M. P. 225° to 235°F.	Standard Oil Company, St. Louis, Missouri
7	No. 1 Red and Black Marine Glue	L. W. Ferdinand & Co., Boston, Massachusetts
8	No. 7 White Marine Glue	L. W. Ferdinand & Co., Boston, Massachusetts
9	No. 99 Compound	National Rosin Oil & Size Co., New York, New York
10	Nurex Tabbing Compound	The Lee Hardware Co., Salina, Kansas
11	Paraplex R. G. No. 2	The Resinous Products & Chemical Co., Inc., Philadelphia, Pennsylvania
12	Rezinel No. 3	Glyco Products Company, Inc., Brooklyn, New York
13	Soft Isolene	National Rosin Oil & Size Company, New York, New York
14	Wood Amalgam	Wood Amalgam Company, Bloomfield, New Jersey

On many types of soil, profiles are very easy to secure because of the fact that the soil particles adhere to each other and almost any type of adhesive material attached to the soil face and combined with a favorable background will hold the soil in a permanent position. Many soils can be securely mounted on a board in which a considerable number of short nails have been driven so that the ends extend through the board about one-half

to three-fourths of an inch and penetrate into the soil when the board is forced against a vertical soil face. This method cannot be recommended unless only temporary samples are being secured under very favorable conditions.

Where soils tend to disintegrate easily some special treatment is necessary in order to mount a satisfactory profile which will be durable and permanent. The most desirable material to use for this purpose in order to secure a sample quickly in the field would be a substance which is a solid at ordinary temperature but can be melted easily and can be applied to a soil face as a hot liquid which will solidify in a short period of time. There are many types of adhesives which melt easily but none of the materials studied will penetrate the soil readily. This is not important in many soils, but it is very essential that the cementing material penetrate the soil under certain conditions. Also many of the adhesives studied are very brittle or glaze when they cool and do not adhere readily to the soil particles; consequently most of them were not satisfactory and could not be used except under very favorable circumstances. Studies conducted on loose sandy soils, in which the colloidal content was so low that the sand grains would not adhere except when the sample was moist, demonstrated the fact that some substances should be added to the soil which would penetrate the soil mass and hold the soil particles together in order that a suitable profile could be secured which would be permanent in nature and would show the different soil characteristics as they appear under natural conditions.

Several different materials, such as shellac, varnish, lacquer, and water soluble glues, were applied to different soils. After a careful study of substances which would penetrate the soil readily and harden in a short period of time, the experiments indicated that a dilute solution of ordinary brushing or spraying lacquer was the most suitable material to use in holding the soil particles together. When a soil is treated with a lacquer solution which is allowed to dry before the profile is mounted, the type of cement to use in attaching the soil face to a suitable background in order to hold the profile in a rigid position is not important; consequently the cheapest type of adhesive available would be the most desirable. A water glue is not recommended if a board is used as a base for mounting the soil profile because of the tendency for wood to warp when it comes in contact with the moist glue. A very suitable adhesive is either a coal tar pitch or asphalt, since these materials are inexpensive and when these materials are applied hot they adhere readily to the wood and to the soil. The asphalt has a higher melting point than the coal tar pitch and it may be more difficult to apply, especially in cool weather. Waterproof cements such as linoleum cement and marine glue have been used with excellent results but are more expensive than asphalt or coal tar. Most of the rosins or hot cements containing rosin are softened by summer temperatures and cannot be recommended. The waxes studied were either too soft or too brittle, although crude Montan Wax could be used if other materials were not available. Several of the other cements studied are entirely satisfactory; however the cost of mounting the profile will be increased if they are used.

METHODS FOR TAKING SOIL PROFILES

The following method for mounting soil profiles is being used at the Oklahoma Agricultural Experiment Station and has given satisfactory results under extremely adverse conditions. Two different procedures may be followed. The soil profile can be taken in an iron trough (See Fig. 3.) according to the method used by Glinka and can be transferred to the

laboratory before mounting, or the profile can be secured directly from the field if preferred. In case the latter method is used, at least two trips to the area will be required, which may be objectionable in some instances because the profile to be mounted may be located at a considerable distance from the laboratory.

