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A DEVICE FOR PROCURING UNDISTURBED CORES OF CRACKING-CLAY SOILS

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SUMMARY

A device is described which inserts a 10·9 cm diameter soil core into a rigid liner during sampling. The technique is quick and simple and has been used to obtain cores to 60 cm depth in a cracking-clay soil. The sampling tool could be constructed of any dimensions and appears suitable for a range of soil types. Evidence presented indicates that the cores suffer a minimum of compaction.

I. INTRODUCTION

Most workers conducting pot or column experiments deliberately disturb the soil by drying and grinding it. While these treatments remove heterogeneity in soil chemical and physical properties, they also destroy natural structure as well as altering the biochemical (Craswell and Waring 1972) and chemical (Peterson 1971) characteristics of the soil. Furthermore, Ritchie, Kissel and Burnett (1972) have shown the necessity of retaining the natural soil structure for any studies of solute movement in soils, particularly cracking clays.

A simple technique is needed for procuring soil cores in which the natural soil structure has been relatively undisturbed. Tackett, Burnett and Fryrear (1965) developed a method employing rocket casing pushed directly into the soil and then removed to the laboratory. Another method is to use the Proline auger (Bradley and Vimpany 1974) to cut and insert cores into metal pots. However, both of these techniques are impractical for many workers because of the cumbersome and expensive equipment required. The inexpensive technique described in this paper overcomes these problems by using a simple hydraulic soil sampler to insert the core into a liner during sampling.

