

## High-Energy Pneumatic Vibration Corer for Subaqueous Sediments.

With 2 Text-Figures and 2 Plates.

DIETER MEISCHNER & HORST TORUNSKI & GERHARD KUHN.

### Abstract.

[MEISCHNER, D. & TORUNSKI, H. & KUHN, G. (1981): High-energy pneumatic vibration corer for subaqueous sediments. — *Senckenbergiana marit.*, 13 (4/6): 179-191, 2 figs., 2 pls.; Frankfurt a. M.]

A pneumatic vibration corer for any type of subaqueous sediment is described. The instrument is operated from a commercial size 160 building compressor. Cores up to 10 metres have been taken from the Bermuda Platform and inshore waters. Sediments varied from coarse, hard biogenic sands and silts over fresh water mud and peat to indurated calcareous sand and coral. Cores are virtually undisturbed even in difficult situations. The pneumatic vibration corer is inexpensive, durable, and highly reliable.

### Kurzfassung.

[MEISCHNER, D. & TORUNSKI, H. & KUHN, G. (1981): Pneumatisches Vibrationslot für Flachsee-Sedimente. — *Senckenbergiana marit.*, 13 (4/6): 179-191, 2 Abb., 2 Taf.; Frankfurt a. M.]

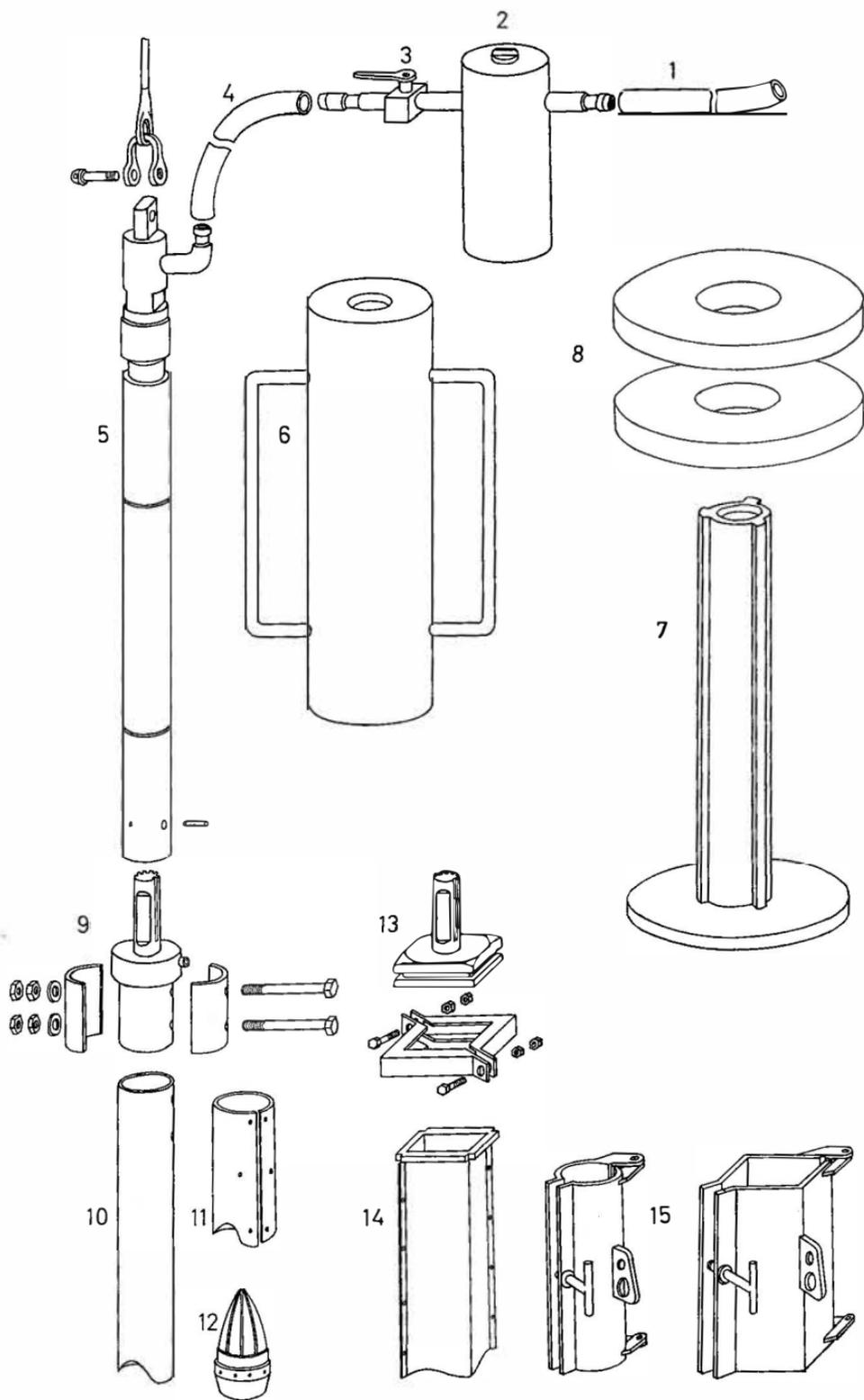
Ein pneumatisches Vibrationslot für jede Art Sediment wird beschrieben. Das Gerät wird mit einem marktüblichen Baukompressor betrieben. Auf der Bermuda Platform wurden bis 10 m lange Kerne aus grobkörnigen, harten biogenen Sanden und Silten und Süßwasser-Mudden und Torfen genommen. Auch erhärtete Carbonat-Sande und Riff-Korallen wurden gekernt. Die Kerne sind auch in schwierigen Sedimenten ungestört. Das pneumatische Vibrationslot ist preisgünstig, unempfindlich und sehr zuverlässig.

