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1979/21

A ROCK AND SEDIMENT DRILL FOR USE ON CORAL REEFS

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Summary

A portable rotary drilling rig, built for coring coral reefs, has been successfully tested in the Southern Great Barrier Reef Province. The rig is hydraulically powered and can be operated both above and below water. Seven holes have already been drilled on seven reefs, with recoveries ranging from 50-95%.

The rotary drilling system is convertible on a sediment coring unit. A hydraulically operated jackhammer is used to push 75-mm I.D. plastic tubes into lagoonal sands. Practical coring depth was determined more by the capacity of the winch to withdraw the core tube than by the penetrating capacity of the jackhammer. Cores 5 m long were attained in field tests at One Tree Reef.

INTRODUCTION

Geological studies in the Great Barrier Reef have in the past concentrated on surface processes and products. More recently, however, remote sensing techniques have been used to differentiate the three-dimensional structure. In particular, seismic refraction studies have shown that the pre-Holocene substrate is relatively shallow and exhibits relief variation which controls modern reef morphology. Such studies have, however, served only to focus on further problems such as the nature and age of the substrate, the date of the onset of reef growth, and the rate of reef calcification and its relation to sea level. Solutions to such problems can be attained only by drilling. Though such special problems have been only recently defined, drilling has been going on in the Great Barrier Reef for more general scientific reasons. But in all cases the drills used were general-purpose drilling rigs not adapted for work on coral reefs. We have therefore designed and built a drilling rig specially for use on coral reefs. We define three factors as critical in a coral reef drilling rig, viz.: portability, versatility, and power. The major scientific problems on coral reefs are not restricted to sand cays, so the rig must be light enough to be easily transported and erected on any part of a reef system. Most of a coral reef is below water, so the rig must also operate as a submersible unit. Under-water drilling necessitates not only that the rig be portable, but that it also be easily assembled and disassembled by divers. Much of a reef is mantled by unconsolidated sandy sediment, undisturbed samples of which can only be obtained by vibro-coring rather than rotary drilling. The rig must be convertible from rock drill to vibro-corer. The power capability of a coral reef drilling rig is a compromise between weight and power. The power requirements in our case, were to drill to a maximum depth of 50 m and if necessary to operate in depths of water down to decompression depth i.e. 15-20 m.

Very early in the development of our drilling rig we spoke to and corresponded with Ian MacIntyre (Smithsonian Institute) and Eugene Shinn (US Geological Survey). The equipment developed and used on Atlantic reefs by those workers was viewed at Miami, and many of their ideas were incorporated into our own rig. A letter from Shinn brought to our attention the potential of a jackhammer as a power source for sediment sampling. Very early in our deliberations we were convinced that a drilling rig designed specifically for coral reefs shouldbe hydraulically powered. We believe that hydraulics are safer than electrics, and more efficient than pneumatics, especially under water. Four months of trouble-free drilling have justified our faith.

THE DRILLING SYSTEM

1. Drill Rig

The assembled drilling system is shown in Figure 1. The supporting frame is a tripod, each leg being 4 m long, of 50 mm O.D. x 5 mm wall-thickness aluminium scaffold tube. (The splints shown in Figure 1 were added after a leg buckled because too much stress was applied). The legs pivot from a top plate (Fig. 2A) which also provides an anchor point for the top pulley shown in Figure 1. The legs are pointed at their lower end, and are welded to a plate 200 mm in diameter (Fig. 2C) to enable the legs to sit on sediment without appreciable penetration. The legs are braced with aluminium scaffold tubing (Fig. 1) near the bottom (Fig. 2B), and the top. The bracing provides greater stability and the means of supporting the central saddle frame.
The vertical scaffolding tubes of the central saddle or sub-frame are 2.73 m long and act as runners for the drill head saddle (Fig. 3A). All scaffolding is fixed together by means of "Cyclone" brand swivelling scaffold clamps (Fig. 2B). The drill head and saddle, also constructed of aluminium, is

