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The collection of natural soil profiles from arid regions — A field method and manual

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Summary

Soil profile peels, combined with a field description, are of great value for the study of soil morphology, for soil classification and for instruction purposes.
Various methods of soil peel preparation with moist soils have been described by many authors. A short review is given, of some existing techniques.
As a result of experience, gained in central Turkey, succesful field methods are described for:
a) The preparation of soil peels of dry, calcareous soils, in particular of clayey soils, and
b) The preparation of soil peels from vertical walls instead of from sloping ones, especially with regard to dry soils.
Advise is given on how to transport ready soil peels without damage. An example is given for the calculation of the production cost of one soil profile peel in a Middle East country. Estimates are based on the use of local personnel and material as far as possible.

Introduction

A detailed profile description, how well done it might be, can never fully recall the actual form of the described profile, not even in combination with pictures. Because of this, it is of great importance that techniques have been developed to preserve soil profiles in undisturbed condition. Such profiles are being used widely for demonstration, education and research purposes (e.g. Refs. 2, 6, 8, 9, 18, 19). Their size should be at least 30 cm (1 ft.) wide and 100–150 cm (3–6 ft.) long to serve the purpose well. Several names have been used for preserved profiles i.e. 'lakfilm' (7, 10, 11), 'monolith' (9, 14) and 'soil profile peel' (6, 19). The latter name will be used here, together with the more general name 'soil peel'.
Peeling techniques for moist (including slightly moist) and wet soils are well described by many authors (2, 4, 5, 6, 7, 10, 11, 20). A short review will be given.
Attention is confined to methods for preserving large profiles by applying plastic or lacquer to the back of the soil peel in situ. Other procedures have been described elsewhere (1, 4, 9, 21). Dry and hard calcareous soils, commonly encountered in arid

regions seem more difficult to 'peel' adequately. Little information could be found in the literature. The techniques described here were developed and successfully applied by the senior author during three visits to the semi-arid Konya plain in central Anatolia, Turkey.

Short review of soil-peeling techniques

Common procedure

The procedure for preparing a soil peel commonly has the following basic stages:

Basic stage 1 The section to be preserved is flattened and smoothed to obtain a favourable 'face' for the application of lacquer.

Basic stage 2 The lacquer or resin is applied to the profile face [1]. After penetration and impregnation, the material will harden gradually, fixing the constituents of the soil material in its natural arrangement.

Basic stage 3 The impregnated section, the soil peel, is gently separated from the soil mass that has not been fixed.

Basic stage 4 The peel is preserved and stabilized usually by sticking it onto a board. This assembly is then framed to safeguard the peel during handling, transport etc.

To avoid duplication in the text the above stages will be often referred to as 'basic stages'.

The degree of penetration of lacquer or resin is the result of capillary forces in air-filled soil pores.

Many techniques have been devised and reported for adapting the basic stages to specific soil conditions and to special purposes (2, 4, 6, 7, 8, 10, 11, 20).

Moist sandy and loamy soils

For sandy soils with a medium moisture content, basic stage 2 can be accomplished in the field by pouring the lacquer down a flat but sloping wall of a profile pit or excavation. Depending on soil texture, roots, stoniness etc. the slope may vary from 10–30° from vertical. The resulting soil peel, which can be torn off the wall (basic stage 3) looks natural only if the original soil has no structure or a weakly developed structure and small peds.

Moist clay soils

Heavier texture, the development of higher structure grades and larger peds often go together. They call for a more complicated procedure for basic stages 2 and 3. Firstly the peel should be taken from a vertical wall in view of a natural presentation of structural elements, often prisms (see the section on *Soil peels from a vertical wall* and Fig. 1–4). Secondly moist clay is difficult to impregnate with lacquer or resin. A well described technique to solve these problems is to push a steel elongated metal box into the vertical profile wall and cut it off, after which the soil can dry up gradually in the laboratory (11). Basic stage 2 can now be completed as described for sandy soils, by placing the soil-face at any angle required and pouring the lacquer from above. Cheesecloth should be stuck with lacquer to the back of the peel for

[1] These can be cellulose lacquers (10, 11, 20, 21) or resins (4). Other chemicals are used as well (5, 7, 13, 15, 16).

reinforcement. Basic stage 3, the peeling, should be done with greatest care to avoid the disturbance of the arrangement of fixed structural elements.