### Introduction.

Extremely hard biogeneous sands were encountered in the open lagoon of the Bermuda Atoll. Conventional coring devices failed even when high energy was applied by the free fall of a 1,000 kg box corer. This experience prompted the construction of a powerful vibration corer.

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## Design.

Hammer and counter-weight (Fig. 1; Pl. 1 figs. 1-2).

The ZIMMERMANN Type THZ 80 a drilling hammer was chosen because of its well acclaimed performance and durability. It is regularly used to drill hard rock for blasting in quarries and for prospection holes. With a size 160 compressor (160 cft/min at 100 psi, actual) as a standard supply the drill runs at 2250 beats/min. Details of the construction may be taken from Fig. 1.

On lowering, after the bottom is reached by the core nose, the hammer is triggered by a counter-acting force of ca. 300 N. This force is provided by a steel weight of 140 kg centred around the hammer. The corer is slowly lowered to assure a vertical position during the initial coring phase. The corer will soon maintain its vertical position, and the weight can act as a counter-weight to the action of the piston. For difficult sediment and unusually long or thick cores the weight may be changed for a weight holder that allows variable loads from 80 to 700 kg. In most situations however the standard weight is quite sufficient.

The air is supplied through a 1 $\frac{1}{4}$ " pressure hose. This diameter is sufficient for hose lengths up to 50 m.

In depths up to 30 m a commercial size 160 building compressor is adequate. In greater depths a second hose is required to lead the air back to the surface in order to avoid the counter-pressure of the water (ca. 1 bar per 10 m depth).

The hammer is continuously oiled during operation. The air from the compressor passes a jet atomizer, and the aerosol is carried directly to the moving parts. Very little oil is used, and there is no danger of pollution.

## Core barrels and adapters.

Core barrels are fitted to the hammer by means of adapters made from worn drilling tools. The upper ends of the tool shafts remain unaltered, the lower ends are welded to solid adapters that fit commercial tubes. Barrels can thus be easily fitted to the hammer within seconds.

The most commonly used barrel is a 90 × 2.5 mm standard aluminium tube (alloy: Al-Mg-Si 0,5 F22). It is produced in lengths of 6 m, but may be put together to any length by connection tubes held in place by ca. 20 ea. stainless 4 mm dia. pop rivets.