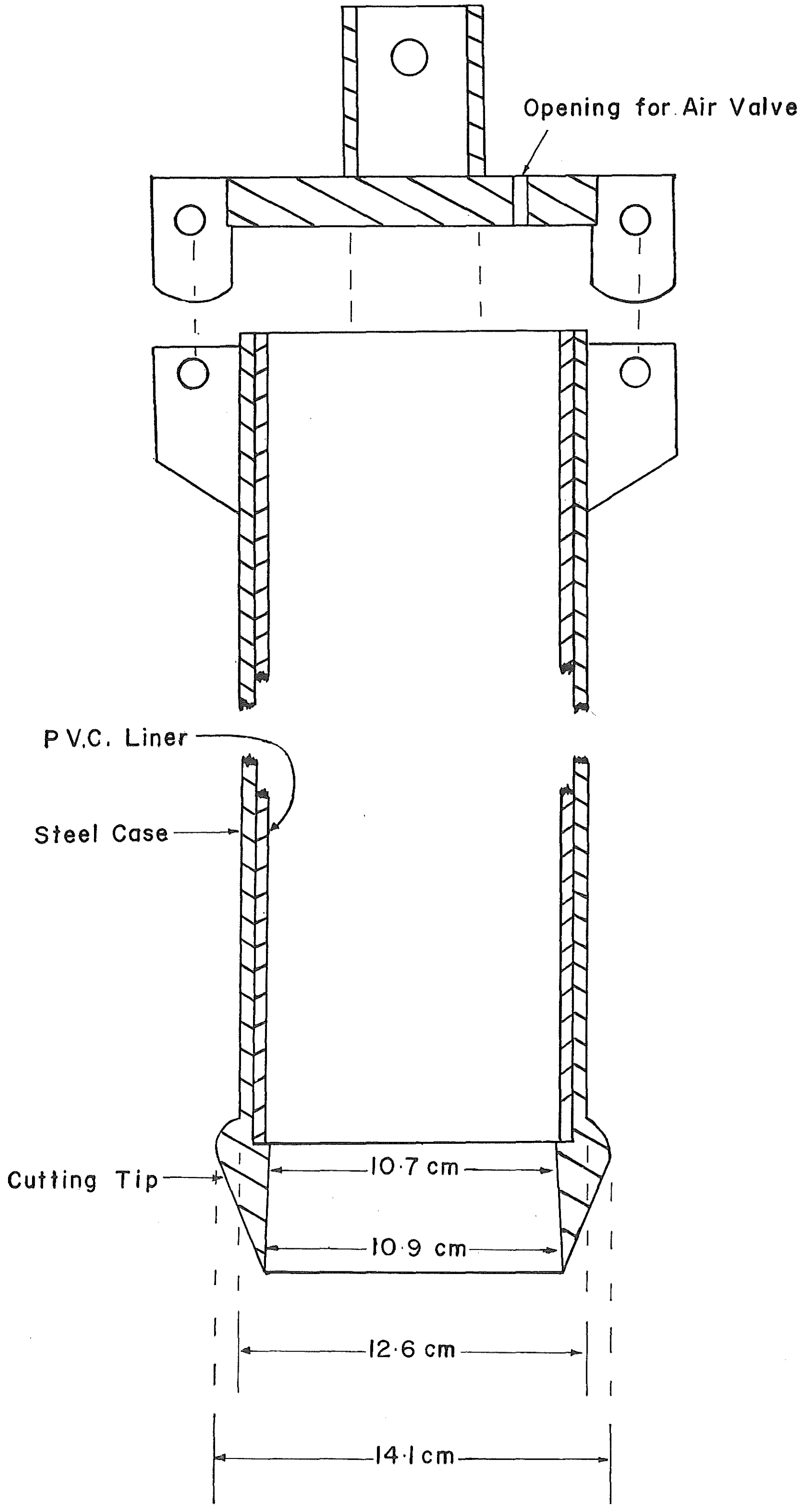

Figure 1.—Longitudinal section of sampling tool.

II. MATERIALS

The tool for cutting the soil core was designed to accept a piece of polyvinyl chloride (PVC) pipe, 10.9 cm inside diameter (3 mm wall thickness) and 67 cm long, as an inner sleeve. The tip and casing of the cutting tool were constructed of heavy duty steel pipe of the dimensions specified in figure 1. A ledge at the junction of these two components supports the PVC core liner. Lugs are positioned on either side of the casing so that a top can be fitted over the casing. The top keeps the core liner firm on the ledge during penetration and provides a central attachment at which a downward thrust is applied. A rubber seal is positioned under the casing top to make an air-tight seal.

Cracking-clay soils are extremely plastic when wet and swell slightly when confining pressures are removed during sampling. Both internal and external clearance in the sampling tool described was found necessary to allow the core to enter the liner and the tool to be withdrawn from the soil.

III. PROCEDURE

The tool was tested in an Irving clay soil (Thompson and Beckmann 1959), located near Toowoomba on the eastern Darling Downs. This soil type has a clay content of greater than 70% and exhibits gross swelling and shrinkage with changing water content.

An hydraulically-powered soil sampler, with two-way vertical and rotational movement and mounted on a utility, was used to obtain the cores (see figure 2). A vertical downwards force of 8 kN was found sufficient to force the cutting edge to a depth of up to 60 cm. In early tests, frictional forces between the PVC liner and the soil core appeared to cause compaction. Use of an oil smear ('Shellmold 02' mould oil) on the inner surface of the liner as well as on the cutting tip reduced compaction to an acceptable level.

Rapid penetration of the cutting tool, considered desirable to reduce core compaction (McIntyre and Barrow 1972), was only achieved when the cutting tool and the hydraulic ram were held perfectly vertical before penetration. In the heavy-clay soil in which the tool was used, the rate of penetration was found to be acceptable only at moisture contents approaching field capacity.

A series of cores was taken to obtain data on the efficacy of the method. Before sampling, the 0 to 10 cm surface soil was removed to prevent small particles from increasing friction between the core and liner. Cores were taken along a line at 30 cm spacings to a further depth of 25 or 50 cm. When the tool had penetrated to the required depth, the height differences between the soil surface inside and outside the tool were recorded to provide a measure of vertical compaction.

The sampling tool was rotated when fully inserted to break off the core. In early testing, the soil core slipped from the liner during extraction. A simple one-way valve system was incorporated in the tool to provide sufficient suction during withdrawal to retain the core within the liner. The valve allowed air to escape from within the sampler, as the soil entered the liner.

Soil retained in the cutting tip was removed before the core could be extracted from the casing (see figure 3). To prevent moisture loss from the core during transport from the field, polythene sheeting was used to seal both ends of the liner. Cores were weighed, and lengths measured, before ovendrying at 105°C for 48 h. Gravimetric water, bulk density, and air-filled pore space values were calculated. An absolute density of $2 \cdot 65$ g cm^{-3} was assumed for this in these calculations.

