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Preparation of large thin sections from polyethylene glycol impregnated soil samples

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INTRODUCTION

At the time of writing this paper the authors were aware that other well-documented methods for preparing large thin sections of soil had been published [1, 3]. The purpose therefore, of presenting another method, is to introduce the virtue of using a wax rather than an epoxy resin as the impregnating medium. The preparatory and impregnation stages are thus made much easier and the difficulties experienced with curing an exothermic resin in a large volume are eliminated.

Soil fabric studies in this laboratory are partly conducted by the examination and description [4-6] of a series of polished soil surfaces prepared from a large block of soil impregnated with a polyethylene glycol, Carbowax [1] 4000. Soil thin sections are a necessary part of this procedure for examining the relationship between the smaller soil components and the macroscopic fabric.

A technique to produce optically correct thin sections from soil impregnated with Carbowax has therefore been developed. Because most soils can be easily and successfully treated in this manner, and because high quality thin sections can be prepared with very little difficulty, the method is offered as an attractive alternative to the techniques that use an epoxy resin.

METHOD

The bulk sample of soil, frequently larger than 2,000 cc, is allowed to dry slowly at room temperature until the weight change due to the loss of moisture becomes insignificant. After air drying the soil is gradually brought to 60°C in a container that is larger (to allow a free space of

[1] Carbowax is the name used by Shell Chemicals (Aust.) Pty. Ltd., for an isomeric series of polyethylene glycols. The number indicates the approximate molecular weight of the compound.

a few centimeters at the top and sides) than the block. Sufficient molten Carbowax 4000 is then introduced into the container to cover the sample, and the container and its contents are kept at 65°C for 5-7 days in a chamber that can be evacuated [2]. The application of 2-3 hours vacuum per day, allowing the vacuum to dissipate slowly after this period, is sufficient to impregnate all but the heaviest soils. Molten Carbowax is added at the beginning of each day, if necessary, to maintain total immersion of the sample. After impregnation the container is allowed to cool slowly, and the block can then be removed by gently heating the sides of the container until sufficient wax melts to allow the contents to slide out.

A soil face is exposed by cutting the block on a slabbing saw using a diamond impregnated wheel and kerosene as the cutting lubricant. (A cutting speed of 1,300 surface metres per minute and a carriage travel between 6 and 10 mm per minute produce very satisfactory results). The exposed face is hand polished on a large plate glass sheet, using thin pastes of corundum powder (grit sizes 15μ, 11μ, 8μ) and kerosene, until the surface is optically flat and free of scratches. After rinsing with kerosene the surface is carefully wiped and allowed to dry face down on absorbent paper.

The prepared face is mounted on a clean object glass using Epimount [3] No. 2659E as the mounting medium. The liquid as poured onto the prepared face and the object glass (usually prepared with a 45°C bevel on both ends of the surface adjacent to the sample) is lowered, hinge like, onto the surface. After removing any trapped air bubbles by gentle pressure and movement at the centre of the glass, the sample and glass are then inverted, so that the weight of the soil block, or an additional weight, bears down on the object glass to minimise wedging. The resin is then allowed to cure for 16 hours at room temperature, and after curring, the bulk of the soil block is cut away to leave a thin slice of soil (3-5 mm thickness) adhering to the glass.

With the help of metal strips (bevelled so that a glass to metal contact can be made) the glass plate is securely mounted on the horizontal table of a surface grinder. (The object glass will be held secure if the bevelled edge contacts are at right angles to the major table movement, and if

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[2] If facilities for keeping molten wax under vacuum are available, the impregnation is best achieved by introducing this wax, through a valve in the lid of the chamber, to the soil sample which has been under continuous vacuum for several hours. If this procedure is adopted the vacuum may be dissipated, over several hours, immediately after the sample is completely covered, and the solidification process may then begin soon after.

[3] Epimount is the name of a two-solution epoxy compound developed for use in microscopy. The refractive index of the curred material is 1.5813±0.0005. It is manufactured by Indelab Pty. Ltd., Granville, N.S.W., Australia.

lateral restraint is imposed by strips adjacent to the other two sides). The thin slice of soil is then reduced to a 25-30 micron section with either a diamond impregnated wheel or a coarse, open-textured carborundum wheel. Kerosene is again used as the cutting fluid. The diamond wheel is generally satisfactory for soils in the range of silty clays to sands, the carborundum wheel is mainly used on clays or any other soil that tends to smear during grinding. The surface finish with either wheel is good enough to allow the final section thickness to be approached to within a few microns. At this stage the process is completed by hand polishing the section on plate glass, again using corundum powder and kerosene as the abrasive pastes.

