

NE 2 and SR 8), there is predominance of angular quartz grains of high to medium relief having high frequency of arc-steps and small and large conchoidal fracture faces. These are characteristic primarily of glacial origin grains¹⁹. These features can be observed on the quartz grains from the remnant glacial lake at Kedarnath Temple (Figure 2). The precipitation of silica on grains is also considered a glacial character. The abrasion of quartz can produce local enrichment of silica²⁰ and result in its precipitation in suitable environment on grain surfaces. As the particle size decreases, there is an increase in rate of solutioning, which can result in smoothening of the surfaces. The dominance of grains with extensive silica precipitation in samples NE 1 and NE 2 could be due to their being at the bottom of the glacial lake, where silica taken into solution at higher levels has resulted in the enrichment of silica at the bottom⁶. The grains in sample SR 8 have relatively higher frequency of upturned plates and large breakage blocks – features which indicate minimal effect of diagenesis and characteristic of grains released from the source rock under glacial environment. The lower precipitation of silica also indicates minimal stagnation. Rai *et al.*²¹ have recorded glacial terraces in Sarju valley at low altitudes such as Bilkhet (1180 m) and Semdevta (1060 m).

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A special core liner for sub-sampling of aqueous sediments

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A portable and reusable special core liner (splc) has been developed to accomplish real-time sub-sampling of aqueous sediments. Besides being revolutionary, inexpensive and user-friendly, the splc is capable of collecting undisturbed sediment sub-sections. The splc also facilitates rapid sub-sampling of sediments on-board with remote possibility of core shortening, sample outflow, contamination or mixing. The proposed method of sub-sampling by splc saves time, money and manpower, without inducing changes in the physical and biogeochemical properties of the sediments.

Keywords: Aqueous sediments, gravity corer, special core liner, sub-sampling.

AQUEOUS sediment samples from the seabed can be obtained by various methods and the choice of a particular

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sampler depends upon its capability to meet the objectives of the research topic undertaken. The seabed samples obtained by different types of grab (Peterson and Vanveen) have the possibility of mixing. Comparatively, the corer brings undisturbed long vertical section of unconsolidated bottom sediments. The box or spade core brings relatively short (<60 cm) samples of the sea floor¹. The modern gravity corers are 6 m long against 4.6 m in the initial stages², and the piston corers are 10–15 m long against 6.1 m earlier².

Considering the changes in temperature and pressure the sediment undergoes during its travel from the sea floor to the surface, it is necessary that the sediments in the core liners are sub-sampled immediately and preserved for the wide range of applications and experiments. Different methods are already in use for sub-sampling the cored sediments. Generally, the long (6 m or more) core liner(s) from the gravity or piston corer are cut in 1 m sections, capped and stored in the refrigerated room at 1–4°C for handling and preservation purpose³. In another method⁴, 6 m sediment core from gravity corer is cut into 1 m long sections, and then sub-sampled by a single or combination of (a) pushing out the core at one end with a large piston and sub-sampling from the core end with small coring tubes or syringes, (b) cutting windows in the side of the core liner with a vibrating saw blade and inserting small coring tubes or syringes, or (c) splitting 1 m sections of the core open for core description and sub-sampling from the exposed half-core⁴. As the above methods primarily require cutting of the core liner, different cutting machines were developed by a few workers^{5,6}. Recently, an apparatus was also developed⁷ for finer-scale sub-sampling of sediments from box/spade core sediments. Although hand-operated push core sub-sampling method is popular, it has limitations and cannot be used for sub-sampling the sediments from gravity or piston core. Further, the gravity and piston core samplers do have problems with them³. A recent review⁸ on existing sampling systems seriously points at errors and sample disturbance due to sample tube penetration, retrieval and extrusion, etc. for sediments from gravity or piston corers^{3,9}.

In addition to the number of errors in the existing sub-sampling methods, there is unavoidable time delay – which is not taken seriously – in actual obtaining sub-sections from the core liner. This time delay is mainly due to the time spent in cutting and splitting the core liner, removing fine fibres from the exposed sediment surface and cleaning the surface, making sub-sampling interval marks on the sediments, removing sub-sections by knives, washing/cleaning the knives every time, labelling the sample bag, packing, etc. It is also important to note that a team comprising 5–6 persons is generally required for such type of sub-sampling. Therefore, it can be said that the sediment sub-sampling methods are not fully evolved. Consequently, there is ample need and

scope to modify and revive the sub-sampling methods in order to improve the precision, accuracy and efficiency.