The directions for taking and mounting a soil profile are as follows: Select a location in a roadside cut which is typical of the soil type. If such an exposure is not available, dig a pit about four feet square and five feet deep or down to the parent rock if it is encountered at a shallower depth. Smooth a vertical section of the soil with a square-pointed spade so that it will exactly fit a board 5½ inches wide and 4 feet long. In case of deeper profiles the length of the board may be increased or two separate sections may be mounted. Slope the soil face slightly toward the bottom of the excavation. This will aid in applying the subsequent treatments. (If the sample is taken in an iron trough, the soil face does not need to be perfectly smooth since the exposed surface on the open side of the trough will be the surface to which the board will be attached. The metal trough should be made of 18 gauge iron and should be about one or two inches wider and two or three inches longer than the board on which the profile is to be mounted.) Attach the soil profile to the same board which is used in smoothing the soil face in order to secure a perfect contact between the board and the soil. If the soil is very loose or contains small stones or pebbles, it will be necessary to moisten the profile with the dilute lacquer solution in order to hold the soil particles together while a smooth surface is being formed. If the soil face is wet it should be allowed to dry to a depth of one-half to one inch before any lacquer is applied.

Treat the dry soil face with about one or two pints of dilute lacquer, depending upon the porosity of the soil and the thickness of the profile which will be taken. The dilute lacquer solution is prepared by adding one part of clear lacquer to two parts of lacquer thinner. Allow the lacquer to harden thoroughly, which usually requires from 12 to 24 hours depending upon the temperature of the soil. In case of very stony or gravelly soils undiluted lacquer may be needed to hold the soil particles firmly together. The thinned lacquer can be applied to the soil face by sprinkling it from a bottle equipped with an aluminum nozzle used for sprinkling clothes, or it can be applied to the surface of the soil profile with a compressed air sprayer.

After the lacquer has hardened, secure a quantity of asphalt having a melting point about 100°C.; however coal tar with a lower melting point has given very good results. Heat this material until it will brush easily and apply it in a layer about one-eighth of an inch thick to one side of the board and on the soil face. Spread the asphalt evenly on each surface by heating with a blow torch and press the treated surface of the board against the asphalt on the soil face so that all of the space is filled between the board and the soil. Hold the board firmly in position for a few minutes in order to allow the asphalt to solidify. Then remove the soil on each side of the board to a depth of five or six inches as shown in Fig. 2. (If the soil profile is taken in a metal trough and attached to a board in the laboratory, only the soil which extends beyond the edge of the board will be removed.) Cut in behind the soil mass until it can be broken off without injuring the mounted profile. Grasp the board firmly with both hands and turn it sideways in order to separate the mounted sample from the soil mass. Remove the board with the soil attached and place it in a horizontal position with the surface of the soil exposed. Carefully break away the excess soil until the thickness of the soil attached to the board

is about one inch. This depth may vary depending on the soil structure and the features which are to be emphasized in the profile. If the soil is very dry, it may be necessary to moisten it with water in order to aid in removing the excess soil. Do not cut the soil on the exposed surface of the soil profile because such a treatment destroys the natural soil structure.

The profile should be preserved by fastening strips of wood 2 inches wide and ½ inch thick to each edge of the board, using screws instead of nails, which might cause an injury to the profile due to the impacts occurring when the nails are driven into the wood. In case of soils which tend to disintegrate easily the profile can be made more durable if the edges of the soil are treated with dilute lacquer solution before the strips of wood are attached. Soil profiles which have been prepared for study are shown in Fig. 4.

DISCUSSION

If the soils are moist, in most cases it will be more desirable to collect the profiles in a metal trough as recommended by previous investigators and take them to the laboratory where they can be attached to a suitable background more conveniently than can be done in the field. The metal trough can be filled with soil very easily if the soil on each side of the trough is gradually removed as the container is being pressed into the soil face. In case the soils are dry, friable soils can be sampled very conveniently in the field, but satisfactory profiles cannot be secured from dry soils which contain a high percentage of clay.

