File Copy

INTERNAL DOCUMENT 52

I.O.S.

DEVELOPMENT OF SEDIMENT CORING TECHNIQUES

by

S.E. CALVERT

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

INSTITUTE OF OCEANOGRAPHIC SCIENCES

Wormley, Godalming,
Surrey, GU8 5UB.
(042-879-4141)

(Director: Dr. A. S. Laughton)

Bidston Observatory,
Birkenhead,
Merseyside, L43 7RA.
(051-652-2396)
(Assistant Director: Dr. D. E. Cartwright)

Crossway,
Taunton,
Somerset, TA1 2DW.
(0823-86211)
(Assistant Director: M.J. Tucker)

INSTITUTE OF OCEANOGRAPHIC SCIENCES

DEVELOPMENT OF SEDIMENT CORING TECHNIQUES

by

S.E. CALVERT

(This report was commissioned by the Department of the Environment Contract DGR481/160).

INTERNAL DOCUMENT NO. 52

June, 1979.

Institute of Oceanographic Sciences,
Wormley, Godalming,
Surrey. GU8 5UB.

CONTENTS

ABSTRACT

A commercial large-volume gravity box corer was tested on R.R.S. *Discovery* Cruise 99. Operation and handling were evaluated and samples from the cores collected for determinations of some physical and chemical properties. Based on the limited experience gained, it is concluded that the corer can provide good quality sediment cores of pelagic sediments for geochemical and geotechnical work.

INTRODUCTION

Samples of the unconsolidated sediments of the deep sea floor will be required for a research programme concerned with the behaviour of radionuclides released from high level waste disposed of in the oceans. It will be necessary to obtain undisturbed samples of greater volume per unit depth than those routinely collected at present and in sections up to some hundreds of metres in length.

At the present time, sediment cores up to a few tens of metres in length can be collected from conventional oceanographic vessels. Short cores (few metres) can be collected by gravity corers, where a hollow metal tube, the barrel, is driven into the sediment by a weight at the top of the tube. Longer cores are collected by piston corers, where a tightly fitting piston inside the barrel reduces the pressure above the sediment as the corer penetrates the sediment and overcomes the frictional retardation between the sediment and the barrel wall. Descriptions of various coring devices are given by Rosfelder and Marshall (1967) and Moore and Heath (1978).

The operation of both gravity and piston corers can cause disturbance of the sediment recovered. In the case of the gravity corer, some shortening of the sediment section relative to the total depth of penetration has been frequently noted (Ross and Riedel, 1967); in the case of the piston corer, severe disturbance is produced if the shearing stress produced by the operation of the piston is greater than the strength of the sediment, either because of the properties of the sediment or because the internal piston is incorrectly rigged and sediment is drawn into the barrel too quickly or when the corer is removed from the sediment after incomplete penetration. For these reasons, most of the available information on the mechanical properties of deep-sea sediments has been obtained from cores collected by gravity coring where some allowance for core shortening can be more easily made.

The recovery of sediment cores and the disturbance of the recovered core section are governed by the inside and outside dimensions of the core barrel and the core nose assembly. A study by Hvorslev (1949) has formed a basis for evaluating the design of corers by defining the dimensions of core barrels and noses for maximum penetration for a given overall weight with the minimum of core shortening. These dimensions are given in Table 1, together with the dimensions of some available gravity corers. From available information, it is clear that longer core sections with minimal disturbance can be obtained by using core barrels with larger cross sectional areas and with thinner walls.

THE KASTENLOT CORER

For the purposes of this project, it was decided to test a commercially available gravity corer which had been used previously to obtain large-volume core samples up to 10 metres in length. This would provide a useful basis for further evaluations of corers which collected longer sections, including piston corers.

The Kastenlot ("box sounder") is a development of the conventional gravity corer. It was designed by Kögler (1963) to obtain large-volume samples of unconsolidated sediment with minimal disturbance. The corer is available in two sizes from Hydrowerkstätten, Kiel, West Germany. The main features of the corer are the shape and the large cross-sectional area of the barrel, enabling simpler subsampling of the core, large penetration and large volume of sediment recovered per unit length of core.