Wet soils
Wet sandy, loamy, clayey or even peaty soils are extremely difficult to peel and preserve. If basic stage 1 can be done succesfully, the steel sample box-technique, as described above, may be applied to obtain a suitable soil peel (11). During the process of drying-up the peel may be subjected to exaggerated cracking.
The face of the soil peel exposes the colours of the dry soil. Liquid colourless plastics can be applied to the face of the peel in order to establish a colour that resembles the moist colour of the soil. These plastics also act as a means of support for the structural elements on the soil peel (3, 4, 20). The micro-structures however, tend to be spoiled.

Soils of arid regions

Soils deposited and developed in regions with an arid or semi-arid climate are in general calcareous and dry (if not irrigated). The soil mass is hard, often cemented and may contain concretions, caliche or hardpans. Loamy and clayey soils normally have strong often angular structures and may have a cracked surface. Residual soils sometimes are stony and shallow.
Such soils differ in many respects from those of the temperate regions. Some conditions, as will be discussed below, form a serious limitation for the succesfull preparation of soil peels if one wants to apply the techniques common for moist and wet soils. Modified procedures have to be applied to meet the difficulties involved. The arid climatic conditions favour the application of field methods, help to speed up the production and are of advantage where adequate indoor facilities are lacking.

Modified techniques for soils of arid regions

Calcareous soils
Profile lacquer does not easily adhere to or penetrate into a dry calcareous soil e.g. a calcic horizon. Such a soil is hard when dry and little soil will continue to adhere during basic stage 3.
Adhesion can be improved greatly by wetting the soil face or the calcareous part of it repeatedly with water — preferably with a fine spray to avoid run-off and micro-erosion. Lacquer should be applied as soon as the moisture is absorbed. Moist calcareous soil is soft and the covering film of lacquer will keep it that way. As a result separation is easier and basic stage 3 can be carried out successfully. The fresh peel will be fragile however, and should be left to dry and harden before transport.

Clayey soils
Apart from often being calcareous, dry clayey soils are an extremely difficult material for making a soil peel. The soil is hard when dry and difficult to moisten, so basic stage 1 is very laborious. Moreover stage 2 could fail because lacquer penetrates very slightly into clay even when moist. This will result in poor fixation (where it should be very good) of the heavy structural elements.

The following technique is recommended to meet the difficulties mentioned, in basic stages 1 and 2.

a) The profile wall, preferably cut vertically, is made flat and smooth immediately after digging the pit. Repeated moistening may help.

b) The profile face is then left *to crack*. If atmospheric conditions are hot and dry, the cracking process should begin overnight and the face should be shaded in day time to avoid unnatural formation of cracks. The lacquer can be applied to the wall when cracks are 2–4 mm wide. The lacquer should be rather viscous so as not to penetrate too deeply into the cracks, however, just enough to hold each structure element in a 'setting'. Succesful techniques for basic stages 3 and 4 in clayey soils are described in the section *Soil peels from a vertical wall.*

Soils with structure of high grade
Dry calcareous soils, expecially if loamy or clayey commonly have a moderate or strong structure with elements which are hard or very hard when dry. The type of structure is often platy or prismatic at a certain depth. In connection with this and for other obvious reasons to be mentioned in the next section soil profile peels in arid regions should preferably be taken from a *vertical* wall instead of from a slanting one. Authors, describing peeling procedures for 'soils-with-structure' in temperate climates have recognized the advantage of vertical peels as well. They suggest minimizing the slope, to use a steel sample box or to carve out a true 'monolith' that fits a box.
The two last mentioned ways are extremely difficult in dry soils because of hardness. With regard to the first solution, there is, on the contrary, a strong tendency to increase the wall-slope rather than to minimize it in order to obtain a sufficient penetration of lacquer (poured from above) around protruding concretions and stones and into holes and spaces which are so numerous in dry soils.
A proper field method for the application of lacquer onto a vertical profile wall and the preparation of a profile peel of a dry, calcareous, loamy or clayey soil will now be described.

Soil peels from a vertical wall

Advantages
The advantages of making preserved profiles from a vertical wall are as follows:

1) The depth measures of the horizons are true to nature and profile descriptions, made for the vertical pitwall in situ, do not need adjustment of the measurements.

2) Soil structure is presented in a more natural shape. If the soil has prismatic or platy structures, the image of a soil peel from a sloping wall will look very unnatural, showing broken off prisms and plates which point out and downwards at an angle equal to the slope of the wall. Compare Fig. 1 with Fig. 3B and Fig. 2 with Fig. 4B. Slicken-sides of 'vertic' soils will mostly be hidden under protruding elements.

3) Soil peels from vertical walls cover a deeper portion of the soil than from slanting walls, if the peel lengths are equal.