After rinsing in kerosene the Carbowax is removed from the section by immersing the object glass in high quality pine oil (85% terpene alcohols) heated to 65°C. With gentle agitation the wax in the pore spaces can be removed in two or three minutes, with no damage to the soil phase. After three minutes the section is removed, cooled, washed with clean pine oil and allowed to dry face down on absorbent paper. If any wax remains in the pore spaces the process is repeated once.

After drying, the cover glass is applied with a slight excess quantity of Epimount that is first poured onto the surface of the section. The cover glass is worked down onto the section using a small figure of eight movements, so that the excess fluid has a chance not only to flush the surface of any moisture that has been picked up from the atmosphere, but also to fill the pore space previously occupied by wax. The milky fluid that results if moisture is present can be displaced to the edges of the cover glass by working the mount as described. A second or subsequent attempt to mount the cover glass can be made if the section is badly affected by moisture.

The completed section is left for the resin to cure and then cleaned by cutting away the excess solids and by rinsing in acetone.

APPLICATION

Apart from the application already described, the technique has been used successfully in the examination of both the undisturbed and post-failure fabric of beach sands to investigate the relationship between fabric and modes of failure in a drained triaxial test.

To obtain a sand sample with as little disturbance as possible, brass containers with internal dimensions of 20 cm×10 cm×10 cm and a wall thickness of 1 mm, are constructed with removable top and bottom lids and a loose-pinned joint along one edge. With the top and bottom lids removed, a container is pressed into the moist sand close to the water's edge. This process is facilitated by removing sand from the outside of the container, behind the leading edge, as the sampling proceeds. When the box is *completely* filled the top lid is replaced, and by forcing a plate under and some centimeters below the container, the container and sand can be removed and inverted. After trimming the sand so that the surface is flat and flush with the container edges, the bottom lid is replaced and the sample returned to the upright position.

The removable lids allow the sand to drain freely and this technique therefore makes use of the negative pore water pressure that develops since the sand is removed from the saturated zone close to the water's edge. Sand samples such as these are easily transported back to the laboratory with only the same amount of care given to cohesive soil samples of the same size. The absence of compaction (i.e. no visible settlement within the container) in a sand with a void ratio of 0.5 is good evidence that the transportation of a freely drained sand presents no difficulty.

There is no allusion, however, that the technique does not produce disturbance at the edges of the sample. For this reason the containers are made larger than the actual sample required so that a useable core can be extracted. (For the size quoted the 20 cm×10 cm×10 cm prism is reduced, after impregnation, to a 15 cm×7.5 cm diameter cylinder).

In the laboratory the sands are flushed using a repetitive filling and draining technique [2] to remove the high salt content, and then allowed to dry ready for impregnation as already described. A comparison between the efficiency of the two methods of impregnation shows that for a sand with a voids ratio of 0.5 the "5 day" method produces a degree of saturation between 92 and 96%; the "1 day in vacuo" method consistently shows that a degree of saturation better than 98% is possible.

The sand, once impregnated, is cut down so that the zone disturbed by the container edges is removed. The thin sectioning process is then applied either to the block of sand, for a natural fabric analysis, or to the impregnated sample after it has been subjected to a controlled melting-testing-resolidification process developed by one of the authors (D.R.W.).

DISCUSSION

The method described in this paper has several advantages that make the impregnation of very large soil samples with molten polyethylene glycol an efficient and almost infallible process. The advantages inherent in using this wax are that it is compatible with water and that solidification is reversible and easily controlled. These properties are particularly attractive when compared with the difficulties experienced with impregnating large volumes with epoxy resins.

The mechanical preparation of large thin sections likewise produces good results as experienced by other workers provided the contacts between the baseplate, the object glass and the sample are parallel because, unlike manual preparation, no allowance can be made for wedging. The hand polishing stage is necessary only to ensure that the quartz grains are of suitable thickness by exhibiting grey-white colours between crossed nicols.

The serious disadvantage of using polyethylene glycol as an optical medium is overcome by the replacement of this material with a medium of more suitable optical properties. The wax has a high refractive index and a birefringence close to that of the clay minerals and makes any quantitative analysis on a thin section with this material present subject to serious errors. The wax is easily removed and should not be tolerated in these thin sections under any circumstances.

SUMMARY

A method of producing thin sections from a block of soil impregnated with a polyethylene glycol is described in detail. The adverse optical properties associated with polyethylene glycol as an interstitial medium are overcome by its replacement in the final stages by the mounting medium. Thin sections of soil of the order of 200-300 sq cm can be produced without difficulty, the size and quality being dependent on the facilities available. The method is further extended by describing the technique the authors use to obtain an undisturbed core of beach sand.

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