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Conversion of shallow water gravity coring equipment for deep water operation

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Abstract

Lacustrine sediment sampling equipment, such as lightweight gravity corers, are limited in operation to relatively shallow water environments (less than 50 m). This is because the ability to control such equipment becomes difficult with increasing water depth. In addition, adverse weather conditions, wind and waves etc. can further limit the success of such operations. The deep water equipment is designed to attach to gravity corers of the Kajak-Brinkhurst type, and extend the operating depth by eliminating the need for direct control from the surface. The equipment stabilizes the corer on entry into the sediment and automatically closes the top of the core tube after driving is completed. No changes are required to be made to the corer whose mechanical operation remains the same.

Introduction

The use of simple gravity-operated sampling devices is well established for recovery of lacustrine sediment. In such operations, the weight of the coring device is used to drive an open-ended core tube into the sediment. To secure the sample for recovery, the top of the core tube is closed after driving to prevent loss of material as the tube is raised from the bottom. This technique is referred to as 'open drive sampling' (Hvorslev, 1949). Such a technique has limitations, particularly when equipment is operated in wind and wave conditions and in deep water (e.g. depths over 50 m). Most of these limitations relate to the operator's inability to detect the sediment surface under these conditions. For coring devices that close by means of a messenger released from the surface, sensing the point at which the device has entered the sediment is particularly critical.

The equipment described in this note was designed to extend the operating depth of existing messenger-operated gravity coring devices (KB type corers, Kajak, 1965; Brinkhurst, 1969), permitting them to operate in conditions that would likely prevent the successful recovery of cores by conventional means. Specifically, the deep water equipment described here enables the corer to perform automatically without direct control from the surface. Because the coring devices with which this equipment was designed to operate have been widely adopted and are presently being used for a number of ongoing projects, careful consideration was given to the initial design in order that the sampling operation and dynamics would remain identical to the existing unmodified equipment. For this reason, all elements of the equipment were designed as 'bolt-on' items.

Description and operation

The equipment consists of two main parts. (1) A support frame that ensures stability on reaching the sediment surface. This frame is fastened to the corer and helps maintain the device in a vertical position. In addition, the frame prevents the device from sinking too deeply into the soft sediment surface. (2) A messenger release mechanism (MRM). This component senses the arrested descent of the device at the sediment surface and releases the messenger to close the corer. The release mechanism is attached to the line 10 m above the corer. Figure 1 shows the general arrange-