The aluminium tubes are light-weight (1.92 kg/m), sea-water resistant, hard and stable (BRINELL-hardness 700 N/mm<sup>2</sup>), and cheap enough to be used for one core only (ca. US\$ 6.—/metre). Cores are left in the barrels for transport and storage, and the tubes later opened by cutting lengthwise with a circular metal saw. No liners are used, and no extrusion is necessary with round aluminium tubes.

When larger volumes are needed, the corer may be used with square box barrels of the "Vibrocorer Type Kiel VK 200 or VK 300", Hydrowerkstätten GmbH, Kiel, W-Germany. Two right-angular galvanized steel V-profiles are screwed together along two edges. The cores can be opened after recovery simply by unscrewing. Barrels of this type come in 100 × 100 mm or 150 × 150 mm calibers and 3 or 6 metres long. They are expensive (US\$ 100.—/metre) and are more easily deformed in hard sediments.

## Core noses and catcher.

Barrels may be used without any cutting or catching device, and this may prove satisfactory in many cases. But with longer cores the increasing friction along the inner walls will result in core shortening especially when softer sediments are to be cored underneath harder surface layers. It is therefore advisable to use core catchers with a recess along the inner walls. Relatively blunt core noses of hardened steel are used with the aluminium tubes. The recess is 1.5 mm (Fig. 1, item 12).

Loss of cores is prevented by use of core catchers when no stiff clayey or indurated sediments are expected that could act as plugs. Orange peel type catchers are made from phosphor bronze. Core noses and catchers are fitted to the barrels by means of pop rivets. In indurated sediments "lost noses" may be used. In addition to the inner recess they are thicker than the barrel on the outer side, too. This keeps the barrels clear of the walls of the hole. The noses are pulled off and remain at depth when the barrels are recovered from the holes.

A simple hinge flap catcher was constructed for square box barrels. A right-angled metal flap is pop-riveted to one barrel wall by means of a commercial hinge band. During penetration the flap rests against the wall, it closes across the barrel if the core starts slipping or is washed out.

## Operation.

In Bermuda the vibration corer was operated from a working barge as detailed above (Pl. 1 figs. 1-2). The compressor was put on a wooden boat moored alongside the barge. When no second hose was used the air flowed back to the surface with considerable force. This caused a strong current away from the centre of the barge. Therefore the barge and boat had to be carefully anchored with three 35 pound (15.8 kg) C. Q. R. plough anchors and chains from  $\frac{3}{4}$ " polypropylene ropes. Anchoring gave less trouble when the released air was lead back to the surface through a specially designed adapter and a  $1\frac{1}{4}$ " pressure hose.

The hammer with counter weight is hoisted on a 10 mm diameter steel rope by means of a RAMSAY GUS 2000 electric winch operated from 24 V truck batteries. A barrel with adapter is then fitted to the hammer, and the corer lowered under a little over-pressure from the compressor as a safety measure against possible flooding of the hammer. Careful depth readings and corresponding marks on the rope are required for safe coring. Readings are taken by means of a chain plummet to  $\pm 5$  cm in quiet waters.

When the core nose touches the bottom and starts to enter the sediment, a counter force builds up that squeezes a spring until the piston is released, and the hammer starts vibrating. The winch is stopped until during ongoing penetration the spring is released and the hammer stops again. In this way the corer is successively lowered until the vibration becomes permanent, and no further penetration is observed. The winch is then reversed, and the barrel slowly pulled out from the sediment. The extraction is eased by the pumping action of moderate sea or swell.

Floation of the barge can be increased by large truck tubes placed underneath the barge and inflated in-place. Traction can be increased by a chain hoist applied to the rope by a self-tightening clamp in addition to the winch. Pulling forces may thus be increased to some 40 kN.

Only in two cases did a barrel have to be left behind in the sediment — extremely hard indurated sand. In most of the other cases the barrels were extracted with ease.

Penetration was always down to really indurated rock appearing on UNIBOOM seismic reflection records as strong reflectors, and even some way down into the harder rock.