To overcome the above-mentioned problems, a portable special core liner (spcl) has been designed, developed and tested on-board for obtaining 1 cm size sub-samples of aqueous sediments in real time. Details of preparation and operation of the spcl are given and the method of sub-sampling is described here. The merits and demerits of the proposed method are also discussed.

The spcl method of sub-sampling can be successfully exercised with the standard gravity corer, piston corer or other similar corers comprising a wire connected to a triggering device, weight stand and core barrel with nose cone and a core catcher. In the present study, two acrylic liners 2 m long and 64 mm outer diameter (OD) suitable for core barrel (2 m) of gravity corer on-board *CRV Sagar Sukhti* (NIO), were used for testing.

PVC or acrylic core liners suitable for gravity, piston, or other similar core barrels can be used for making rings/sections of required sub-sampling intervals. The length and size (OD) of the spcl depends upon the actual length and size of the core barrel of the sampler to be used. In the present study, two acrylic liners (2 m long, 64 mm OD) were cut into pieces to make a equal size rings/sections of little more than 1 cm each. This involved many steps such as marking the core liner @ 1.4 cm interval, cutting by a hacksaw, smoothening/facing of top and bottom surfaces of each ring/section, etc. At the end, the size (1 cm) of each ring/section was confirmed using a vernier caliper. The deformed rings/sections and those having stains or scratches were discarded. Similarly, rings/sections of other sizes (0.5, 2, 3, 5, 10 cm, etc.) can be prepared. It is necessary that all the rings/sections are cleaned from machine oil and other stains, washed and air-dried (Figure 1).

A clean PVC rod of ~1.6 m length was used for aligning the rings/sections and to facilitate preparation of the spcl. Totally 100 rings/sections of 1 cm size were mounted on the rod, aligned and sealed using packing tape. The packing tape holds the rings/sections tightly. Similarly, another 1 m long spcl was prepared and joined with the previous one using packing tape (Figure 2). In this way, spcl of 6 m suitable for gravity corer or > 10 m for piston corer can be prepared. Pre-decided sub-sampling interval(s) help in the selection of rings/sections and their order in preparing spcl (Figure 3 a and b). In the present study, only 1 cm size rings/sections were used for preparing 2 m long spcl.

Each ring/section of the spcl can be identified quickly if numbered sequentially and/or by adopting a colour-code scheme, which is optional. Here, every 10 cm ring/section from the top was recognized by fixing a blue tape, 50 cm ring/section with yellow and every 100 cm ring/section with red tape. This method was found useful for spot identification and separation of interesting rings/sections.

RESEARCH COMMUNICATIONS

For testing purpose, the 2 m long spcl with a core catcher at the bottom was inserted in the 2 m core barrel of the gravity corer. The gravity core was loaded with heavy weights on the top and operated from *CRV Sagar Sukti* in ~5–7 m water depth. After the operation, the gravity corer was lifted on-board and the spcl was slowly removed from the core barrel, washed and cleaned after protecting both the ends. For handling purpose, the spcl containing sediments was cut into four pieces of 0.5 m each, using a pen knife. Both the ends of the cut pieces of the spcl were protected by tightening with polythene bag before transferring them into a crate.

Prior to sub-sampling, all the cut sections (0.5 m) of the spcl were arranged sequentially in the wet laboratory. The required sub-sample was collected in three steps as follows. First, the packing tape from either side of the spcl was slowly pulled down up to the bottom of the first ring/section. The ring/section along with the sediment was then removed from the spcl and collected on a plastic plate. In the third step, the sediment section was transferred to a labelled polythene bag using a spatula (Figure 4). Later, the polythene bag was sealed and kept in an ice-box to facilitate transferring into a deep fridge. Similarly, the remaining 1 cm sub-sections were removed from the spcl. Precautions were taken every time to clean and wash the plastic plate and spatula to avoid sample contamination. The sub-sampling was completed in ~30 min with the assistance of only one person (Figure 4). It was observed during the sub-sampling that no sample