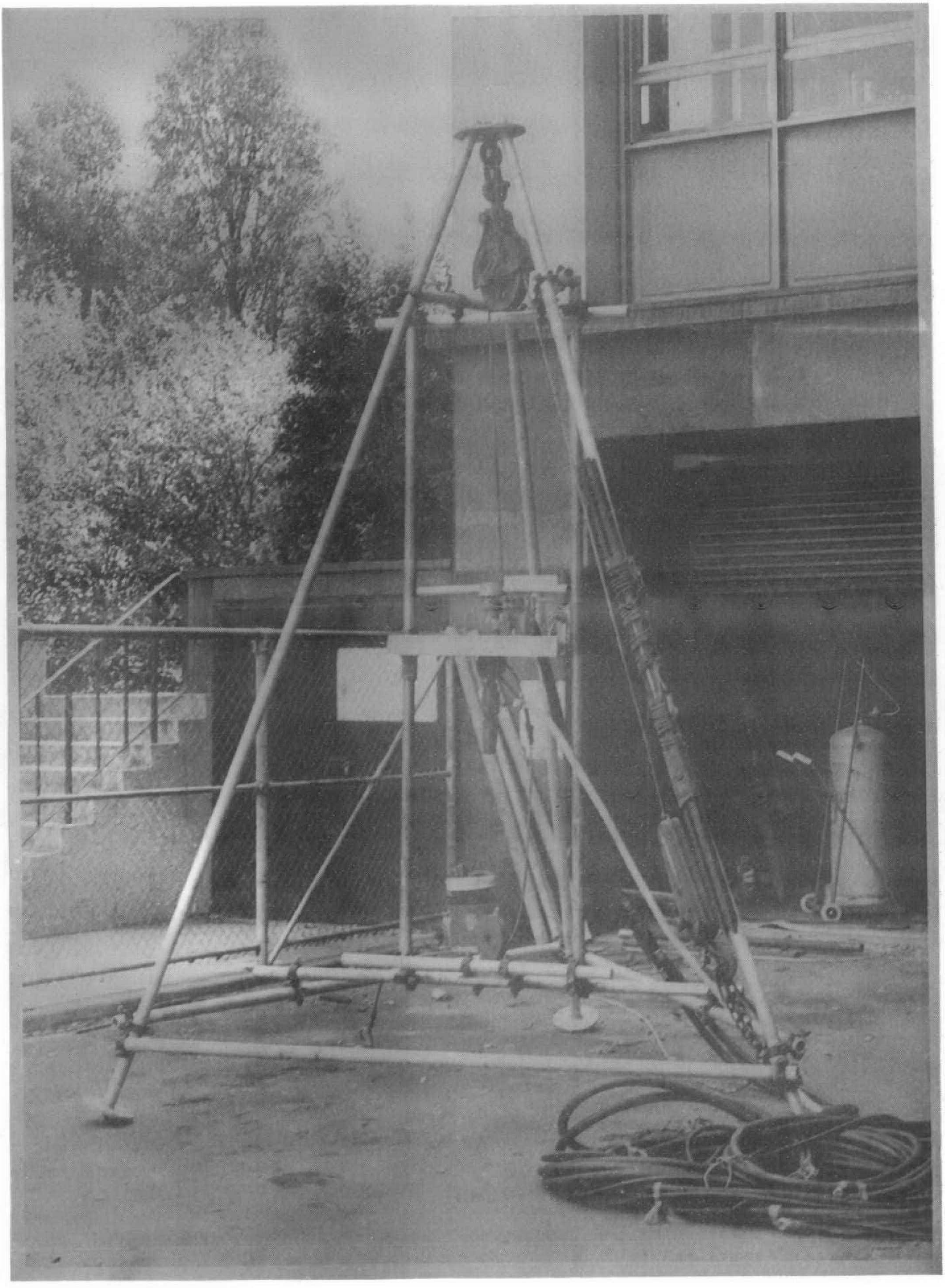


Fig. 1 The assembled tripod

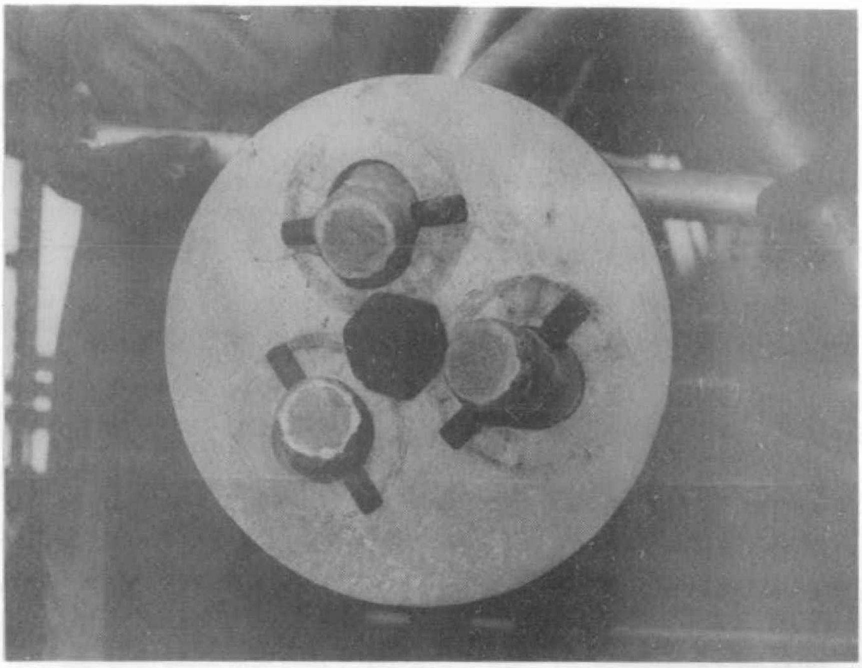


Fig. 2A

The top plate assembly

Fig. 2B

Bracing and clamping arrangements near the base of the legs

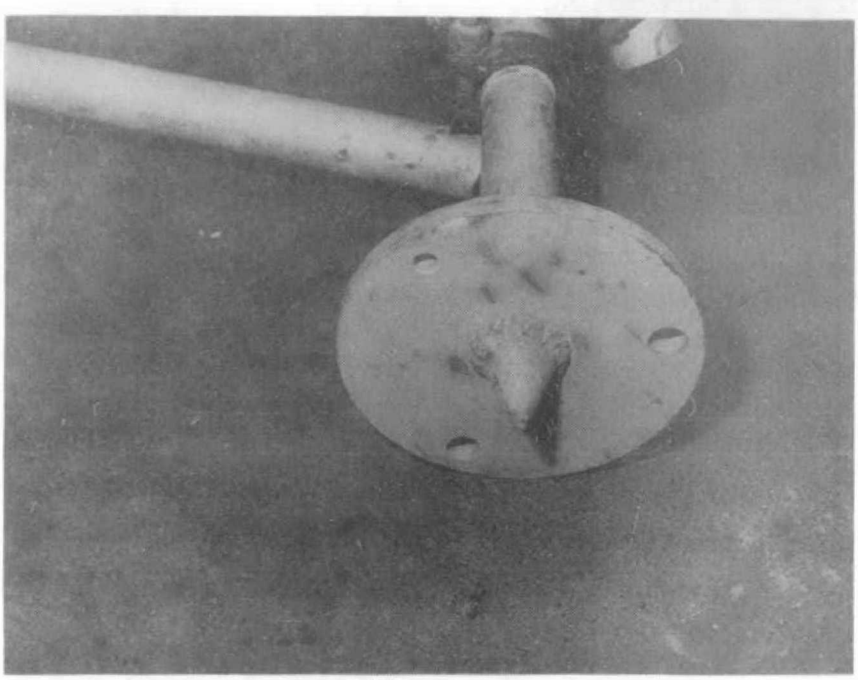


Fig. 2C

Foot-plate at the base of the legs. Holes in the foot-plates are for steel anchoring spikes

800 mm x 175 mm x 75 mm. A central hole in the saddle, 40 mm in diameter, takes the drive head of the drill. The saddle can be unlocked from one of the uprights by releasing a bolt, and swung out of the work area (Fig. 3A).

The lower horizontal members of the central sub-frame have a plate bolted to them (Fig. 3B) which is used for the attachment of the lower 6-inch pulley. This pulley provides a downward force on the drill head.

A 1.5 tonne "TIRFOR" brand mechanical winch (Fig. 4B) is used for lifting and lowering, and for applying the downward force during the drilling operation. The winch was attached to one leg of the tripod with strong chain; it worked well both above and below water when packed with carbon grease.

2. Drill Head (Figs. 4B, C)

The drill head weighs 15 kg, and is 335 mm long and 610 mm wide across the handles (Fig. 4B). It is hydraulically powered and has a minimum output of 8.2 kW at 6000 rpm, producing 75 Nm of torque. The speed of the drill head is infinitely variable from 0-600 rpm and is manually controlled. It is fitted with a sealed thrust assembly which prevents the axial loading on the drill head from being placed on bearings within the hydraulic motor. The three hoses entering the trigger box in Figure 4B are the supply, return, and trigger hoses. The supply and return hydraulic hoses are 20 mm diameter double steel braided hoses fitted with snap hydraulic connectors (Fig. 5A).

