A device for finer-scale sub-sectioning of aqueous sediments*

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A modified hand-operated mechanical device has been developed to facilitate precise sectioning of the aqueous sediment in a core liner. The device allows the core liner to remain vertical on the disk protecting physical, chemical and mechanical properties of the sediment. The disk rotations are initially calibrated for moving unit distance on the threaded rod and later used proportionately for desired increment of the sediment. The sediment is exposed on the top of the liner when the disk and liner are lowered. A collapsible scale provided with the coupler on the top of the liner helps verify the required thickness of the sediment to be sectioned. Disk rotation does not cause compaction of sub-core sediment, and sub-samples are not mixed or contaminated. The apparatus is low-cost (< Rs 2000), portable, user-friendly, lightweight (about 9 kg) and occupies small floor area (0.25 sq. m). The apparatus is made up of non-magnetic and anti-rusting material for wide-scale application. It can be taken to the field or on a small boat or a research vessel, and quickly assembled and or dissembled. It is especially useful in a team with limited manpower. The core liners can be cleaned, washed and reused number of times, thus saving expenditure and making it environmental friendly.

Oceanographers use different coring devices (grab, corer, etc.) to obtain undisturbed deep-sea sediment samples. Whichever type of sampler is used, the corer allows a vertical section of unconsolidated bottom sediments to be brought to the surface to conduct various analysis and tests. The cored sediment requires immediate sub-sampling at certain intervals, for a wide range of applications. By and large, geologists prefer sediment sections of 0.25, 1, 2, 5 and 10 cm intervals, whereas biologists prefer them at 0.5, 2, 3, and 5 cm intervals. Different methods are in use for sub-sampling the cored sediments obtained by piston or gravity core, and spade or box core.

The length of a normal piston or gravity core liner is quite large and according to the requirement it varies from 5 to 15 m. Once on-board, the long PVC (or acrylic) core liners are removed from the core barrel and cut into pieces (0.5 to 1 m) for handling and preservation purpose. The method of sectioning the sediments from the piston or gravity core is relatively different than that of the box core. The long core liner removed from the piston or gravity corer is first mounted horizontally on a supporting platform and cut along the length using a cutting machine with a diamond wheel. Then, the top PVC cover is removed and the sediment is exposed. After that, the sediment surface is marked with sharp edge (usually by knife) at required intervals and sections are removed. This method has many drawbacks; the fine PVC/acrylic particles of the liner contaminate the sediment surface due to spread-over; the sections cut are of approximate thickness; the physical and mechanical properties of the sediment may vary due to change in liner position from vertical to horizontal, etc. Earlier piano wire, spatula, knife or razor blades were used to cut the soft core. Later, hand-operated saw[1], electro-osmotic knife[2], and two high-speed steel blades[3] were used to cut the piston or gravity core liners.

The box or spade core takes relatively short (< 60 cm) essentially undisturbed samples of the seafloor[4]. Once on the deck, the sub-cores are obtained by inserting the core liners in the sediment (Figure 1). Sub-sampling of the sub-cores is done using one of the following techniques. In the push-core method, sub-samples of required interval are obtained basically by pushing a piston from the bottom of the liner. This is a fast but crude method of sub-sampling and has many drawbacks; (i) the core liner is held in one hand and pusher or piston in the other; (ii) the core liner remains in a tilted position while pushing out the sediment; (iii) the sedi-

Figure 1. Photograph showing sub-cores of different diameters (2.5 and 5.7 cm) inserted in the sample box of box corer on-board *A. A. Sidorenko* (AAS-46).

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Table 1. Comparison of major parameters between the proposed model and that of Glew[6]

Parameter	Proposed model	Glew's model[6]
Total height (cm)	50	> 75
Total weight (kg)	< 9	Not stated, but should be ~ 15 kg due to ram, support frame and adjusting blocks
View	Sleek and slender	Bulky, due to tetrahedral frame, parallel guides, travelling blocks and extruding ram, and upper and lower adjusting blocks
Technique used for extrusion of sediment	By lowering the liner with gravity	By pushing the sediment against gravity
Minimum increment	Tested satisfactory for extrusion of sediment @ 0.25 cm increment	Minimum increment possible is not given. Incremental motion of the ram is set by fixed stops
Provision of scale and slicer/cutter	Collapsible scale and cutter is provided with the coupler. Calibrated values can also be used	Scale is fixed on the support frame. Sectioning box is external
Assembling time	~ 5 min	Not specified
Cost	~ Rs 2000	~ 80 US$ (1988)