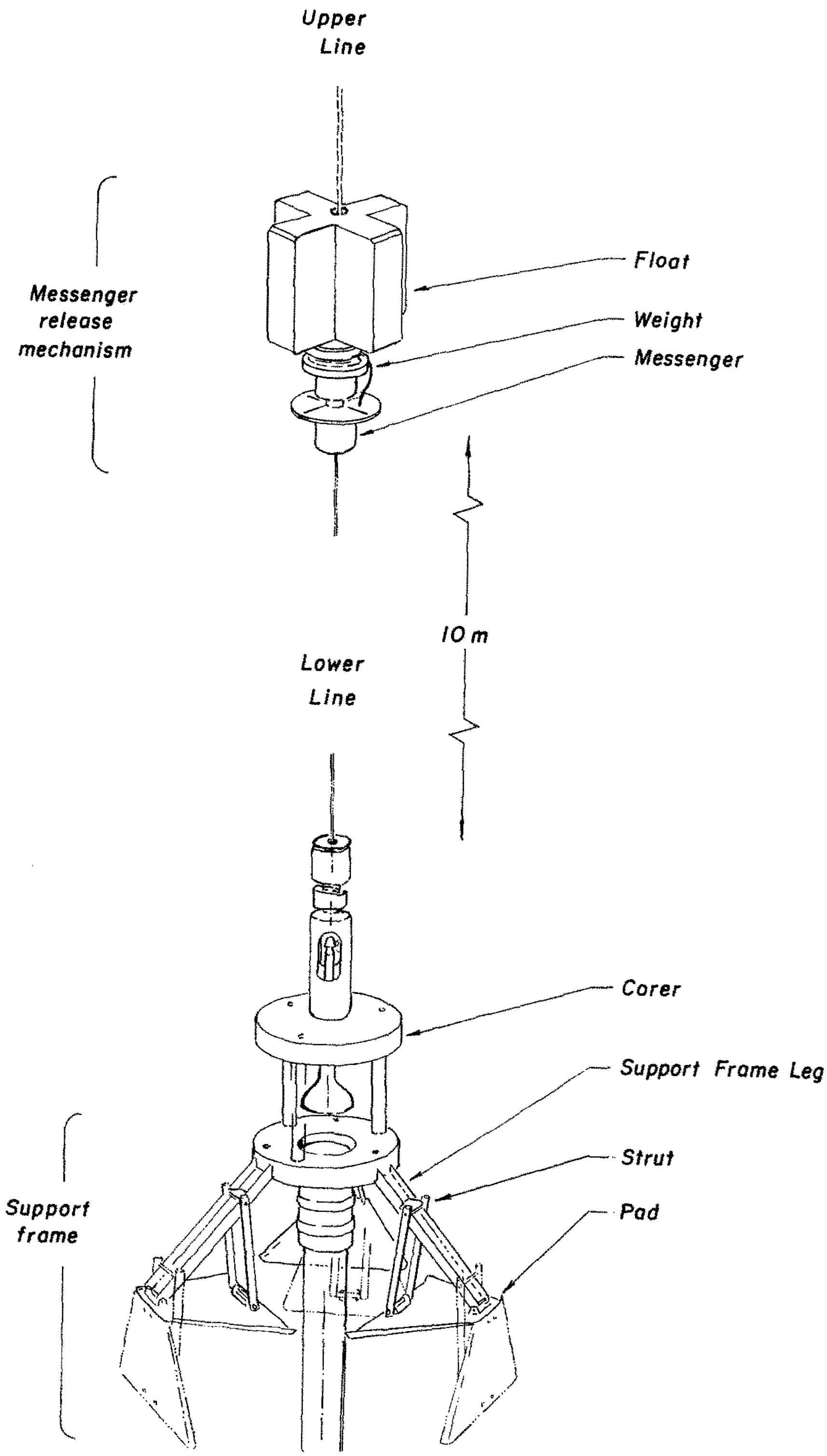

Fig. 1. General arrangement of the corer, support frame and messenger release mechanism (MRM). The overall diameter of the corer with the attached frame is 74 cm, the MRM is located 10 m above the top of the corer. The support frame is fabricated from aluminum alloy and the MRM float is made from wood, the lower 10 m line is of 6 mm braided nylon.