When soils contain many small stones in either the surface or subsurface layers, it is difficult to secure a smooth soil face. Rough places can be eliminated and cavities can be filled with soil which has been moistened with the lacquer solution. It may be necessary to obtain a thicker profile in case of stony soils as compared with fine textured soils in order to show the true characteristics of those soils. If the soil is sandy in texture and the particles do not adhere, a smooth soil face can be secured if the lacquer solution is applied to the irregular sandy surface and the board on which the soil profile is to be mounted is pressed against the soil face, after which it is moved up and down until all of the depressions are filled and the high points removed. (See Fig. 1.)

If too much lacquer is added or if too much of the soil is removed from the face of the profile after it is mounted, the soil will be darker in color than the natural soil, due to the presence of an excess of lacquer which tends to accumulate near the surface of the soil face when the solvent evaporates. This can be reduced to a minimum by the addition of the proper amount of lacquer to hold the profile together depending upon the thickness which is required to show the desired soil characters.

When a soil profile is taken from a roadside cut, frequently a layer of abnormal soil may be found at the surface. The soil may come from the adjacent field due to the action of wind or running water, or it may be derived from the dust carried from the roadway by the wind. Protected areas can usually be found where the surface horizon has not been affected by these factors.

SUMMARY

A detailed study of methods for securing and mounting soil profiles was made.

A large number of substances were studied in order to find some material which could be used to preserve the soil in its natural condition. None of these materials were suitable for use in securing satisfactory soil profiles except under very favorable conditions without first treating the soils in order to prevent them from disintegrating after the profiles had been mounted.

A dilute lacquer solution containing one part of lacquer and two parts of lacquer thinner is the most satisfactory material to use in treating the soil in order to hold the soil particles or granules together so that they will not disintegrate after the soil profile has been secured.

Any type of adhesive material which will not sag or flow at a temperature of 140° F. can be used to fasten the soil profile to a permanent background after the soil has been treated with a dilute lacquer solution and the lacquer allowed to dry. Asphalt or coal tar pitch is recommended because both of these materials are easy to secure and are inexpensive. Linoleum cement can be recommended to attach the soil profiles to a suitable background when they are mounted in the laboratory.

A method which includes the use of lacquer in combination with some other adhesive is proposed.

Blow sand or stony soils which are very difficult to handle can be mounted by this method and kept in a permanent condition without any appreciable change in color or structure.

REFERENCES

1. Anonymous, 1927. A better way of soil sampling. U. S. D. A. Official Record, V. 6, p. 3.

2. Bushnell, T. M., 1930. The Purdue technique for taking and mounting monolithic soil profile samples. Soil Science V. 29, pp. 395-397.

3. Chapman, J. E., 1928. Monolithic soil profiles. Science V. 68, p. 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. Schlacht, Von K., 1929. A new method for the preservation of soil profiles. Zeitschrift fur Pflanzenernahrung, Dungung und Bodenkunde. Vol. 13, pp. 426-431.

Fig. 1. Soil face recently treated with lacquer and smoothed so that board at left may be attached.