ment inside the liner is disturbed and experiences compaction due to inclination; (iv) the sections obtained are of approximate thickness, and (v) the sections are mixed when collected in the bag, etc. To overcome the above drawbacks, a piston extruder was developed[5] using a stationary vertical piston over which a core tube is placed for removing the sediment from it. However, it was pointed[6] that the control of accurate extrusion is difficult for small increments using these arrangements, as the extrusion device[5] consists of a variety of fixtures. The device developed by Glew[6] claims to providing extrusion of sediment from the core tube up to 50 cm in precise increment of any size, and the incremental motion of the ram is set by fixed stops against an adjustable scale. This method involves a lot of movement of the parts, and locking and unlocking of the upper and lower block along with ram to obtain incremental extrusion. It further implies that sectioning is possible only at fixed stops and probably indicates limitations of the device. Comparison of few major parameters of the device by Glew[6] and the present one is given in Table 1.

The device described here provides precise and accurate extrusion of sediment from core tube of 50 cm length, for increment of any size. The main purpose of the proposed apparatus is to facilitate controlled sub-sampling of the aqueous sediments from the core liners of different diameters at desired intervals. Using the apparatus, the aqueous sediments can be sectioned up to millimetres level with precision and accuracy. Another intention is to avoid contamination and mixing of sections during sub-sampling, without disturbing the physical and mechanical properties of the sediment. The apparatus is small, portable, lightweight, user-friendly and low-cost, which can be used to obtain clean, non-contaminated, and high quality sediment sections from the surface to the entire length, without cutting the core liner.

Materials and methods

An overall view of the apparatus and control system of the assembly is shown in Figure 2. Further details are given in Figures 3 and 4. It consists of a basal aluminum plate [3] with a threaded hole in the centre to hold a threaded steel rod [1] having uniform and equally spaced threads with normal (11) tpi. This rod is bolted [2] at the bottom of the basal plate to set it upright. A disk [8] made up of steel (or PVC or acrylic) material with a threaded hole [9] is inserted from the top of the rod [1]. The disk can be rotated on the rod [1], up and down by holding the projections [11]. The disk has a steel cup [10] to position and hold the core liner vertically. A grooved stopper or a rubber cap [7] along with the core liner [12] containing sediment is placed vertically on a projection [5] of the steel rod [1]. The rubber cap [7] prevents the sediment [13] falling down from the core liner [12] (Figure 3). A PVC coupler [14] is fixed on the top of the core liner using the screw [15]. The coupler (Figure 4) has a rotatable steel slicer [18] to section the sediment [13] raised above the core liner [12], and a collapsible steel scale [16] to verify the thickness of the sediment raised above the core liner.

Calibration

Calibration is done prior to the operation, and the number of rotations required to lower the disk 1 cm vertically on the rod is calculated. This is accomplished by measuring the total length of the threaded rod (L) in centimetres and by counting the number of rotations of the disk (R) required to cover the same length (L) of the rod. Then, following formula can be used to calculate the calibration.

No. of rotations required for displacement of 1 cm sediment = R/L.

The calibrated value is a number which is applicable as long as the instrument is in use. The calibrated value is used in proportion for obtaining the required increment of sediment thickness.

Operation

The device is operated mechanically in order to have full control over precise sub-sampling of the sediment from the box/spade corer. Before removing the sub-core from the box spade corer's sample box, a rubber cap [7] is inserted at the bottom of the liner. The sub-core is then carried vertically to the apparatus and mounted on it with a rubber cap [7] fitting firmly on the projection [5] provided on the steel rod [1]. The sediment in the sub-core is protected from slipping down