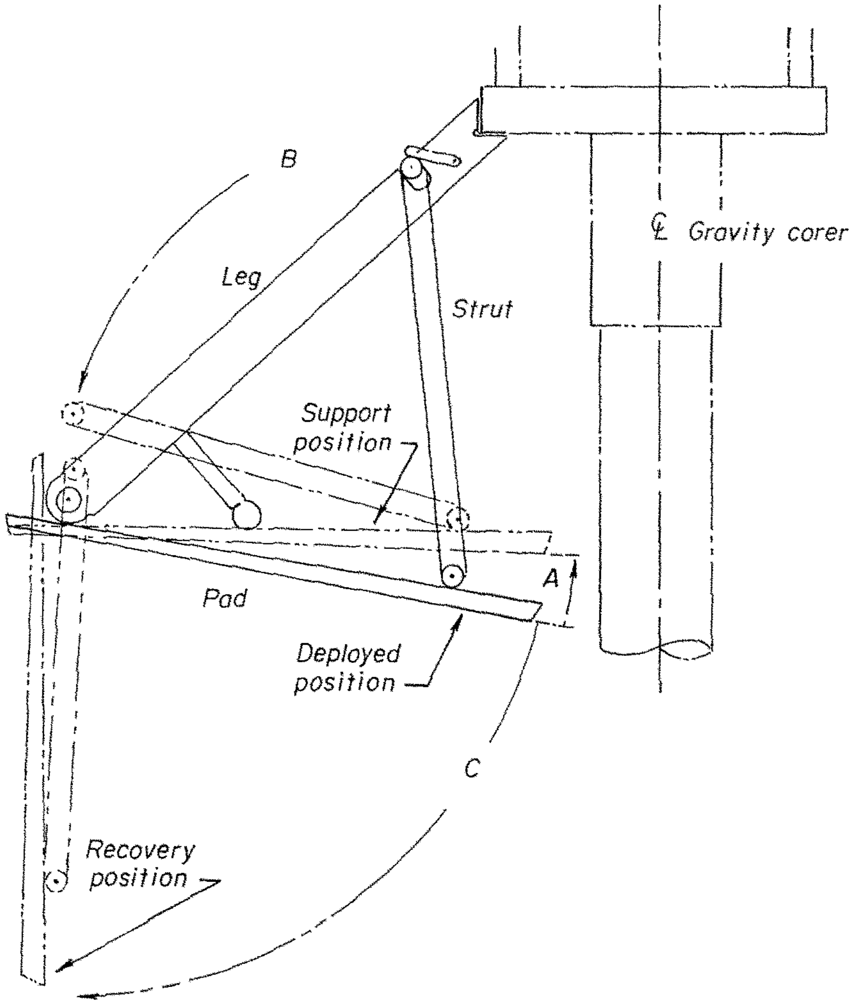

Fig. 2. Detail of support frame layout showing arrangement of the main elements, the pad is shown in the deployed position located by the strut. On contacting the sediment, the pad is displaced upwards (A), this action detaches the upper end of the strut from the leg (B). On recovery, the pad and strut assembly are free to rotate about the outer end of the leg (C) to reduce the drag in the water.

ment of the typical coring device with the attached equipment.

Support frame

The support frame consists of three separate but identical leg assemblies that are fastened to the corer. Each supporting leg has an articulated plate that is held in position by a strut that is unlatched once on the sediment surface (Fig. 2). The articulated plates are designed to rotate about the outer leg attachment once the corer is pulled up from the sediment surface; this enables the device to be extracted easily from soft sediment and reduce the drag in the water column when being recovered. Each of the three leg assemblies is attached to the corer at a single point in a radial configuration.

Messenger release mechanism (MRM)

The MRM assembly consists of a messenger, a restrained float and a release weight (Fig. 3). A 10 m line connects the MRM to the corer, and an upper recovery line of any selected length can be secured to the MRM. The weight and float assembly are so arranged that a constant pressure is applied between them by the weight of the suspended coring device; this pressure is used to restrain the messenger at the upper end of the 10 m line (Figs 3a, 4a). Once the corer has reached the sediment surface, the tension on