The basic corer used in this study is the smaller of the two Kastenlot sizes. It consists of 3 components (Fig. 1): a bronze weight-stand containing a set of 50 kg removable lead weights in bronze castings; a core box, consisting of a 15 cm x 15 cm square section mild steel box 2, 4 and 6 m long; and a core nose containing spring-loaded core retaining doors that can be locked in the open position by a pair of trip levers. The core boxes can be opened lengthwise into two equal halves by removing sets of bolt-on brackets on either side of the box. The total weight of the corer with all 17 lead weights assembled is 1000 Kg.

OPERATION

The corer was tested on R.R.S. Discovery Cruise 99 to the Cape Basin, South Atlantic. It was assembled on the aft deck of the vessel in a wooden deck cradle (Fig. 2a). It was lifted in a horizontal orientation by a polypropylene line attached to the corer bridle and the base of the weight-stand (Fig. 2b). For this purpose, a 5 ton steel lifting eye was added to the plate used for attaching the core boxes to the weight-stand.

When launching the corer, it was lifted clear of the ship's rail by the main crane and then brought to the vertical by hauling on the coring winch. The corer was then lowered at between 0.25 and 0.75 m sec^{-1}, depending on sea-state. The distance to the bottom was monitored by a 10 kHz acoustic beacon positioned on the wire 100 metres above the corer. The corer was lowered into the sediment at 0.5 m sec^{-1} and bottom contact was clearly seen on the winch dynamometer. After a few minutes delay, the winch was then put slowly into reverse and a watch kept on the dynamometer for an indication of an extra 1.0 to 1.5 ton load indicating that the corer had been pulled clear of the sea floor. Thereafter, the corer was returned to the surface at 0.75 to 1.0 m sec^{-1}.

The corer was brought to the horizontal position while remaining outboard of the ship's rail by lifting on the polypropylene line with the main crane. It was then guided into the deck cradle. The supernatant water drained through the top valve (Fig. 1) when the corer was brought to the horizontal position and some surface sediment was lost as a consequence.

The core box was disconnected from the corer and placed in supports on deck. The two halves of the box were then separated, exposing the core for subsampling (Fig. 2c). Measurements of core recovery were made immediately by noting the total depth of penetration of the corer from sediment smears on the outside of the box and the recovered core length.

RESULTS

Details of the station information and the cores recovered on <u>Discovery</u> Cruise 99 are given in Table 2. The corer was unfortunately lost, together with nearly 5000 m of wire, on Station 9942 due to the wire parting on deck. Consequently, no further trials of the corer with the longer boxes and the available weights could be undertaken on this cruise.

Apart from the loss of small sections of the surface sediment due to corer handling, thecores recovered on Stations 9936, 9937 and 9940 were visibly undisturbed; they were sufficiently competent to remain undisturbed after one half of the core box had been removed (Fig. 2c). On the other stations, the corer either malfunctioned or failed to penetrate the sediment sufficiently for the catcher doors to operate effectively. It is known that this occurs when more consolidated sediments prevent or retard penetration and the corer becomes top-heavy.

The corers were subsampled extensively on deck for the determination of the water content and the bulk density of the sediment, for pore water studies and for organic and inorganic geochemical analyses. Available water content and bulk density measurements on these cores show marked gradients in the upper 20 cm of the cores and nearly constant values of these parameters in the deeper sections. The near-surface properties appear to be very similar to those measured on shallow box cores (30 x 30 x 60 cm) collected on the same stations.

CONCLUSIONS

Based on the limited experience on Discovery Cruise 99, and on reported results of other users of similar equipment, it can be concluded that the Kastenlot corer can provide large volume sediment cores showing little evidence of disturbance. Further trials of a replacement corer using the longer boxes and more weights are needed; it is anticipated, however, that cores of pelagic clays at least 6 m long could be recovered using this technique.