## Results.

With the pneumatic vibration corer it has been possible to completely core the Holocene sequence at any point of the Bermuda Platform and its inshore waters, plus a good deal of the underlying Pleistocene sometimes through the next Inter-Glacial into older rocks. 70 cores have been taken in 5 weeks in 1980.

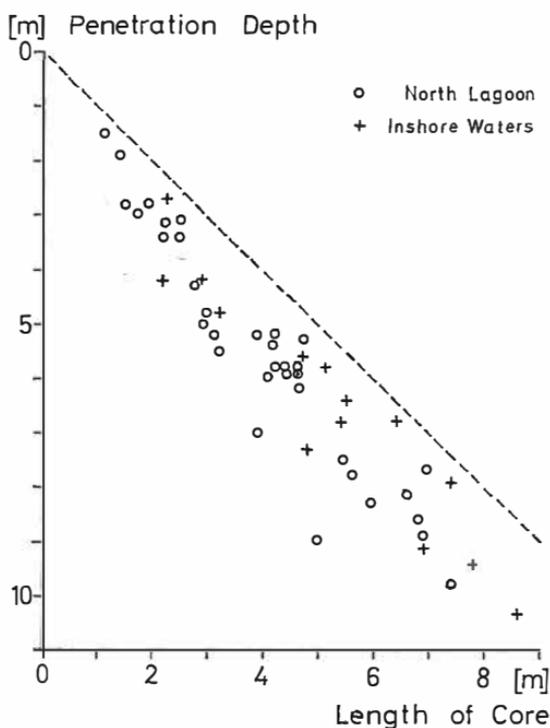


Fig. 2. Core lengths plotted against penetration depths.

Abb. 2. Kernlängen gegen Eindringtiefen aufgetragen.

The maximum core length was 8.85 m, maximum penetration was 10.35 m (Fig. 2). Coring was virtually limited by the availability of porous sediments.

The quality of the vibration cores is excellent. No disturbance is seen even along the walls of the tubes. Fine lamination remains undeformed, hollow bivalve shells in living position like those of *Codakia*, *Laevicardium* and *Anodontia* remain intact, open cavities stay open (Pl. 2 figs. 3-4). Hard obstacles like larger shells and corals are cut out to the shape of the barrel; they are not pushed aside or dragged down through the sediment. This applies even to massive *Diploria* heads and algal-vermitid growth.

However, some plugging may occur when muddy sediment is overlain by hard or dry material like indurated sand or stiff clay. In peat, core shortening may be caused by solid tree trunks that need some time to cut through during which the muddy matrix is pushed aside. Even in homogeneous sediments there is sometimes 10 to 30% core shortening (Fig. 1). This is more pronounced in coarse sands than in fine grade material, and is partly due to the recess of the core nose. A 1.5 mm of recess means a loss of 7% volume. The rest is probably due to compaction and loss of pore space dominantly in sands.

### Further developments.

The corer described here is a compact, dependable, and powerful instrument. It is therefore the ideal tool for small vessels in shallow waters and for difficult sediment. But it may also be further developed for use in more open and deeper waters and for rocks that still require rotary drilling techniques such as cemented reef rock. An even more powerful hammer is available with the ZIMMERMANN Type THZ 110. Coring reef rocks with 90/85 mm aluminium barrels was successfully attempted in summer 1981.

### Summary.

Any type of sediment can be successfully vibration-cored by use of a pneumatic drilling-hammer and simple core barrels. The pneumatic drive has the advantage of being simple and durable and still applying much higher energies to the corer than other systems of comparable size and weight. It is comparatively inexpensive and highly reliable.

Cores taken with the high-energy pneumatic vibration corer are of excellent quality. The limits of the system are still not reached at more than 10 metres penetration and 8.85 m of core.