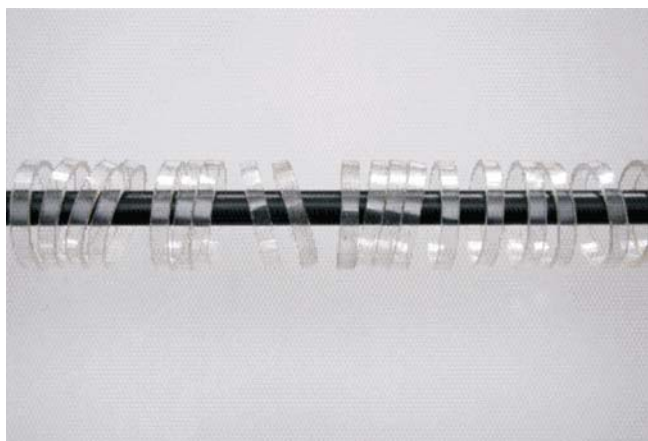


Figure 1. Rings/sections of 1 cm size from acrylic liner.



Figure 2. Special core liner (spcl) of 2 m, prepared from 1 cm rings/sections using packing tape.

could leak, mix or fall apart from the spcl. At the end, all the rings of the spcl were cleaned, washed and air-dried for reuse.

Earlier tests were carried out with 50 cm long spcl having 2 cm interval rings/sections, which was designed for box core sub-sampling of silty-clay sediments from the Central Indian Basin (CIB) during *R/V A.A. Siderenko* cruise (AAS-61) in 2003. The method was found useful to meet sample requirement for geological and biological

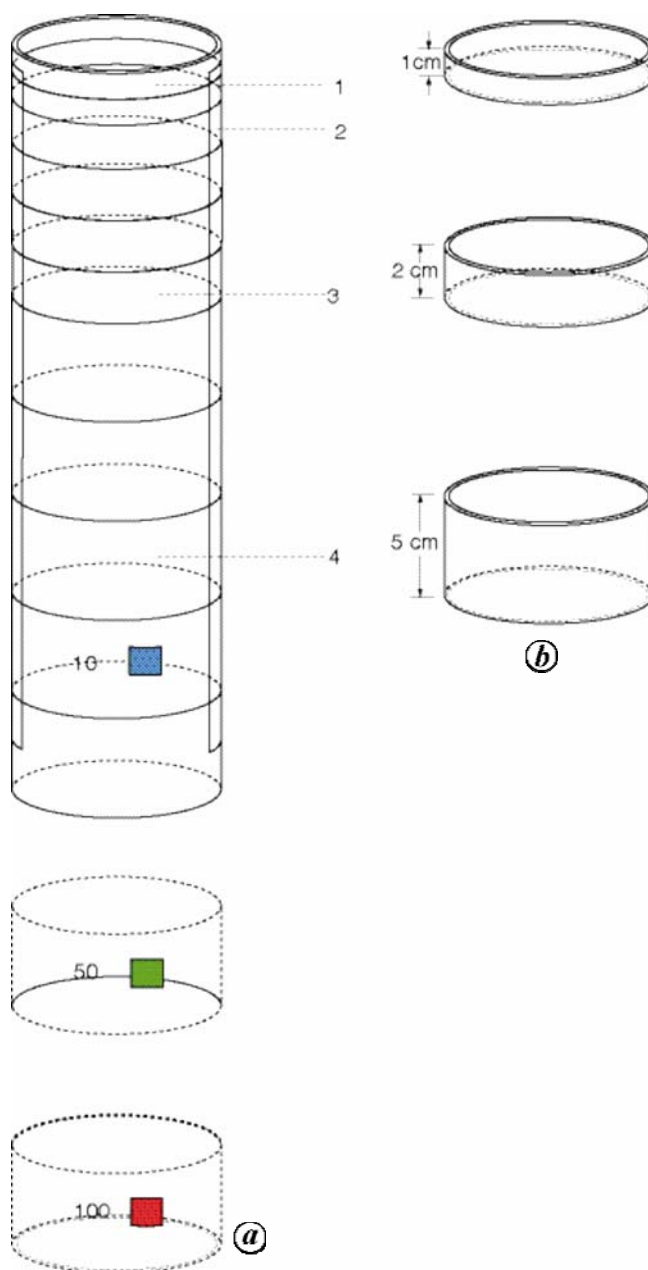


Figure 3. *a*, Spcl with different size intervals. 1, Ring/section of 1 cm size; 2, Packing tape; 3, Ring/section of 2 cm; 4, Ring/section of 5 cm size. Suggested sequential numbering and colour scheme: Every 10 cm ring/section and its multiple to be identified with blue colour/tape, 50 cm ring/section and its multiple by green, and every 100 cm ring/section and its multiple by red colour/tape. *b*, Enlarged view of 1, 2 and 5 cm rings/sections of spcl.