The advantages of using this type of corer include:

1) deep penetration, because of the large- cross-sectional area of the corer barrel, without the aid of a piston.

2) Immediate subsampling for studies of sediment properties which change drastically on prolonged storage and handling, e.g., physical properties, pore water composition.

3) Fine-scale subsampling, because of the large core volume, for studies of sediment variability over short time scales. This is especially important in studies of pelagic clays which accumulates very slowly.

In future work with this type of corer, it is recommended that a hydraulically operated gantry be provided at the ship's rail in order to make the handling of the heavy corer safer and easier during launching and recovery.

REFERENCES

HVORSLEV, M.J., 1949, Subsurface exploration and sampling of soils for civil engineering purposes. U.S. Army Corps of Engineers, Waterways Experimental Station, Vicksburg, Mississippi, 521 pp.

KÖGLER, F.-C., 1963, Das Kastenlot. Meyniana, 13, 1-7.

MOORE, T.C., Jr. and HEATH, G.R., 1978, Sea-floor sampling techniques. In: Chemical Oceanography, 2nd Edition, Volume 7 (J.P. Riley and R. Chester, editors), Academic Press, London, 75-126.

ROSFELDER, A.M. and MARSHALL, N.F., 1967, Obtaining large, undisturbed and orientated samples in deep water. In: Marine Geotechnique (A.F. Richards, editor), Univ. Illinois Press, Urbana, 243-263.

ROSS, D.A. and RIEDEL, W.R., 1967, Comparison of upper parts of some piston cores with simultaneously collected open-barrel cores. Deep-Sea Res., 14, 285-294.

ACKNOWLEDGEMENTS

The assistance of the Discovery officers, crew and scientific party during Cruise 99 is gratefully acknowledged.

Table 1 Dimensions of gravity corers

	Hvorslev (1949)	Conventional Gravity Corer	IOS Gravity Corer	Kastenlot
Outside diameter of barrel (mm)	D_t	57	115	154
Inside diameter of barrel (mm)	D_s	50	101	151
Outside diameter of nose (mm)	D_w	70	115	166
Inside diameter of nose (mm)	D_e	46	100	150
Cross-sectional area (cm^2)	-	16.6	78.5	225.0
Inside clearance ratio[1] (C_i)	0.75-1.5	8.7	1.0	0.7
Outside clearance ratio[2] (C_o)	3	22.8	0	7.8
Area ratio[3] (C_a)	10	131.6	32.2	22.5

Footnotes:

1. $$C_i = \frac{D_s - D_e}{D_e} \cdot 100$$

2. $$C_o = \frac{D_w - D_t}{D_t} \cdot 100$$

3. $$C_a = \frac{D_w^2 - D_e^2}{D_e^2} \cdot 100$$

Table 2. Kastenlot Station Data, Discovery Cruise 99

Station No.	Date	Position		Water Depth (m)	Weights used	Box Size (m)	Remarks
		S.Lat	E.Long.				
9934	17/1/79	33°49.7'	16°52.4'	2660	2	2	Small sample; 1 door of catcher open on recovery; 10% recovery.
9936	18/1/79	33°43.7'	15°39.6'	3808	4	2	78 cm calcareous clay; 95% recovery.
9937	19/1/79	33°43.1'	14°18.5'	4290	6	2	192 cm brown clay over cream calcareous clay; 100% recovery
9938	19/1/79	33°43.3'	12°18.6'	4680	8	4	N core recovered; 1m penetration only.
9938	20/1/70	33°01.3'	12°12.0'	4685	5	2	15 cm dark brown clay; 15% recovery
9940	21/1/79	34°10.8'	09°57.8'	4975	5	2	166 cm dark brown mottled clay; 96% recovery
9942	22/1/79	34°29.4'	07°38.7'	5130	9	4	Corer lost.

Fig. 1 Diagram of the components of the Kastenlot.