The drill head is fixed to the saddle with four 10 mm diameter "Unbrako" screws.

3. Drill Head Attachments

A water swivel is attached to the drill head with a 6 mm diameter bolt, secured with a nut and washer.

The T-piece in the water swivel connects to garden hose which is secured with jubilee clips. The lower end of the water swivel is a BQ pin for accepting a BQ box-end on the drilling rod (Fig. 5B).

The dismantled core barrel (Fig. 5C) is an NMLC triple-lined barrel with tungsten carbide bit and reamer. The core barrel provides a core 54 mm in diameter. Adapters, reamers, bits, and tools used for dismantling the barrel are shown in Figure 5D.

4. Vibro-head

The vibro-head is a hydraulically powered Fairmont brand 36 kg paving breaker (Fig. 5E). This is 700 mm long and 380 mm wide across the handles. The three hydraulic hoses are identical to those attached to the drill head. The paving breaker provides 1200 hits per minute, and drives one-metre sections of 75 mm diameter rigid PVC tubes into coarse sand in 15-20 seconds. The PVC tubes are connected to the paving breaker with the adapter shown in Figure 9B.

5. Power Unit (Fig. 6A, B & C)

This is a Treifus model PPV-25 Power Pack, consisting of a hydraulic pump (Fig. 6B, C) of variable displacement fitted with a pressure compensator to allow hydraulic flow control, thus effecting infinite speed variability from 0-600 rpm on the drill head. The hydraulic oil tank is fitted with a 45-litre water-cooled reservoir, fitted with bafflers, suction and returning line filters, and combined level and temperature gauge (Fig. 6C).