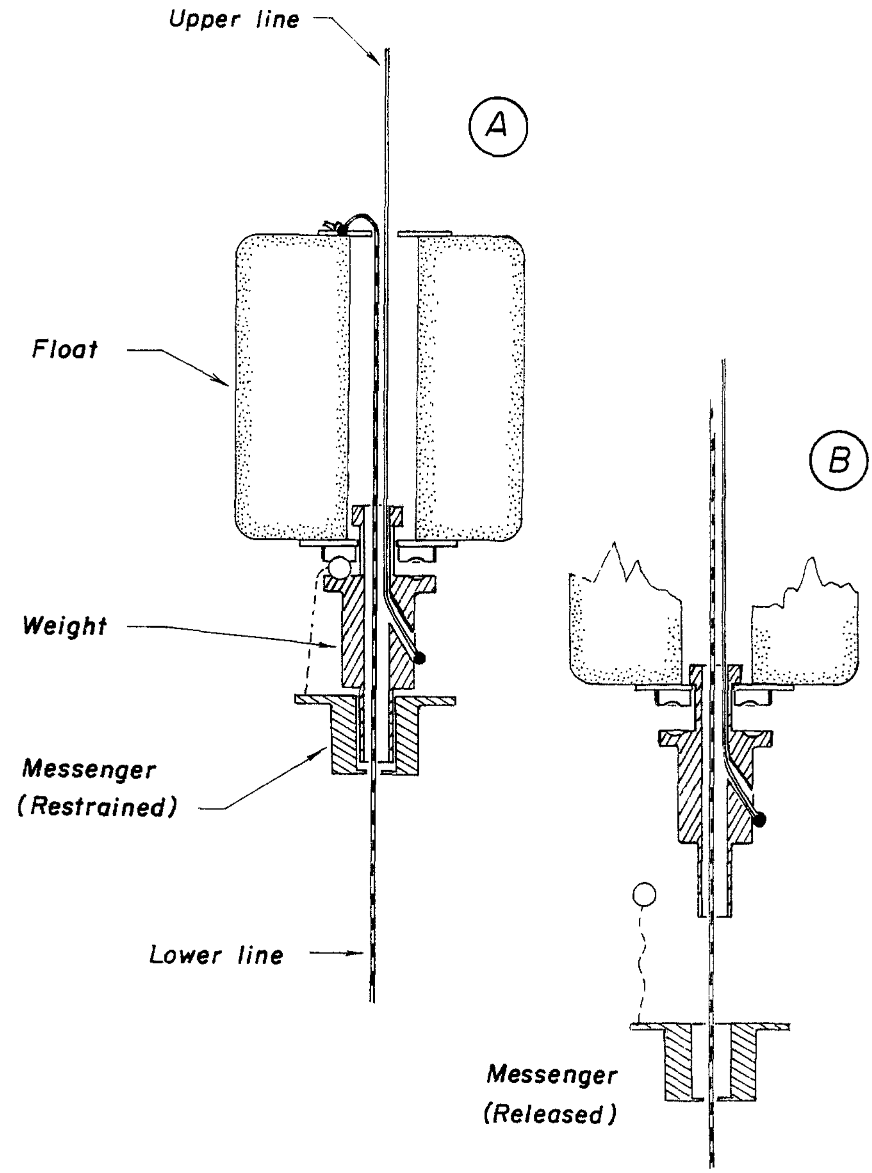

Fig. 3. Sectional view of the messenger release mechanism (MRM) in the lowering position (A) and released (B). Note the upper line passes freely through the float and is attached to the weight. The lower cable is attached to the float. Pressure is maintained between float and weight by the suspended corer (A). Pressure is reduced once the corer is on the sediment surface and the messenger is released (B).

the recovery line to the surface is reduced and pressure between the float and weight in the MRM is removed. At this point the float of the MRM acts to keep the line between it and the corer under tension. This action removes the restraint from the messenger that is then free to descend the tensioned lower line and trigger the corer below (Figs 3b, 4b, 4c).

Discussion

The operation of the corer using the deep water equipment described is identical in most respects to an unmodified gravity coring device operated in a water depth of 10 m and triggered by messenger from the surface. In deep water and in rough wave environments, the modified equipment requires only a steady lowering through the water column. It has been found that a recovery line of braided polypropylene construction