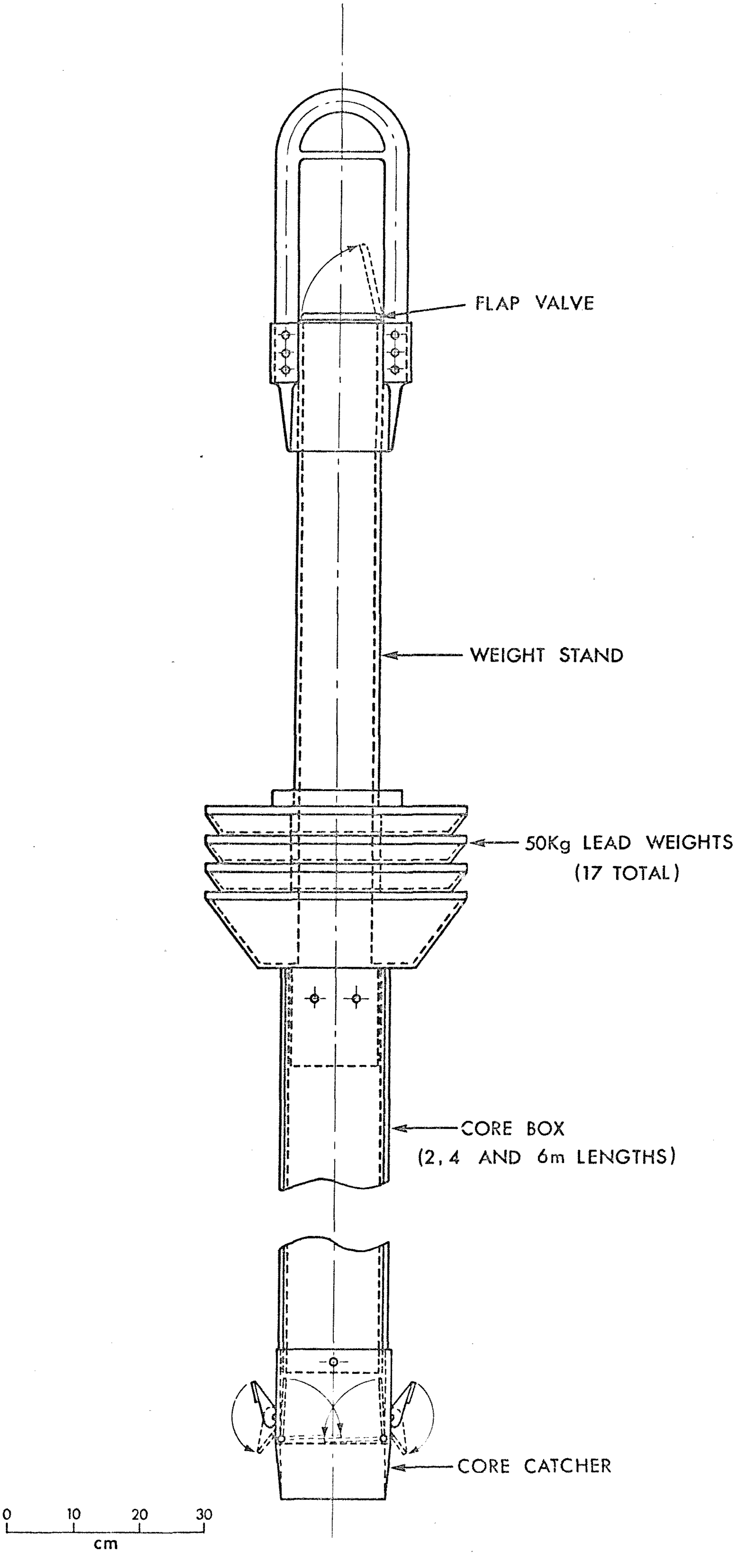
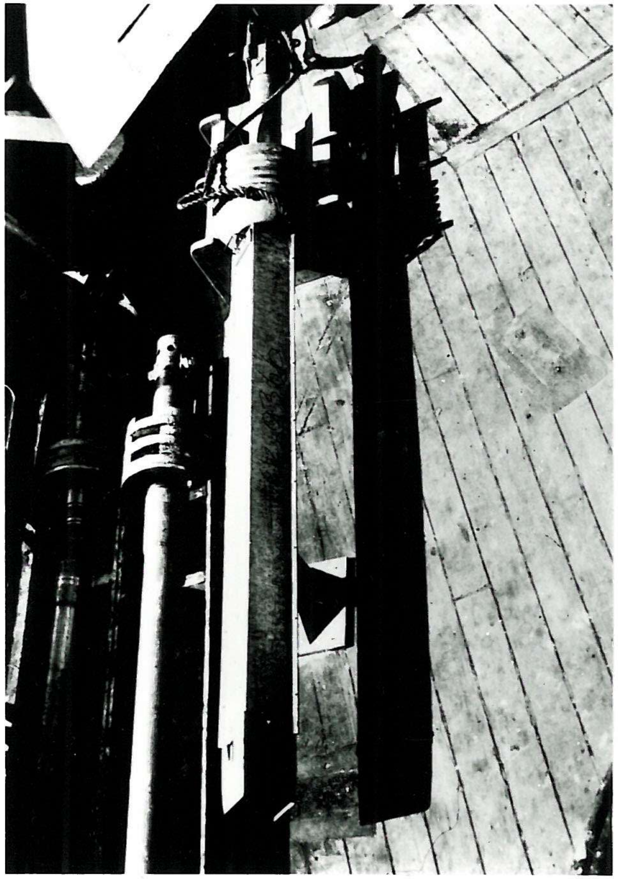