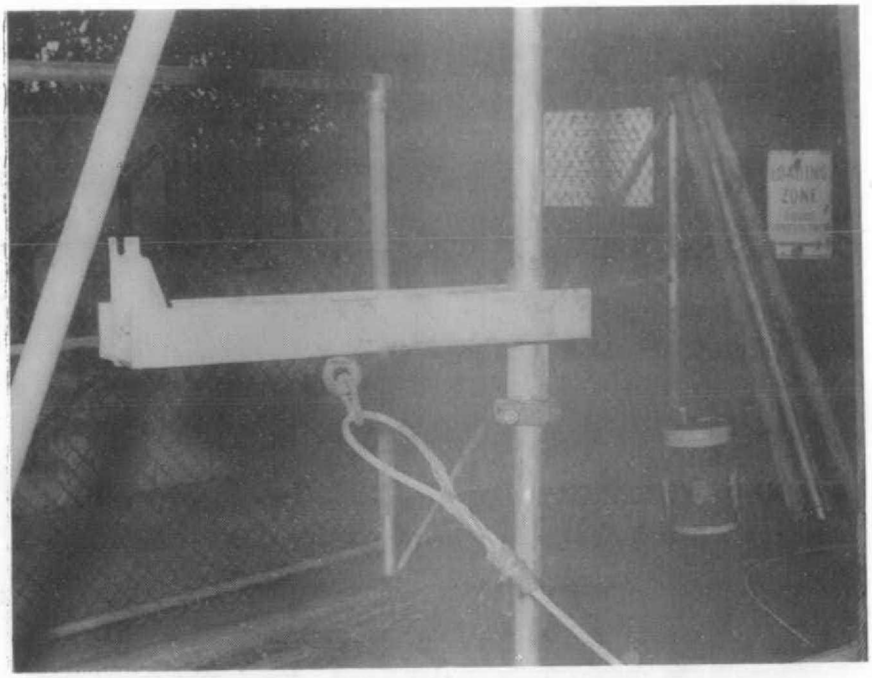


Fig. 3A Drill head saddle

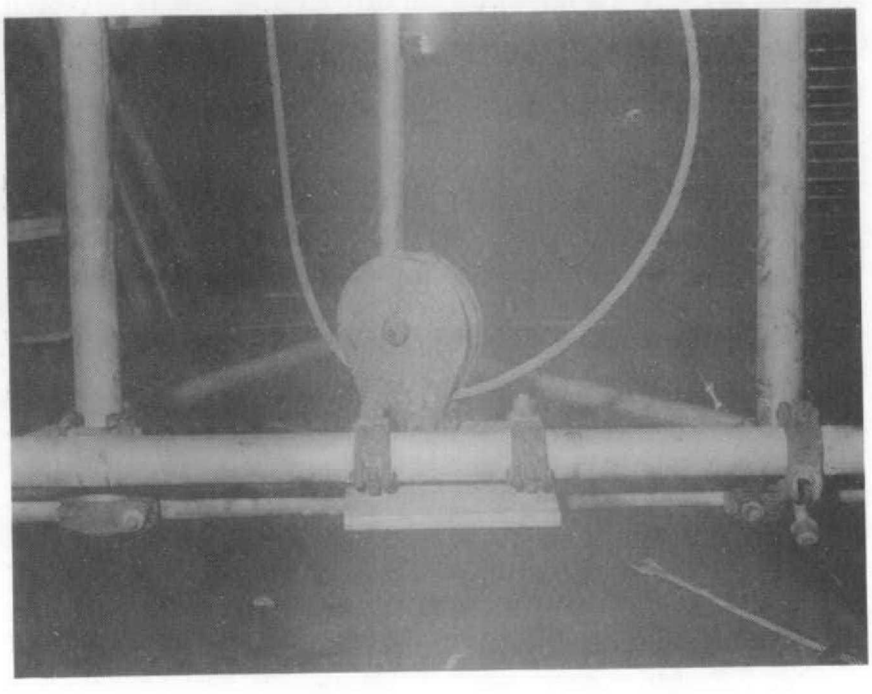


Fig. 3B Plate and pulley for exerting downward force

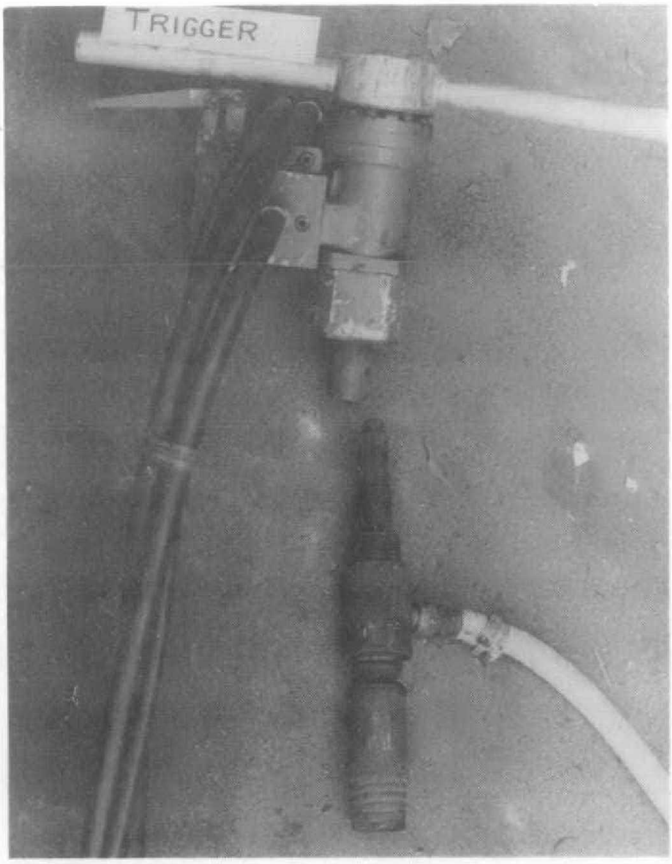


Fig. 4A

Drill head and hydraulic hoses, with the water swivel below

Fig. 4B

Tirfor winch for lifting and lowering drill head