Manual of the field procedure
In order to obtain good soil peels of arid soils from vertical walls, the following technique is recommended.

1) Basic stage 1 (profile face flattening) is best accomplished by following the descriptions of the previous section for the various kinds of dry soils. The wall face should be made vertical or nearly vertical, to a degree of not more than 2%.

2) The wallface is treated or prepared to improve lacquer fixation or penetration as described in the previous section for various kinds of dry soils.

3) Basic stage 2 (application of lacquer) cannot be executed by pouring lacquer from above because of the vertical wall slope. Instead the lacquer *is pushed slowly upward* from bottom to top, using a board with soft rubber rim [2] (hereafter called a 'push-board'), whilst an assistant pours on to it, keeping an ample supply between push-board and wallface. In this way, the lacquer will be distributed well over the vertical profile face and is allowed to flow and penetrate into holes and cracks (see Fig. 4A). The pushboard of a width exceeding the desired peel width by approximately 2 inches (5 cm) should be pressed very gently against the wall, so as not to disturb its structure. Because of the hot and dry atmospheric conditions usually prevailing, spraying of lacquer (20) is not recommended. For the same reason this basic stage should preferably be carried out at sunset, or at least in the shade.

4) After hardening, lacquer has to be applied a second time in the same way and a piece of wide-mesh jute, cheese-cloth or plastic mosquito screen is rubbed into it, serving as a reinforcement. This will prevent the peel from getting spoilt later during basic stage 3 or during transport or storage.

5) After hardening of the reinforced material, basic stage 3 (separation) may be accomplished by cutting and pulling the peel from the wall as is commonly done with thin peels of sandy soils.
However, as the peel is forced to make a bent where it is pulled loose, this way of working often results in a peel with unnatural horizontal cracks (Fig. 5A). Heavy peels of clayey soils are completely spoiled. In particular for the various kinds of dry soils described in the section *Modified techniques for arid soils* it is strongly recommended *to strengthen the back of the peel in the field before peeling* with a 'backbone' of board. This can be done best by sticking a flexible sheet of masonite onto the cloth-reinforced face of the profile, i.e. the back of the future peel. If the board and the back of the peel are covered with rubber glue and pressed together, they are immediately firmly bound. Ordinary rubber solution will do, but special rubber contact glue like 'Bisonkit' or 'Pattex' made in Holland and Germany respectively, are better if used properly.
A secondary advantage of applying the masonite 'backbone' in the field is the possibility of using it as a template for cutting the peel to its proper size, without disturbance of the soil. Prior to the glueing procedure, the masonite sheet (which is to be cut to the desired peel measurements) is pressed against the lacquered profile

[2] Rubber pulley belt simply nailed on a piece of wood with two handles was used succesfully (see Fig. 4).

Fig. 1 Soil peel from oblique wall face. Note protruding and broken-off prismatic structure elements. Depth in cm.

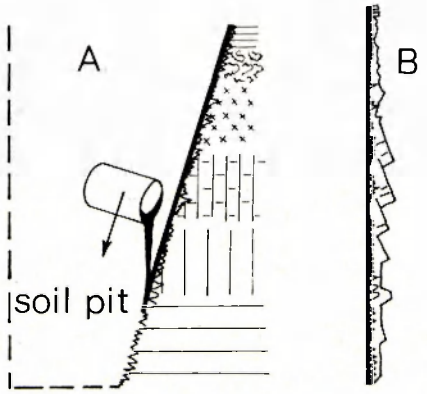

Fig. 3 Cross-section A: The application of profile lacquer to an oblique wall face direct from the can. Penetration into deep cracks or holes is often insufficient.
Cross-section B: Presentation of structure on resulting soil peel is unnatural.

Fig. 2 Soil peel from vertical wall face. Natural presentation of prismatic structure elements. Depth in cm.

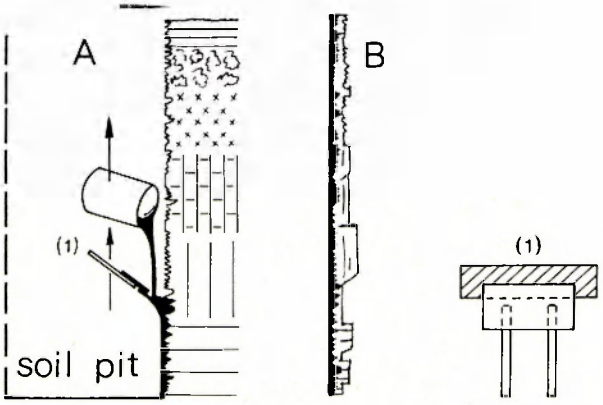

Fig. 4 Cross-section A: The application of profile lacquer to a vertical wall face by means of a wooden pushboard with rubber rim (1). Note better penetration of lacquer into cracks and holes. Cross-section B: Presentation of soil structure is true to nature.

face after which its contours are cut deeply through lacquer and cloth into the soil. Preferably, the peel should be ½ inch (1.5 cm) less wide than the board, to allow for easier framing.