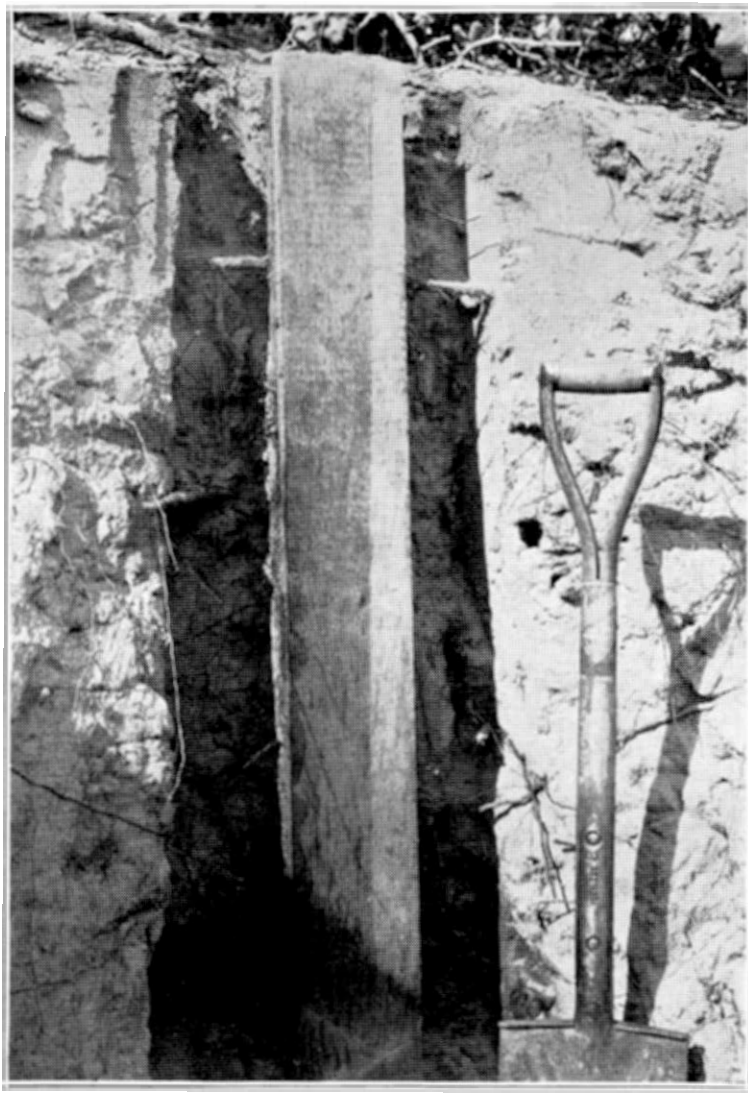

Fig. 2. The board shown in Fig. 1 has been attached to the soil face and the adjacent soil has been removed. Observe the root passing through the profile.

Fig. 3. The metal trough is ready to be forced into soil face, after which the profile will be transferred to the laboratory to be mounted.

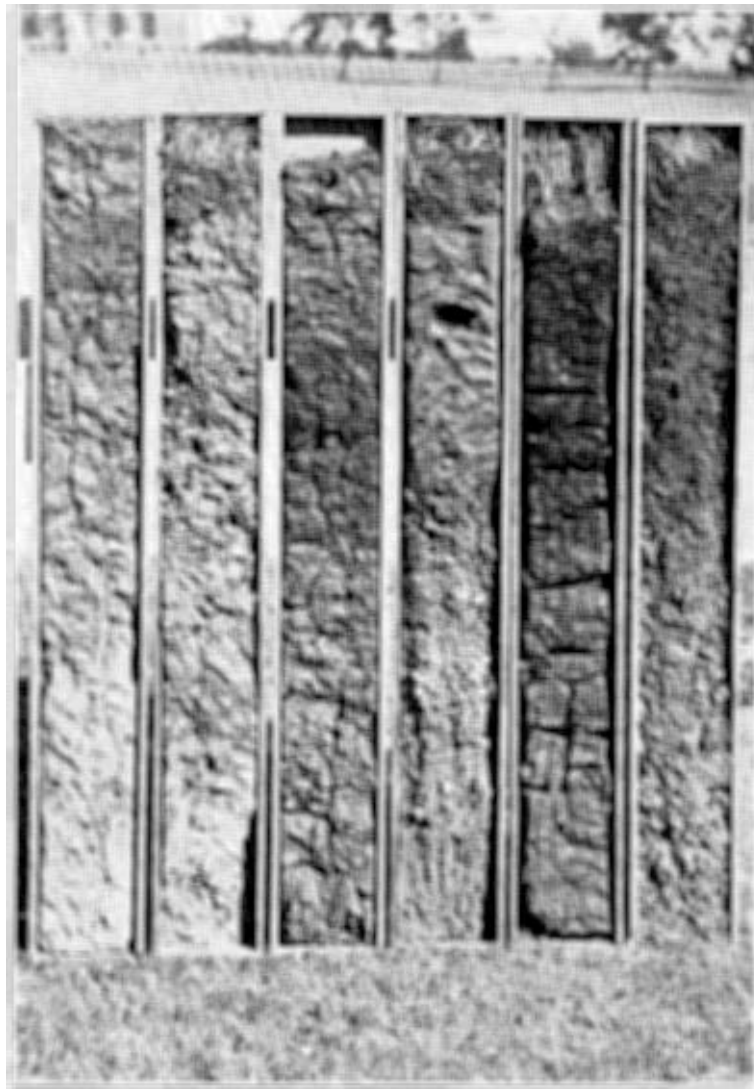

Fig. 4. Soil profiles mounted and ready for display or study.