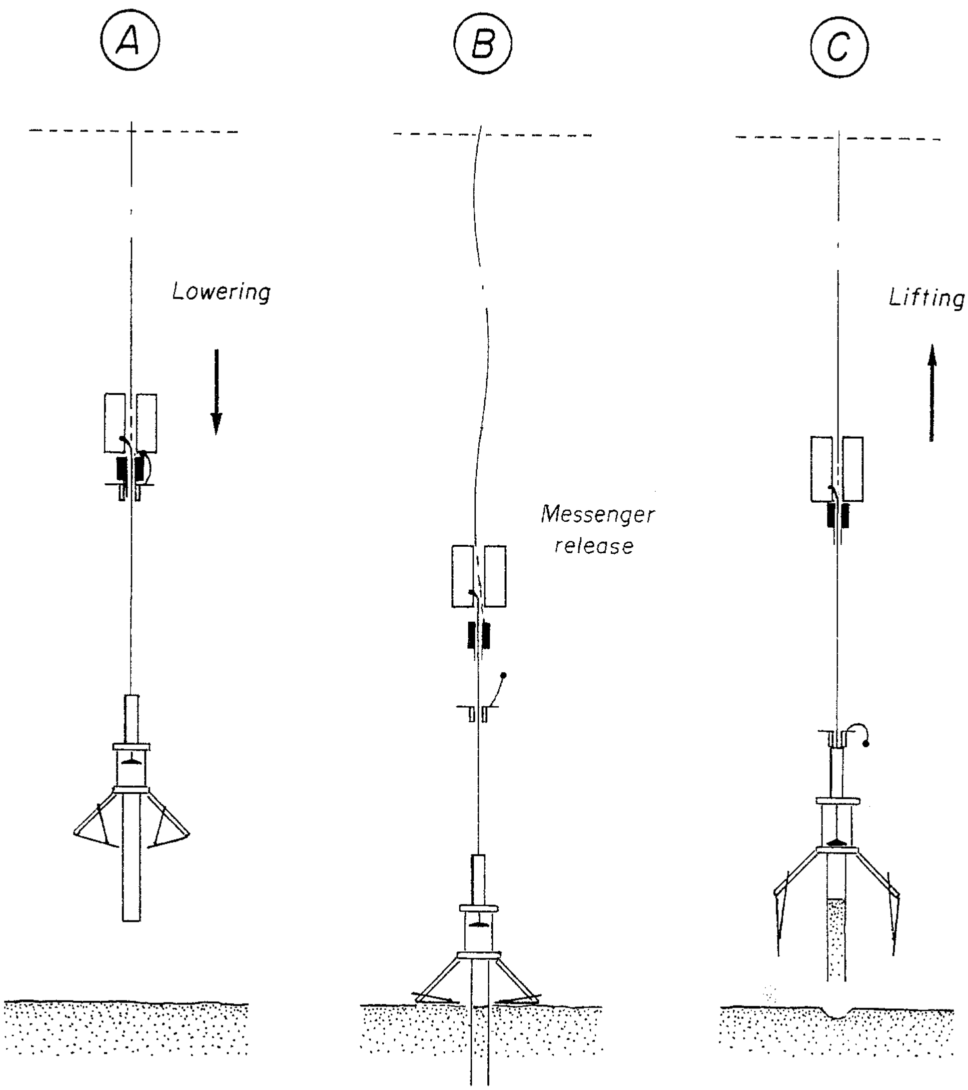

Fig. 4. General sequence of operations for the MRM and the support frame; A. lowering configuration, B. Messenger release position, C. lifting from the sediment.

is advantageous under these conditions because this material is buoyant and will therefore not sink around the MRM or the corer once it has reached the bottom. Such a condition could possibly prevent normal operation and recovery. In addition, experience in shallow water marine work (in water depths less than 150 m) has shown that the accumulation of slack line at the water surface provides an excellent indication that the equipment is on the bottom and ready to be recovered.

Advantages using this equipment over more conventional automatic close-on-contact corers (Kajak, *et al.*, 1966; Brinkhurst *et al.*, 1969) or flow-through types (Frithsen *et al.*, 1983) are considered important. Because surface sediment with characteristically high water content can be easily disturbed and dispersed before entering the core tube (Blomqvist, 1985; 1991), the gravity corer must enter the sediment at low velocity. Under such conditions the corer is arrested by the sediment at a slowly decreasing rate due to increasing resistance of the sediment impinging on the advancing core tube (Piggot, 1941; Hvorslev, 1949). This type of action makes the point at which a close-on-contact or flow-through device is triggered most problematic. In the case of the equipment described (using an MRM), the slow deceleration of the corer is isolated from the release mechanism that is situated remotely in the line. The descent time of the messenger (in the order of 12 seconds for a 10 m line) provides an adequate delay for the corer to sink to its full depth before being triggered closed. Secondly, the action of the buoyant MRM ensures a high degree of vertical stability as the corer enters the sediment (the most critical phase of the sampling drive) (Cumming *et al.*, 1993). The MRM also serves to uncouple motion that may be present on the upper line propagated by wave motion from the surface. A snubbing link (an elastic element designed to remove sudden and uneven loading on the line) may be attached to the top of the MRM to further reduce such motion. In trials using the equipment at depths of 94 m, core lengths corresponded exactly with the position of the support frame indicating that the corer had been driven to full depth before being triggered. Also the corer remained on the bottom for periods up to 30 sec after the core was taken. Long residence times on the bottom may be expected when sampling in deepwater as significant lag times may result between the core being driven and the operator's perception of the corer being on the bottom.

Conclusions

Gravity coring equipment using the deep water modification described here offers to extend significantly the operating depth of messenger-operated coring devices that are already in use. In addition, the furnishing of a support frame and a buoyant element in the recovery line (the messenger release mechanism) helps to ensure the reliability of the corer in remotely sampling the surficial sediments of high water content. Disadvantages with the equipment relate to the increased physical size of the corer when assembled with its support frame, and the additional rigging of the MRM in the line. These are important considerations when operating from small boats or when deploying the equipment through ice cover. The operation and dynamics of the equipment has not been directly observed underwater and therefore the hydrodynamic conditions that exist on lowering and raising have not been fully examined. Premature triggering and/or unlaching of the support plates while lowering are only considered likely in severe wave environments where large, short period upward forces exist. However such disadvantages may be considered less significant in view of the overall extension of range of the basic device.

Acknowledgments

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