6) Shortly after the masonite sheet has been applied, the profile can be peeled almost undisturbed by cutting and gently separating the board-backed peel from the mass (see Fig. 5B). In the case of clayey soils a blanket of soil, at least 3 inches (8 cm) thick should be cut loose in order to preserve the structural elements. Removal of excess soil has to be postponed until elements have become more firm by drying out.

7) Successfully separated peels have to be fitted in a rigid wooden frame (basic stage 4) at once, to avoid damage during the removal from the soil pit and during transport. See further details in the section *Packing for transport.* The peel can be fixed to the frame with glue or lacquer after arriving home, and then the whole assembly should be left on its back for several days to allow soil and lacquer to dry.

8) After excess soil has been removed the soil peel can be put upright. Horizon designations can be indicated on the sides of the frame. The original field profile description has to be checked and completed. The soil peel may reveal characteristics which had not been noticed in the field.

Packing for the transport

Soil peels are very fragile and should be handled with utmost care to maintain their important natural features.
As remarked in the previous section, a fresh peel has to be put immediately in a

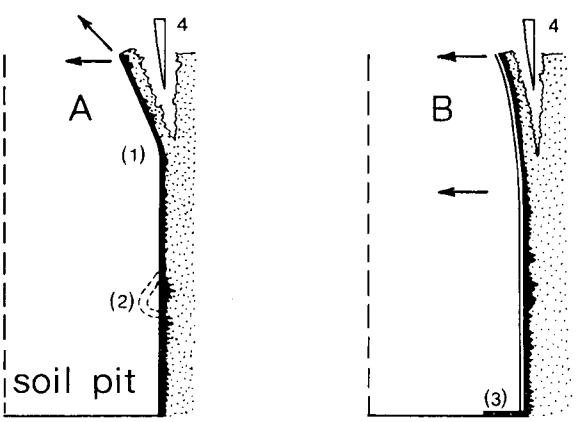

Fig. 5 Separation of soil profile peel from soil mass.
Cross-section A: by pulling peel with back of lacquer and cloth only.
Cross-section B: by pulling peel with 'backbone' of masonite board.
1 = horizontal cracks may develop here, 2 = heavy peels may shear from soil mass and fold here, 3 = support (piece of wood) placed under assembly will prevent soil shearing, and 4 = cutting edge of spade.

