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APPARATUS FOR STUDIES OF ARTIFICIAL SEDIMENTS

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INTRODUCTION

This paper describes the construction of a tank which facilitates the investigation, under monitored conditions, of some chemical, mineralogical, and biological processes which take place in sediments. It is intended to supplement laboratory and field studies and, in particular, to allow examination of specific processes under conditions approaching those in the field, but without the uncertainties introduced by the prior history of the field situation.

The apparatus is equipped for monitoring of physical, chemical and biological changes, and for periodic coring.

APPARATUS

TANK: The central structure of the system is a tank (Fig. 1) made of 4 mm thick fibreglass, the sides being reinforced by embedded 3 x 3 cm wooden cross beams. The edges of the tank are strengthened in a similar manner, with the exception of the top edges which are provided with 5 cm angle iron covered with fibreglass for mounting and guiding the coring rig rails. The present apparatus has the dimensions of 122 cm x 76 cm x 122 cm and a capacity of 1130 litres. The tank is equipped with two armored glass windows (D), 5 mm thick, for visual observation. A distributor plate (F) is placed on a layer of sand (E) at the bottom of the tank. The plate was made of a perspex sheath 5 mm thick. A series of parallel grooves 3 mm deep, 3 mm wide and 15 mm apart is cut into the plate. These grooves are fed by two distribution grooves 10 mm wide and 3 mm deep. A second plate was cemented on the top of the grooved side and holes 0.5 mm diameter, 10 mm apart are drilled through the upper plate above the grooves. This plate, covered by a fibreglass sheet (G) which prevents blocking of the distribution points by the sediments, permits introduction of solutions through polypropylene pipes (H), 10 mm I.D., into the lower part of the tank and their percolation to the upper sediments. The walls of the tank are provided with 24 sampling ports (B) for horizontal sampling. The sampling port (B) is shown in more detail in Figure 2. It consists of a polypropylene tap (T), 5 mm I.D. which is attached to the wall by two perspex flanges (2 and 3), 5 mm thick and 6 cm in diameter. The flanges are drilled to admit 4 nylon bolts (1), 5 mm diameter and 15 mm long. The water-tight seal is achieved by rubber O-rings (O). The tank is first filled with the desired solution and the solids are introduced sequentially as slurries. Sharp, well defined zones are obtained by this technique (Fig. 3).

In experiments where algal growth in the supernatant liquid is required the tank is illuminated by two Osram MCFE white 40W fluorescent lights (A).

CORING RIG AND CORING BIT: To obtain undisturbed cores of the unconsolidated sediment a special rig and bit were designed (Fig. 1).

The rig consists of a 150 cm tower (J) placed on rails. The rails can be moved on the top of the tank west to east and the tower moves on the rails north to south. The rig is positioned by reference to two scales (U) on the tank, (not shown) and (V) on the guide rails. A transparent polycarbonate tube 32 mm I.D. equipped with coring bit (Q) is pushed slowly into the sediment by a clamp attached to chain (K), which is operated by a wheel handle. To minimise any distortion of the soft sediments the core tube has to move with a maximum speed 5 cm per minute. Such a speed is achieved with the help of a gearbox (M). To assure a smooth and straight penetration of the sediments the tube is passed through a guide N_1. The coring bit (Q) is attached to the coring tube by a bayonet fitting (Q_3). The sails (Q_1) of the bit are kept in an open position (as illustrated) during the penetration. The bit (Q) is 15 cm long and 6 cm wide and is smooth inside to minimise any disturbance to the core. After the core tube has reached the bottom of the tank, the guide (N_1) is removed and a protective 12 cm I.D. polycarbonate tube (R) is passed over the core tube, directed by a guide (N_2). The core tube is then turned 360° anti-clockwise. The resistance of the sediments applies a pressure against the sails (Q_1) forcing two knife edges (Q_2) to penetrate the core, and separate it from the main body of the sediment. Thus the orifice of the tube is closed and the unconsolidated material retained inside the tube. (Provisional Australian Patent No. PB 867). The core tube is then removed from the tank by a reverse action of the rig. The protective sleeve is left in the sediment and the cavity is filled with a slurry of sand and bentonite. The composition of the slurry was chosen because of its weight and swelling properties. This technique results in the preservation of microlayers in the core sample, minimises the disturbance to the system, prevents caving in and movements of liquid into the cavity produced by the coring in the main body of the sediments.

After the coring tube is removed from the tank, the majority of the supernatant liquid in the tube is removed for analysis either in bulk or in layers with an all-glass syringe equipped with a L-shaped glass needle. A similar technique is used if the fluid upper layers of the sediments are to be analysed for a detailed vertical profile composition. Otherwise the upper content of the tube is consolidated by addition of approximately 20 g of carboxymethylcellulose in powder form. A solid gel plug develops in a few minutes and the tube can be handled easily. The core bit is removed and replaced by a rubber plug. The core is then ready for X-ray scanning and dissection for chemical, mineralogical and biological analysis.

HORIZONTAL SAMPLING: In addition to the cores a larger number of samples can be collected for analysis by a horizontal sampling technique.