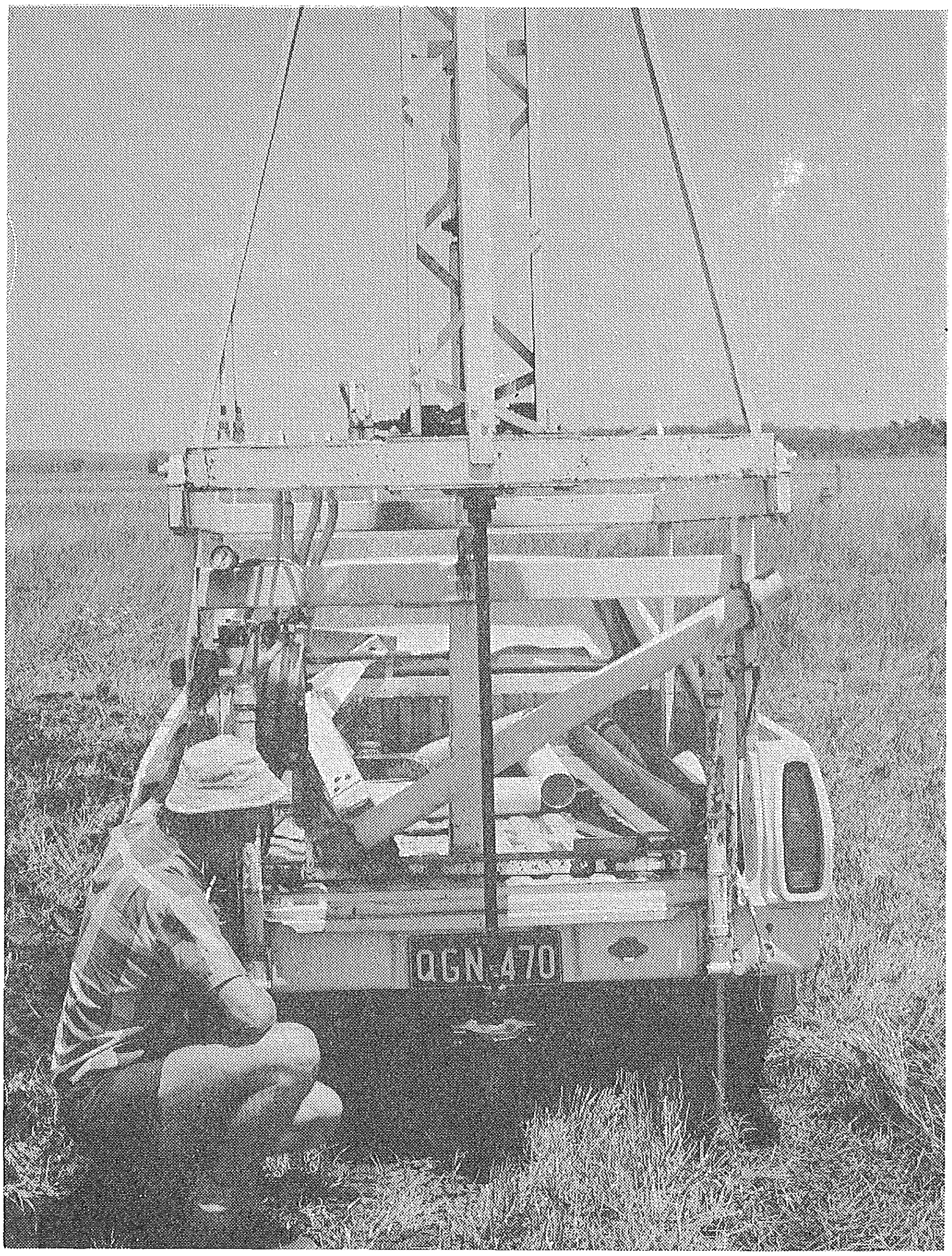

Figure 2.—Sampling tool being inserted by hydraulic soil sampler.