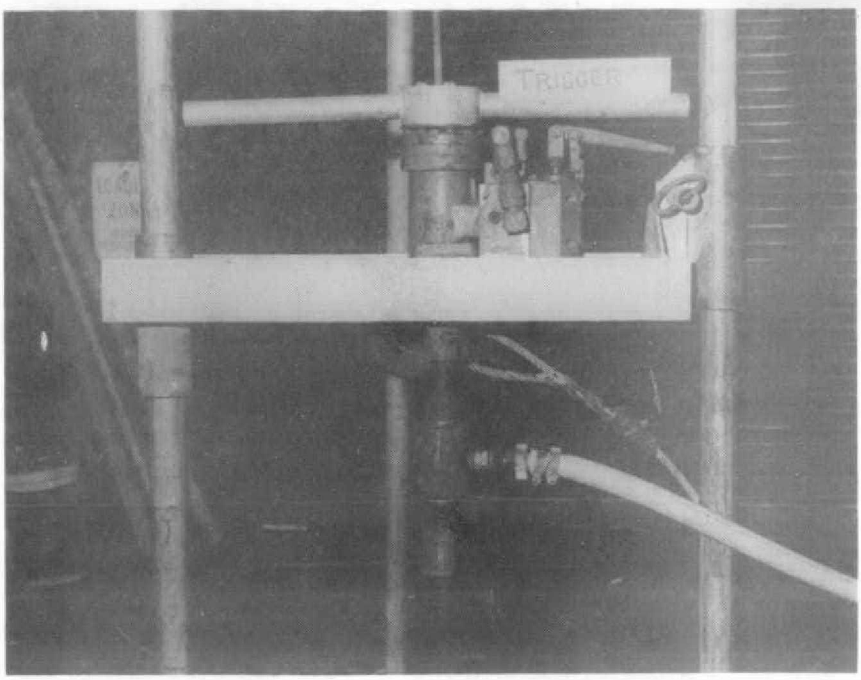


Fig. 4C

Drill head installed in the saddle of the tripod. The water hose is seen attached to the water swivel

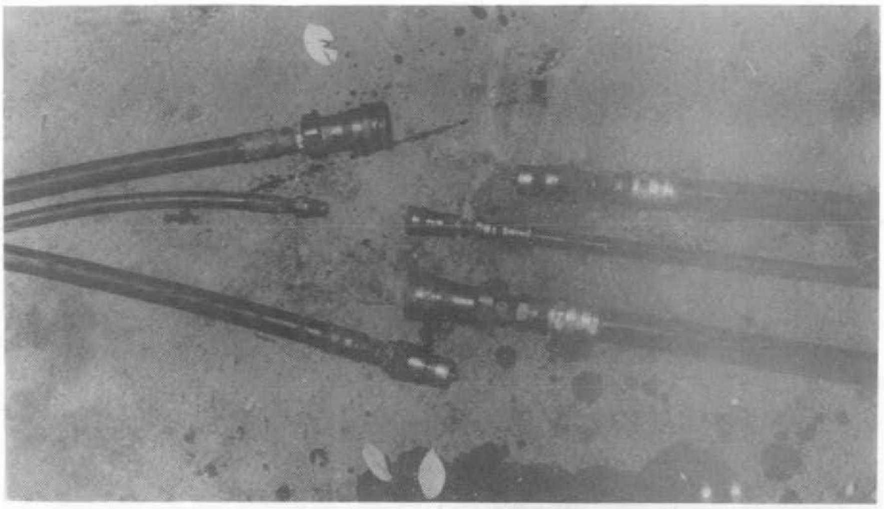


Fig. 5A

Snap connectors to hydraulic hoses

Fig. 5B

BQ drill rod - one section

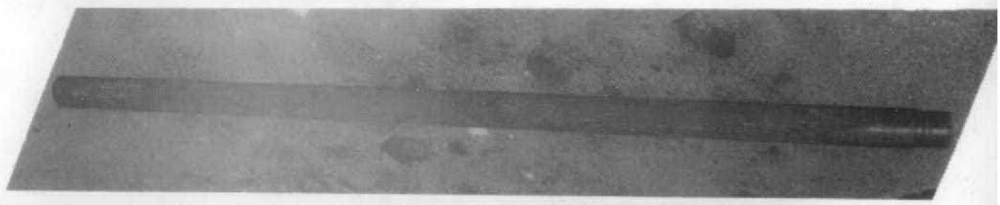
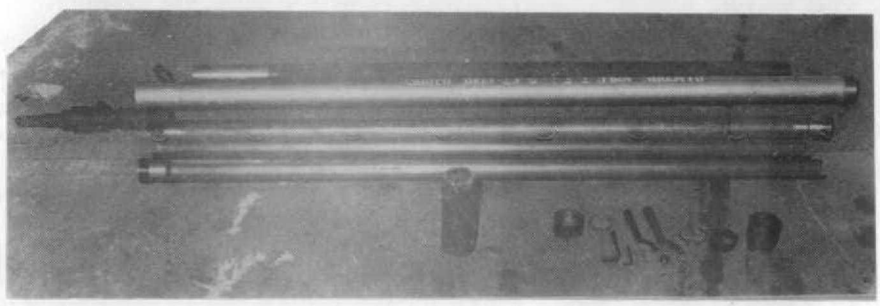