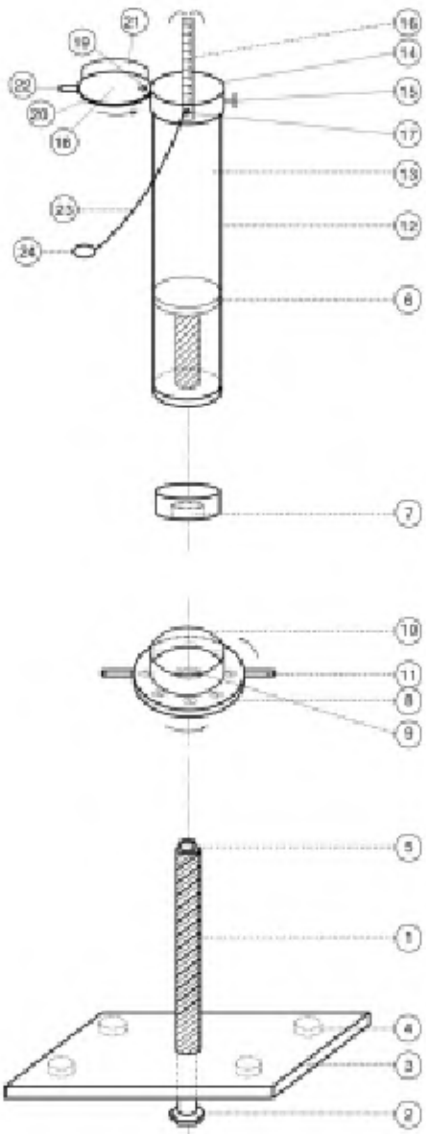

Figure 2. The sediment sub-sampler. 1, Threaded stainless steel rod; 2, Bolt; 3, Aluminum basal plate; 4, Rubber cushions; 5, Small projection for resting the cap; 6, Rubber cap or stopper; 7, Rubber cap with a hole at lower end; 8, Threaded steel disk; 9, Threaded hole of the disk; 10, Steel projection on steel disk to hold the core liner; 11, Screw holder to hold and rotate the steel disk on the threaded rod; 12, Acrylic core liner; 13, Sediment in the liner; 14, Coupler or gripper; 15, Screw for fixing coupler; 16, Collapsible steel scale; 17, Screw for fixing scale; 18, Steel slicer, cutter or sectioner; 19, Screw for fixing slicer or cutter; 20, Sharp edge of the slicer or cutter; 21, Projection on slicer or cutter to prevent the sectioned sediment from falling; 22, Screw for rotating slicer or cutter; 23, Steel wire or thread to cut the sample; 24, Steel ring to hold the steel wire.

as there is no gap between rubber cap [7] and the core liner [12]. Here, possibility of compaction or mixing of sediments is ruled out because the sediment in the sub-core remains in natural conditions and the sediment is not pushed from the bottom. To section the sub-core sediment, the sediment is first brought to the top level of the core liner which is achieved by rotating the disk [8] downwards and then lowering the core liner [12] up to the level of steel cup [10]. The coupler [14] consisting of steel slicer [18] and a collapsible steel scale [16] is then fixed on the top of the core liner with a screw [15]. With this, the scale is set to zero and the core is ready for sub-sampling. Required increment of the sediment is obtained by first lowering the disk by rotation using the calibrated value (or multiple of it) and then by lowering down the core liner to rest on the steel cup or the core holder [10], thereby exposing the sediment of sub-core (Figure 5). The sediment exposed at the top of the core liner (Figure 5) can also be verified for the required increment using a scale [16] attached to the coupler and sectioned using the rotatable slicer [18]. Once the sediment is sectioned and the sub-sample is removed, the slicer is cleaned and washed with distilled water using a wash bottle, by positioning the slicer away from the core liner. The cleaning procedure does not consume much time, but avoids the possibility of further contamination. The operation is then repeated for the next increment.

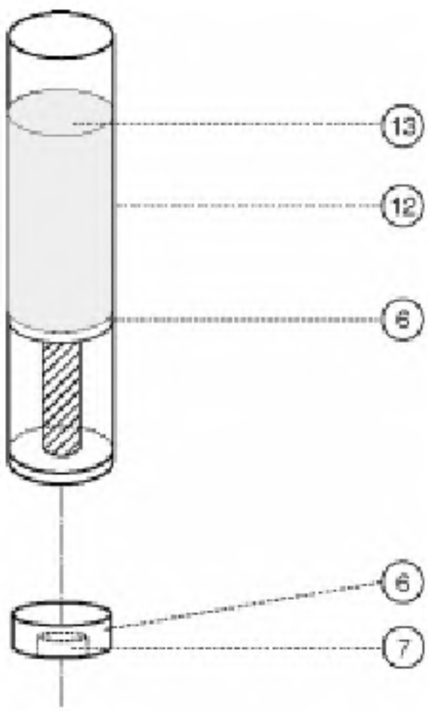

Figure 3. Enlarged view of sub-core [12] with sediment [13] resting on the rubber cap or stopper [6]. Symbols according to Figure 2.