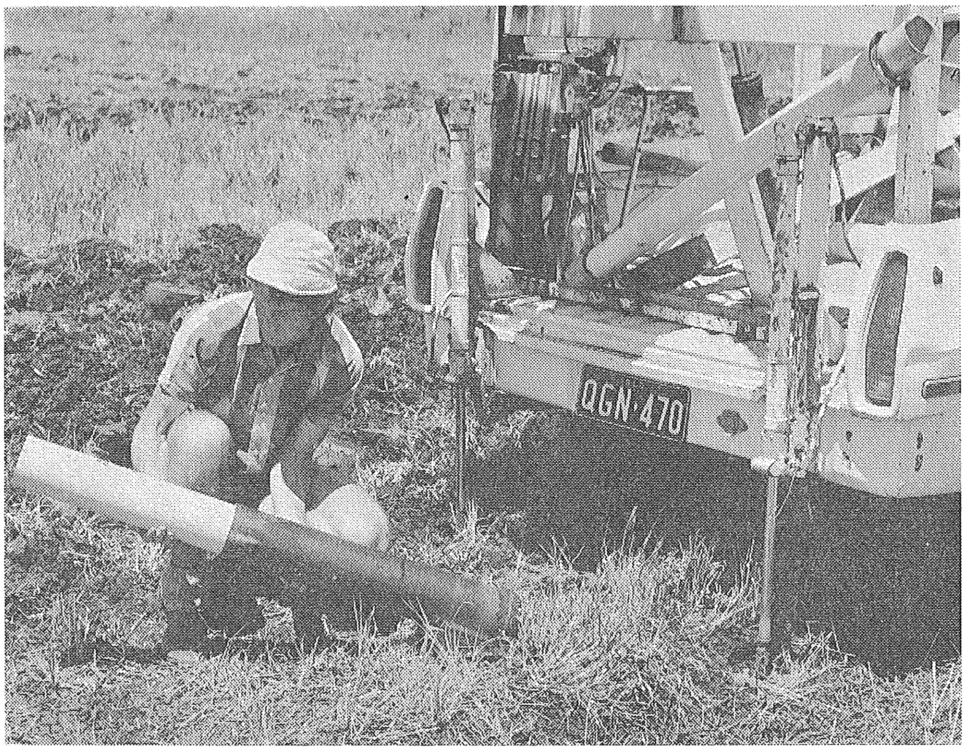

Figure 3.—Removal of PVC liner containing core from the sampling tool.

IV. DISCUSSION

The cores were examined for evidence of both lateral and vertical compaction. The radial compression of 0·1 cm was not sufficient to permanently distort the sample, as the mean diameter of all cores when removed from the liners was 10.9 cm. The device did, however, cause some vertical compaction, which, when expressed as a percentage of core length, decreased with increasing sampling depth (see table 1). The soil in the 10 to 35 cm depth interval probably compacted more because its bulk density is inherently lower than that of soil deeper in the profile. Vertical compaction did not have an obvious effect on bulk density or air-filled pore space, as the observed values were of the order expected for this soil (Fox 1964). The objective of obtaining a soil core with a minimum of disturbance has therefore been largely achieved.

The technique described has been used only with the cracking-clay soils of the Darling Downs. However, as this paper was being prepared, a similar technique described by Robertson, Pope and Tomlinson (1974) showed that the principle can be applied to a number of soil types, including duplex soils with a strong textural gradient in the profile. The technique could be used to obtain cores of any dimensions, provided a mechanism for applying the required force is available. The simple, inexpensive hydraulic soil sampler described by Grevis-James and McLatchey (1974) would appear suitable.

TABLE 1

PHYSICAL DATA (MEANS AND STANDARD DEVIATIONS OF SIX SAMPLES) OF UNDISTURBED SOIL CO.. TAKEN TO TWO DEPTHS

Sampling interval (cm)	Vertical compaction (%)	Gravimetric water content (%)	Bulk density (g cm^{-3})	Air-filled pore space (%)
10–35	3·8 ± 1·8	49·6 ± 1·1	1·07 ± 0·02	6·4 ± 0·9
10–60	2·8 ± 1·6	48·3 ± 0·7	1·12 ± 0·02	3·5 ± 1·2

The technique is quick and relatively little skill is required on the part of the operator. In an 8-hour day, 100 cores have been taken to 50 cm depth by a two-man team. Cores such as these have been used to grow wheat to maturity in a cracking-clay soil (Craswell and Strong 1975). These plants recovered added nitrogen from a depth of 45 cm, suggesting no apparent resistance to root penetration or reduction in aeration in the subsoil. Inspection of cores revealed that they possess the natural structural features of the soil as it exists in the field. The technique should therefore overcome many of the artificial effects associated with commonly used columns of packed soil.

V. ACKNOWLEDGEMENTS

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