The sample collector consists of a stainless steel needle (C) 80 cm long, 4 mm I.D. and 6 mm O.D. It is represented in greater detail in Figure 2. The needle is equipped with a closely fitting teflon plunger (P). The needle, with the plunger in closed position and overlapping holes (H_1 and H_2), is pushed through a self-sealing rubber (R) on tap (B) into the sediments (S), (Figure 2-i). The needle is stopped at a predetermined position, plunger (P) is held firmly and the needle (N) is pushed into the sediment until it is stopped by a guard (G). The length of the guard (G) which is exchangeable, determines the depth of insertion of the needle into the sediments. By this action a sample is collected in the needle (Fig. 2-ii). The needle is then rotated 180° to separate the microcore from the main body of the sediments. The needle and the plunger are then withdrawn from the sediment without altering their relative positions.

ANALYSIS

pH, Eh, O_2, and H_2S may be measured by direct insertion of microelectrodes (E) into the sampling needle (Fig. 2-iii). The following equipment developed by TITRON AUSTRALIA, Melbourne, is suitable:-

H_2S - Micro-combined Ag/Ag_2S metallic electrode No. 373.

E_h - Micro-combined Pt electrode No. 372.

O_2 - Micro-oxygen electrode with 12 μ cathode, No. 514.

pH - Micro-combined siliconized pH electrode No. 196.

Oxygenmeter LR-15.

After the electrode measurements the sample is extruded from the needle for mineralogical, chemical and biological analysis.

REMARKS

The apparatus described in this report was primarily designed to simulate a sedimentary system with the purpose of clarifying some aspects of the geobiological processes leading to sedimentary stratiform ore bodies. Such a simulated sedimentary system, of course, can be used for a variety of sedimentological studies.

The authors would like to express their appreciation to Mr. J.M. McLay, Minerals Research Laboratories, Commonwealth Scientific and Industrial Research Organization, and to Mr. J.M. Mulder of the Bureau of Mineral Resources, for their enthusiastic help in designing and manufacturing of the tank's equipment. The drawings in this paper by Mr. H.G. Becking are gratefully acknowledged.

Fig. 1 Apparatus for studies of artificial sediments.