### Acknowledgements.

The authors acknowledge the excellent engineering and kind cooperation of Messrs. FRITZ ZIMMERMANN and Sons at Wulferdingsen. Mr. RODERICK FOGGO, Carpenter, and Mr. MANUEL RAPOSO, Welder, St. George's, Bermuda, built the working barge and A-frame to scale drawings. Mr. HEINRICH HERBORG and Mr. HERBERT RUMPEL, metal workers, Göttingen, made accessories to order. Mr. RÜDIGER JUNG and Mr. PETER SCHLIE, Göttingen, helped with the test runs and a greater part of the coring.

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- KÖGLER, F.-C. & VEIT, K. H. (1973): Entnahme von Kernen aus Lockersedimenten des Schelfgebietes mit dem Vibrohammer-Kerngerät. — Extraction of cores from loose sediments of the shelf area with the vibration-hammer core gear. — *Meerestechn.*, 3: 91-95.
- LANESKY, D. E. & LOGAN, B. W. & BROWN, R. E. & HINE, A. C. (1979): A new approach to portable vibrocoreing underwater and on land. — *J. sediment. Petrol.*, 49 (2): 654-657; Tulsa, Okla.

### List of manufacturers and materials.

1. Barge Pontoons.  
DURA FLOAT 26" dia. × 36" Gull Wing Sections  
Rotocast Plastic Products, Inc.  
6700 N. W. 36th Avenue  
Miami, Florida  
U.S.A.
2. Winch.  
RAMSEY GUS 2000, 24 V =  
Ramsay Winch Company  
5531 E Admiral Place  
Tulsa, Oklahoma 74115  
U.S.A.
3. Special Steel Rope.  
CASAR 10 mm, galvanized, with cast-on stainless steel terminal  
Robert G. Ernst  
Wall 42-46  
Postfach 2024  
D-2300 Kiel  
West Germany
4. Anchors.  
C. Q. R. N° 0565-6 (35 pounds, 15.8 kg)  
Simpson Lawrence Ltd.  
218/228 Edmiston Drive  
Glasgow G51 2YT  
United Kingdom