Fig. 5C

NMLC barrel dismantled into its component members



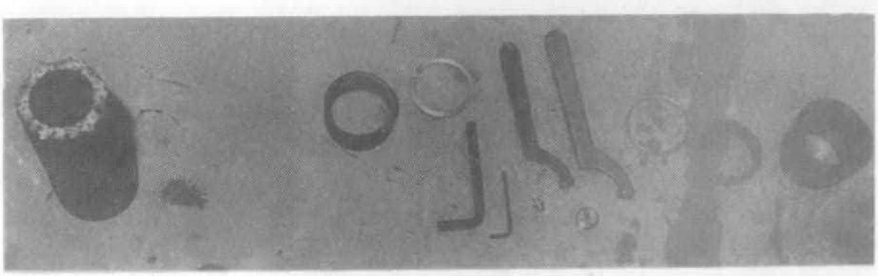
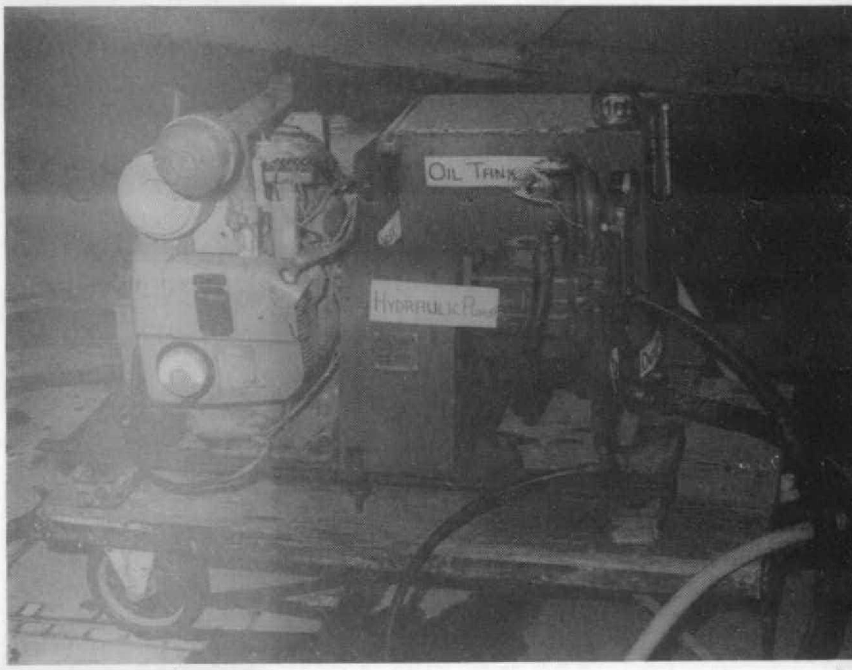


Fig. 5D

Tools and bits used with the NMLC barrel

Fig. 5E

Jackhammer and hoses



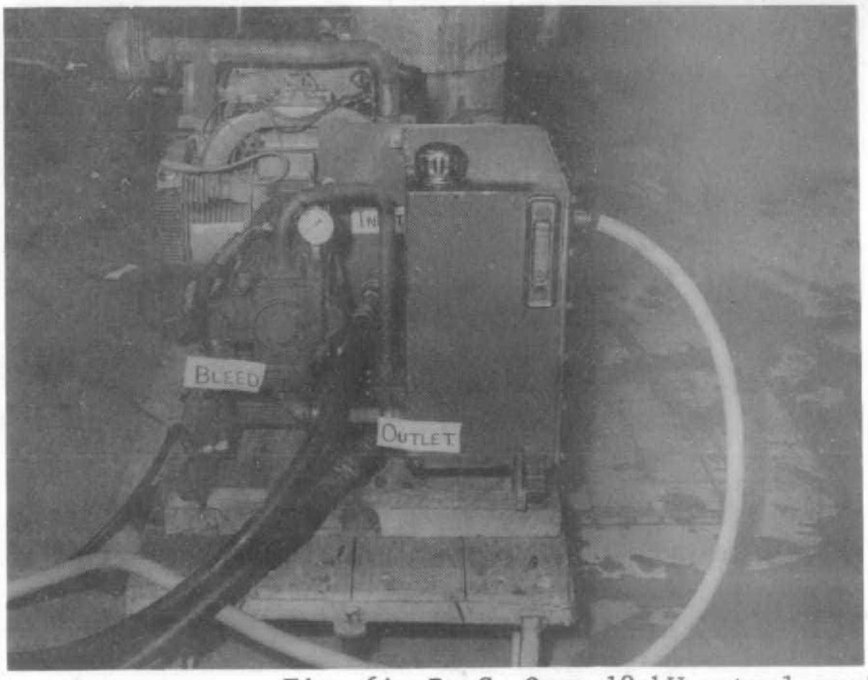


Fig. 6A, B, C Onan 19-kW petrol engine and hydraulic pump

The hydraulic unit is powered by a 19 KW Onan petrol engine with a 25-litre fuel tank. The Onan is electrically started and has a battery-charging alternator.