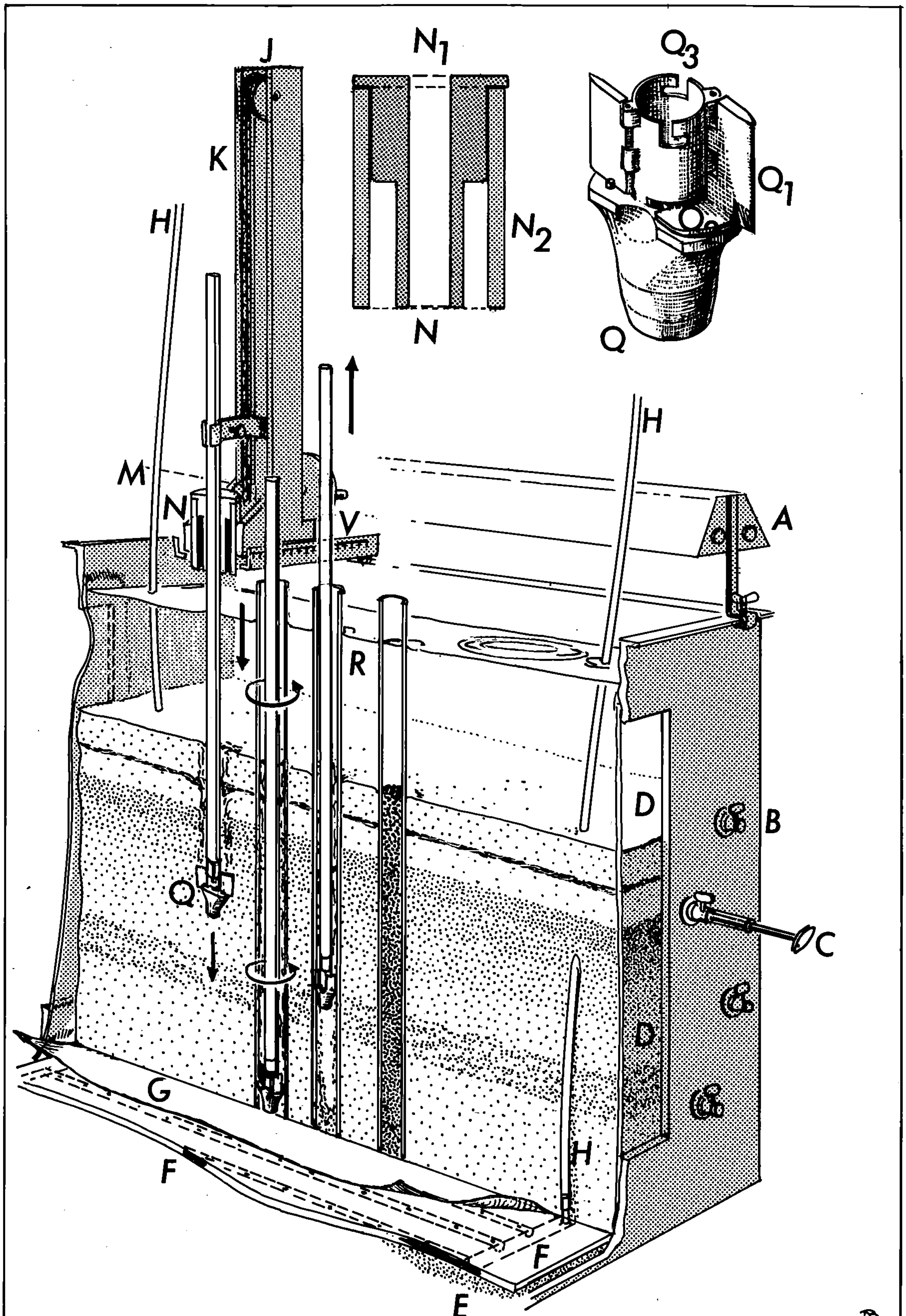

Fig. 2 Microsamples.

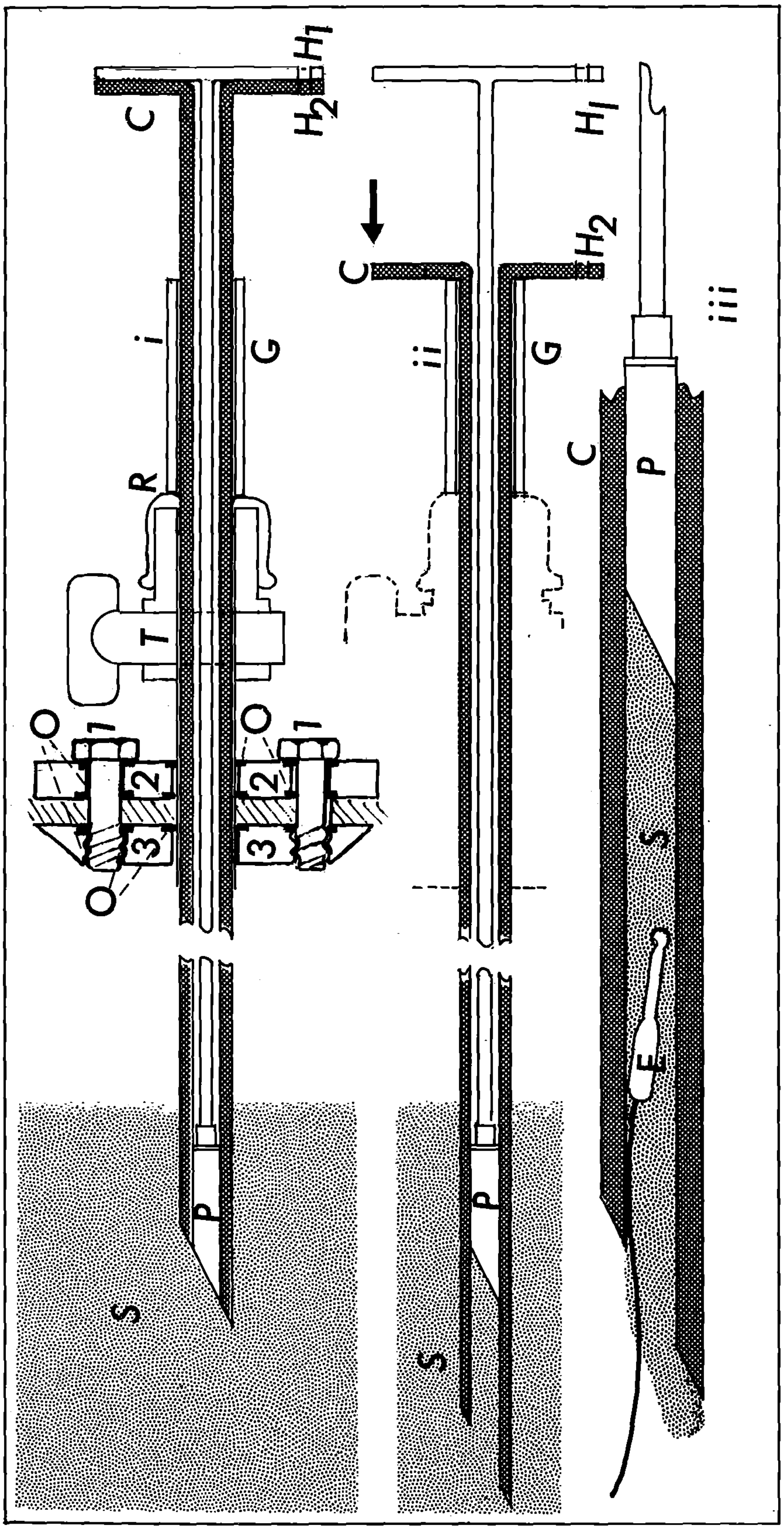

Fig. 3 Simulated Sedimentary System.