Results and discussion

The apparatus has been tested successfully in a number of oceanographic cruises to the Central Indian Basin by the chartered Russian vessels *R/V A.A. Siderenko* (AAS-34, AAS-46 and AAS-61) during 2001–03 and *R/V A. Boris Petrov* (ABP-01 and ABP-04) during 2004–05 (Figure 5). The apparatus was found useful and suitable for all kinds of biological and geological sampling purposes. Initially, silty clay sediment from the seafloor of average 5200 m depth was brought on-board using a box (or spade) core with sampling box of 50 × 50 × 50 cm dimension. Acrylic and PVC core liners of 60 cm length (with 5.7 and 12 cm diameters respectively) were slowly inserted in the box core sediment (Figure 1) and carefully removed using a rubber cap at the bottom. Selected liners were placed on the disk of appropriate size (Figure 5) and the sediments were sub-sampled at variable intervals (1, 2 and 5 cm). Calibrated values were used for all types of sub-sampling. Accordingly, sediment sections of 1, 2 and 5 cm thickness were obtained for determining geochemical, sedimentological and geotechnical parameters. Similarly, sections of 0.5, 1, 2 and 5 cm were obtained for meiobenthos, microbenthos and chlorophyll studies. Sections of 0.25 cm were obtained for magnetic susceptibility studies during AAS-61 using pre-calibrated rotation of the disk.

Advantages

The device has the following advantages: (i) It is fully mechanical, which helps repeated actions of sectioning the soft aqueous sediments at desired intervals up to millimetre levels. (ii) It provides cross-sections of sediments from the core liner. (iii) The core holder allows the core liner to remain vertical without disturbing the physical, mechanical and chemical properties of the sediment. (iv) The cross-sections of the sediment are cut with precision and without contamination. Cross-sections provide an opportunity for not ing core logging simultaneously. (v) No change in orientation of the device is re-

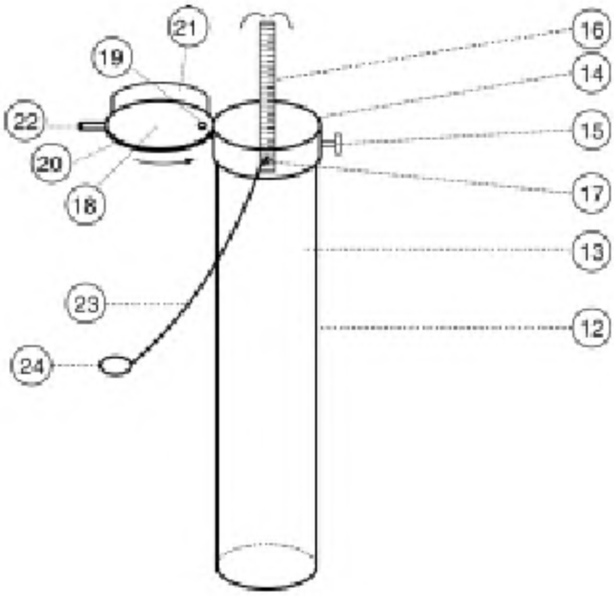

Figure 4. Coupler [14] with accessories of scale [16] and slicer [18] fixed on the top of the sub-core. Symbols according to Figure 2.

Figure 5. Photograph of the sediment sub-sampler used on-board *R/V A.A. Sidorenko* during AAS-46 cruise (2002). Sediment displayed on the top of the sub-core (5.7 cm dia.) is 2 cm thick. The steel scale in the background is to verify the thickness of the sediment to be sectioned.

quired for repetition of operation. (vi) The same core liners can be cleaned, washed and reused. (vii) Wear and tear of the parts is minor or negligible. Therefore, the device has long operational life. (viii) The apparatus requires small area (0.25 sq. m). This advantage is especially useful while using the device on small boats or in a small laboratory. (ix) It is low-cost (less than Rs 2000), lightweight (~ 9 kg) and not voluminous. It can be quickly assembled and dissembled in about 5 min. The device is handy and particularly useful for a team with limited manpower.

Conclusions

A modified portable device has been developed and successfully tested on-board research vessels for precise thin sectioning of aqueous sediments in sub-cores from the Central Indian Basin. During sectioning, the sub-core remains vertical, protecting the sediment properties. The mechanism works with gravity and does not allow compaction, mixing or slipping of the sediment from the sub-core. The device has mechanical controls and advantages over others: it is lightweight, slim, compact, low-cost, user-friendly, and best suited for sample collection in geological, chemical and biological oceanographic sciences.

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