The water supply unit, used both for cooling the hydraulic unit and for lubricating the drill bit, consists of a Myers Du-all water pump of 45 litre/minute capacity, driven by a Briggs & Stratton petrol engine with a 9 litre petrol tank (Fig. 7A, B C). It is fitted with a pressure relief valve which allows variations of water delivery pressure to the drill, and is connected to the water swivel on the drill head, with 20 mm diameter nylon pressure hose.

FIELD OPERATIONS

During the 1978 field season, drilling was mostly on windward and leeward reef flats during low tide (Fig. 8A & B). The hydraulic motors and water pump unit were housed on a 6 m aluminium dinghy (De Havilland Hercules) The assembled tripod was usually laid across the dinghy (Fig. 9A), driven to a pre-surveyed site on the falling tide, and tipped off into its approximate drilling position. On hard rocky surfaces, the tripod was anchored with a spike driven through a hole in the foot of each leg. In sandy areas, more than one spike was driven through each foot. Rigging the winch and assembling the barrels usually took half an hour. When setting up at a new site, the saddle sub-frame was adjusted with a spirit level, to ensure that the aluminium pipes were vertical, this allowing the saddle to move freely. At the end of a day's drilling, the drill rig was left in position, the hydraulic hoses having been disconnected and covered with plastic hoods to prevent corrosion. The rig survived several severe storms on unsheltered windward margins with little harm.

During sediment coring operations, the saddle sub-frame is removed, -only the tripod section being used. The winch is slung from the upper sheave and the jackhammer hangs vertically from the winch wire. The jackhammer operates from the same power source as the rotary drill. An adapter for the jackhammer (Fig. 9B) connects with 75 mm I.D. plastic tube which could be connected in 1-metre lengths by steel collars. Coring operations, therefore, involved vibro-coring for 1 metre, disconnecting the jackhammer, connecting another 1-metre length, and further vibro-coring. A 5-m core, partly withdrawn, is shown in Figure 9B. No difficulties were experienced in driving the plastic coring tubes to 5 m; penetration rates of 1 m in 20 secs were normal. Practical drilling depth was determined more by the capacity of the winch to withdraw the coring tubes than by the penetrating capacity of the drill.

COSTS

Total costs of the components of the drilling and vibro-core units are approximately $7000 at 1978 prices. The major item is the hydraulic pump, oil reservoir and cooling unit, costing nearly $3000 at 1978 prices.