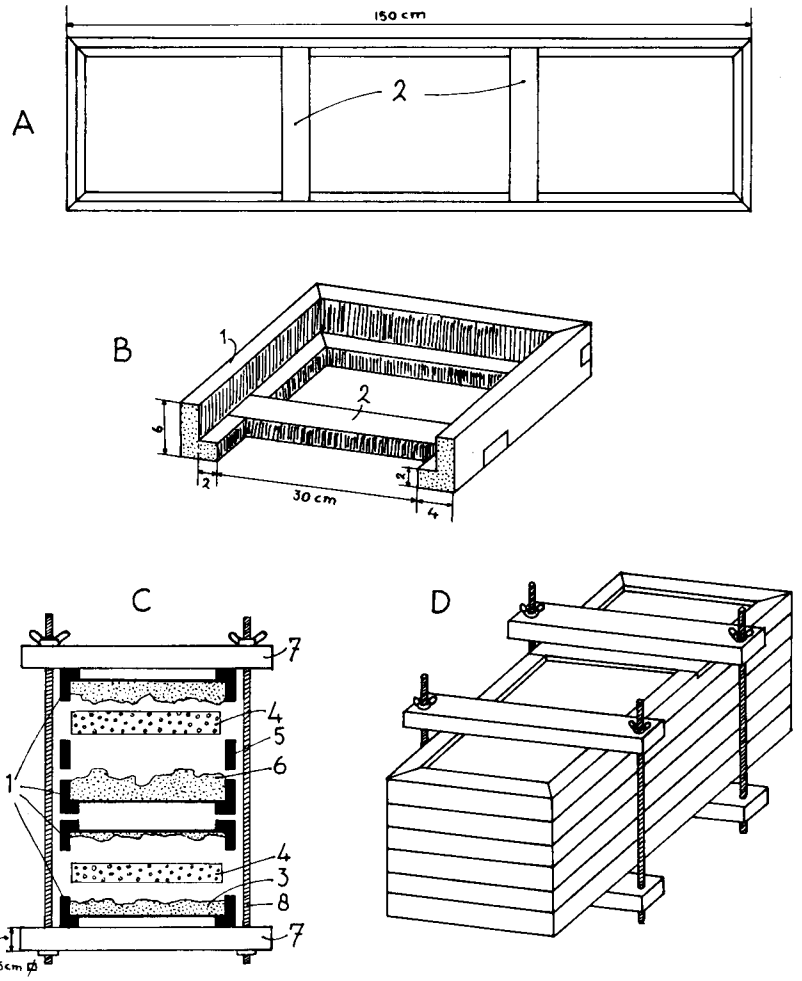

Fig. 6 A and B: Details of construction of a soil peel frame and suggested dimensions (in cm). 1 = frame rim, 2 = cross members.
C: Schematic cross-section through stack of framed soil peels with clamp. 1 = frame rims, 3 = soil peel, 4 = foam plastic, 5 = extension frame, 6 = very thick peel, 7 = piece of wood, and 8 = threaded rod.
D: Package of soil peels ready for transport.

wooden frame and kept horizontal until it is glued into this frame. An adequate frame of rigid construction is shown in Fig. 6A and B.

The frames should be made of hard timber of standard dimensions even if some peels are of smaller size as this will make stacking possible. Several framed soil peels for transport by road, rail or sea can be packed as shown in Fig. 6C and D.

The framed peels are stacked in pairs with a full sized sheet of 5 cm (2 inches) thick foam plastic sandwiched between them and then secured by screwing the two clamps

shown, until wood touches wood. The soil peels must clear each other but every bit has to be under the slight pressure of the foam. Very thick peels protruding beyond the rim of the frame should be separated by inserting an extra 'extension frame' as shown in the diagram.
Wood wool, hay or fine straw may be used instead of foam plastic in emergency. Such a package can stand rough transport without disturbance of the peels. The foam plastic sheets can be used again.

Estimation of production cost

The preparation of soil peels is more costly and time consuming than is often realized. For those who are interested a specification is given in Table 1 of the expenses normally involved (quotations are in U.S. dollars 1966).

Table 1 Estimation of cost for the production of one soil peel

Cost of materials (U.S. $)			
'Nitrol' profile lacquer and 'Nitrol' thinner [1]:			
2500 cm³ at $ 10.00 per 10 litres (from factory)		2.50	
Transport and custom duty for 'Nitrol'		5.00	
Board (masonite) 30 × 150 cm		2.00	
Jute or cheesecloth 30 × 150 cm		1.00	
Rubber solution 500 cm³		1.00	
Wooden frame		3.50	
			$ 15.00
Cost of transport			
3 trips by Landrover or jeep from base to profile site, 60 miles at $ 0.25 per mile			15.00
Salaries peeling team			
3 trips of 3 hours each	9 hours		
Framing, finishing touch	3 hours		
Total hours/man 12 or 1½ working days			
Soil scientist (graduate) at $ 16 per day [2]		24.00	
Field assistant at $ 4.00 per day [2]		6.00	
	Total		30.00
	Failures 20 %		12.00
	Real cost per peel		$ 72.00

[1] Manufactured by Pieter Schoen N.V., Zaandam, The Netherlands
[2] Including overhead cost and field allowance

The estimation is based on the production of one soil profile peel (size 1 × 7 ft. or 30 × 180 cm) of a dry calcareous soil, made from a vertical wall according to the techniques described in this paper. In addition the following assumptions are made:

a) The team, making the peels, consists of a graduate soil scientist and a field assistant.
b) This team is part of a soil survey party. So the making of soil peels is only part-time work. Costs of digging and tools are not accounted for.
c) The profile site is approximately 10 miles (16 km) away from the field base.
d) Except for the profile lacquer, which has to be imported, prices are based on local standards of a Middle-East country.

The estimated cost of 72 U.S. dollars per soil peel would be cut by 10–20 % if use were made of ordinary but less suitable polyvinylacetate and aceton, bought locally or by using cheaper labour and if several profiles are prepared in one trip. On both travel expenses and time could be economized considerably more if a lacquer or resin would be used that is combining the excellent penetration and adhesion properties of 'Nitrol' profile lacquer with a hardening period short enough to allow the whole procedure to be finished in a few hours. Suggestions are very much welcomed by the authors.

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