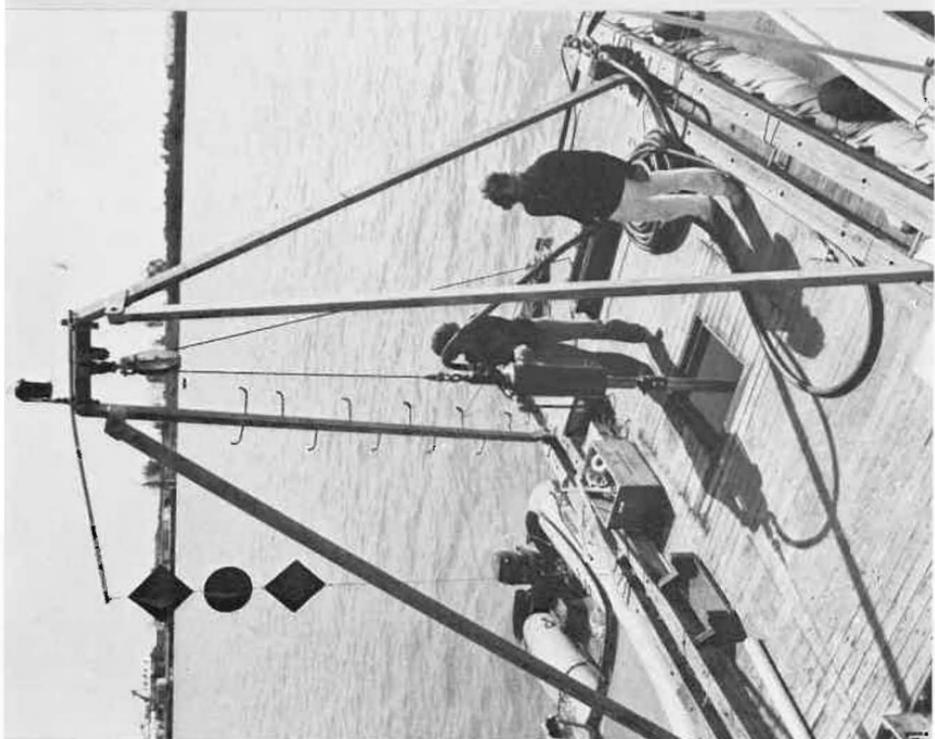
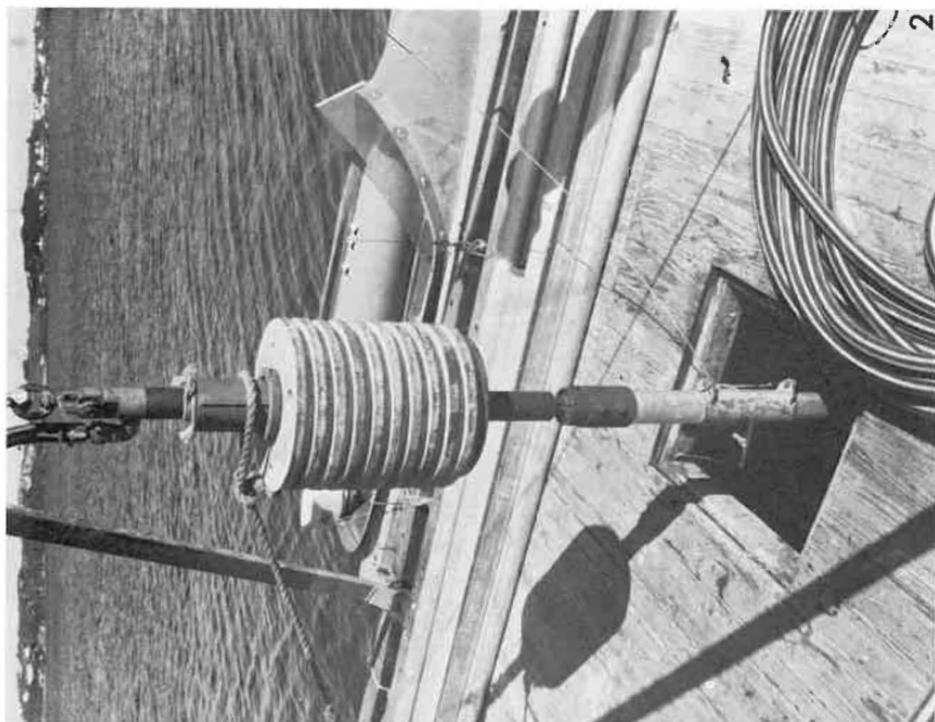
5. Drilling Hammer ZIMMERMANN THZ 80 a, Adapters Custom-Made.  
Fritz Zimmermann  
Maschinen- und Apparatebau  
D-4971 Wulferdingsen 495  
West Germany
6. Aluminium Tubes.  
Al-Mg-Si 0.5 F22, 90 × 85 mm  
Mittelrheinische Metallgießerei  
Heinrich Beyer K. G.  
Postfach 340  
D-5470 Andernach  
West Germany
7. Square Box Barrels, Lead Weights.  
Hydrowerkstätten  
K. H. Veit GmbH  
Uhlenkrog 38  
D-2300 Kiel-Hassee  
West Germany

## Plate 1.

- Fig. 1. Working barge with collapsable double-A-frame, electric winch and pneumatic vibration corer with 90 mm aluminium barrel in St. George's Harbour, Bermuda.
- Fig. 2. Pneumatic vibration corer with heavy weight holder (here: ca. 500 kg) and 90 mm aluminium barrel in Harrington Sound, Bermuda.

## Tafel 1.

- Fig. 1. Arbeitsfloß mit niederlegbarem Doppel-A-Mast, elektrischer Winde und pneumatischem Vibrationslot mit 90 mm Kernrohr aus Aluminium im St. George's Harbour, Bermuda.
- Fig. 2. Pneumatisches Vibrationslot mit Gewichthalter (hier ca. 500 kg Auflast) und 90 mm Kernrohr aus Aluminium im Harrington Sound, Bermuda.



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## Plate 2.