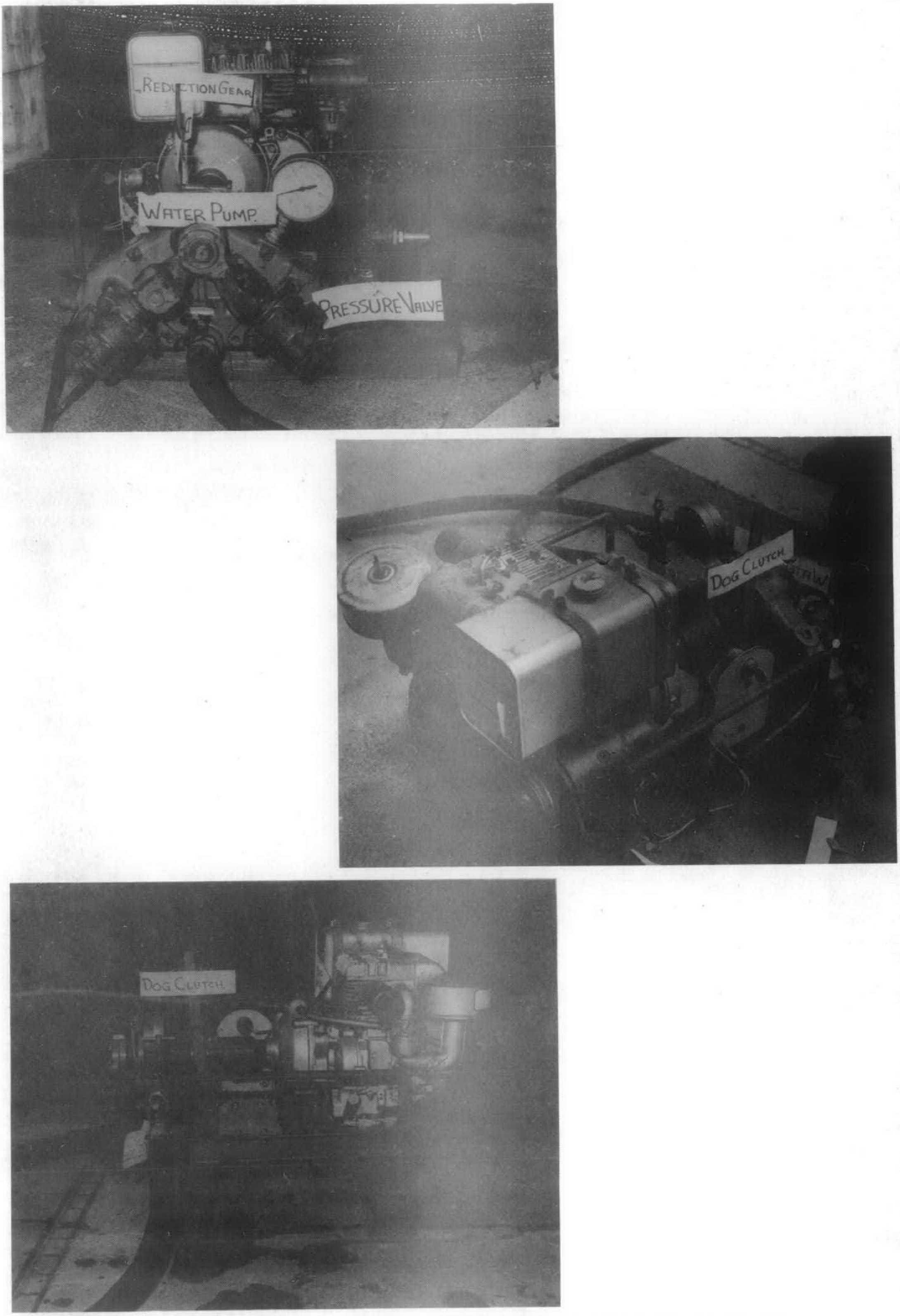
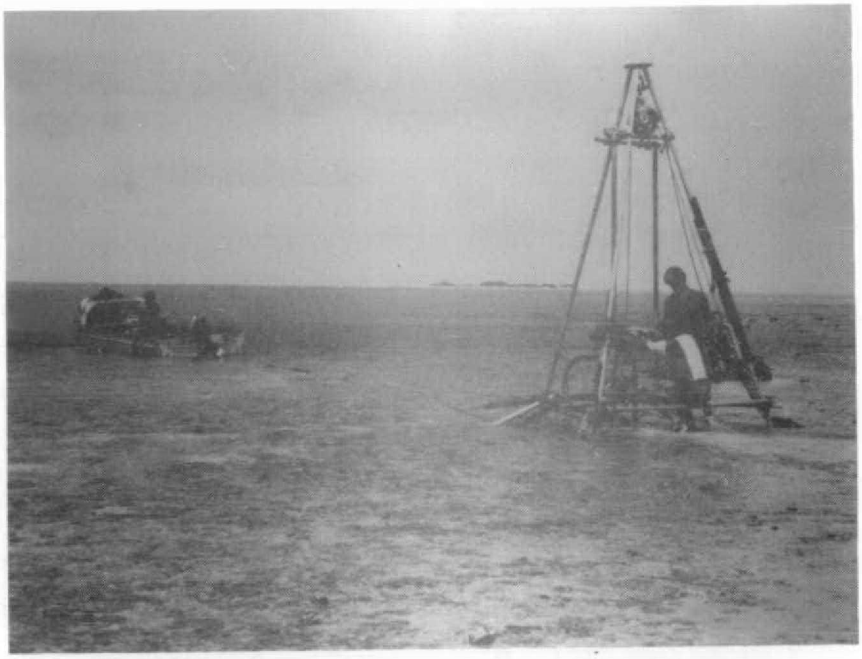


Fig. 7A, B, C Briggs & Stratton 6-kW petrol engine and water pump



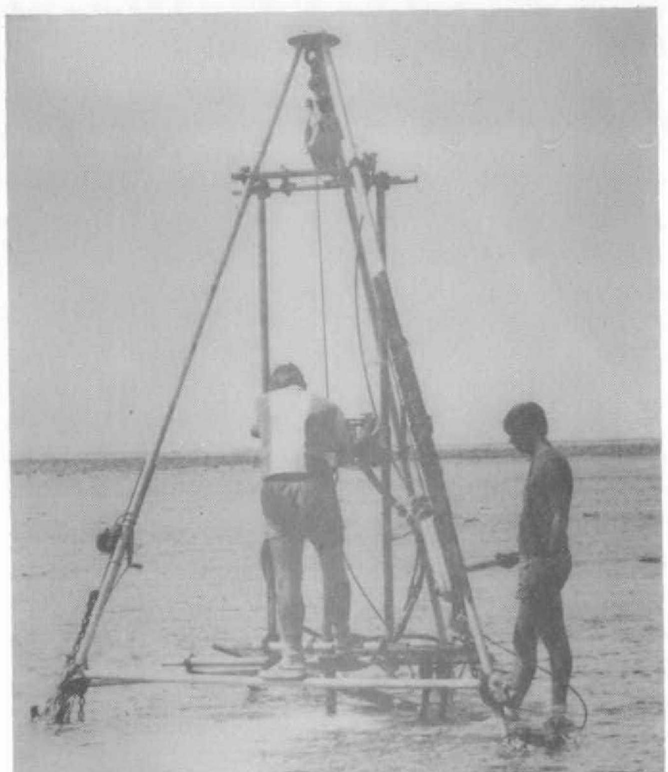


Fig. 8A, B Drilling on the leeward reef flat at One Tree Reef

Fig. 9A Hercules dinghy loaded with equipment ready to move to another drill site

Fig. 9B Coring operations on the prograding sand sheet at One Tree. The core is 5 m long. The adapter connecting coring tubes to jackhammer is on top of the PVC tubes