FLAP VALVE
WEIGHT STAND
50Kg LEAD WEIGHTS
(17 TOTAL)
CORE BOX
(2, 4 AND 6m LENGTHS)
CORE CATCHER
0
10
20
30
cm

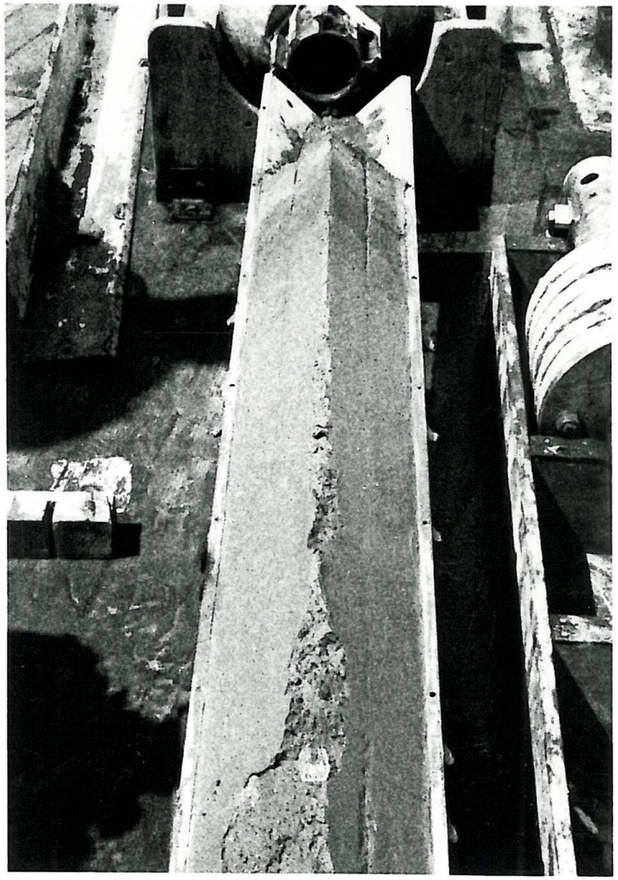
Fig. 2a Assembled corer in deck cradle on R.R.S. *Discovery*.

b Corer being lifted ready for launching.

c Sediment core exposed for subsampling.


a


b


c