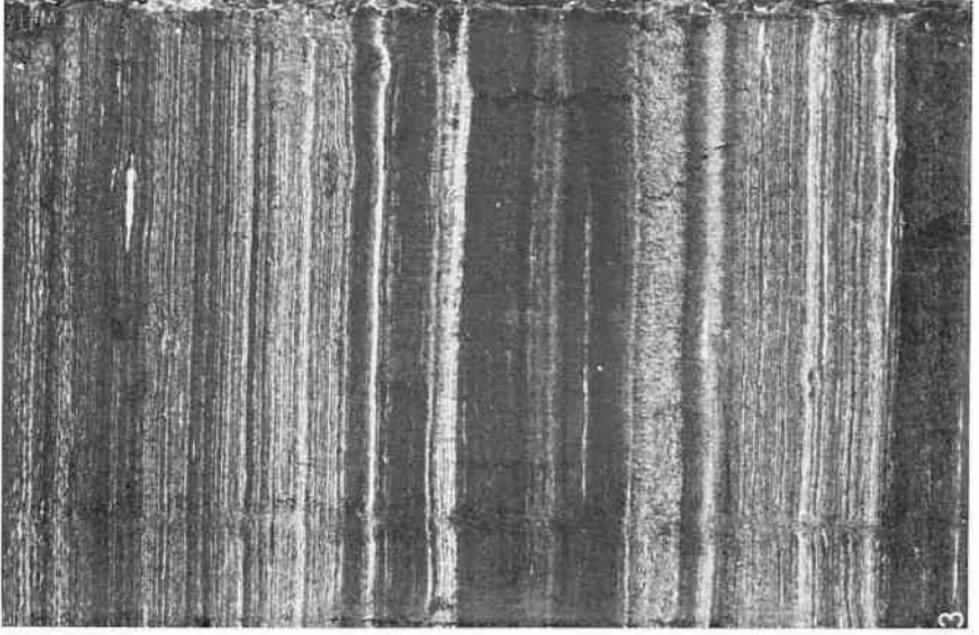
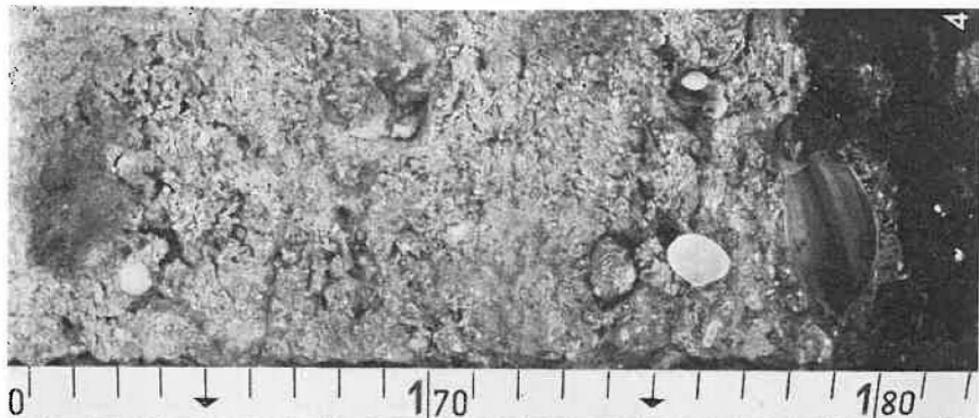
Two sections from typical vibration cores in 90 × 85 mm aluminium tubes, opened lengthwise and cut in half. Note excellent preservation of structures. — Metric scale.

- Fig. 3. Laminated calcareous ooze and plant debris (gyttja type sediment).  
 Fig. 4. Coarse sand and shell, unconformably underlain by peat, burrows in the peat filled with marine sand.

## Tafel 2.

Zwei typische Anschnitte von Kernen in 90/85 mm Aluminium-Rohren, längsweise aufgeschnitten. Sedimentstrukturen ausgezeichnet erhalten.

- Fig. 3. Laminiertes Kalkschlick und organische Mudde (Gyttja).  
 Fig. 4. Grober Sand und Schill mit erosiver Grenzfläche über Torf. Grabbauten im Torf gefüllt mit marinem Sand.



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