Table 1. Merits and demerits of the existing and proposed sub-sampling methods

Parameters	By existing sediment sub-sampling methods	By proposed sub-sampling method with spcl
Collection of undisturbed sample	Possible	Possible
<i>In situ</i> sub-sampling	Not possible	Possible in real time
Sub-sampling	Possible only after cutting the core liner and splitting the sediment core	Possible without cutting the core liner or splitting the sediment core
Precision and accuracy of sub-samples	Sub-samples are not precise and accurate	Sub-samples are precise and accurate
Waiting period to start sub-sampling after core liner is removed from the core barrel	Large	Nil
Contamination and mixing of sample during sub-sampling	Possible	Not possible
Identification of sub-sections after removing the core liner from the core barrel	Nil	100% and immediate
Speed of sub-sampling	Slow	Fast
Cutting/splitting of the core liner	Required everytime	Not required
Reuse of the core liner	Not possible	Possible every time
Core logging	Possible only after cutting the core liner	Possible without cutting the acrylic core liner
Preserving half of the core liner	Possible	Not possible
Manpower required for sub-sampling	Quite large (6–7)	Very small (2–3)
Space requirement for sub-sampling	Large (equivalent to a laboratory)	Small (equivalent to a table)
Handling of core liner	Hard and complex	Simple and easy
Life of the core liner	Short	Long
Durability of the liner	One-time use	Unlimited use
State of the core liner	Rigid and fixed	Portable and non-voluminous
On-board requirement of core cutting gadgets	Essential and large	Not required and small
Processing of core liner after its operation	Not required, as cut core liner is not used again	Required, as rings/sections of the spcl are cleaned, washed, dried and reused
Expenditure on 6 m core liner	Large; about Rs 5000 per operation	Small; <Rs 4000 as one time expenditure
Method of sub-sampling	Difficult, complicated, not environment-, eco- or user-friendly	Simple, easy, environment-, eco- and user-friendly
State-of-the-art	Methods are in operation	Method is proposed and has been successfully tested for near-shore sediments

**Figure 4.** Sediment sub-sample (1 cm) being removed from spcl.

parameters. Later, the spcl was modified for improving intervals @ 1 cm and to suit real-time sub-sampling of gravity core sediments. Accordingly, 2 m long spcl was tested successfully on board *ORV Sagar Sukti* in April 2007. The vessel has the capability to operate only 2 m long gravity corer. The on-board test showed that the spcl method of sub-sampling the aqueous sediments has many advantages over the existing methods. During the entire operation, the sediments inside the spcl were intact and

undisturbed. Similarly, during sub-sampling, there was no mixing or contamination of the sample. It is also possible to improve the spcl for finer-scale sub-sampling, from 1 cm at present to 0.5 cm or less. Another 6 m long spcl with 12.5 OD has been prepared for sub-sampling the gravity core sediments at 1 cm intervals. It is ready for testing on-board *ORV Sagar Kanya* or other similar deep-sea research vessels.

The total amount spent for fabrication of the 2 m long spcl was low. The 1 m acrylic pipe weighs ~800 g and costs about Rs ~400. The pvc liner costs even less. About 70 rings/sections of 1 cm size were obtained from 1 m core liner, and with additional care, 80–85 rings/sections are possible. At this rate, a 9 m liner is required (once for all) to prepare 6 m spcl, which would cost about Rs 3600 and weigh 7.2 kg. The package tape (2" × 65 m) costs about Rs 25 and would last for five operations minimum. Considering all these, the cost of 3–4 spcl (6 m) would be about Rs 10,000.

Requirement of small working area in the laboratory, less manpower and less time are the main factors to be considered while comparing with other sub-sampling methods. For example, many research vessels such as *JOIDS*, *RV Sonne*, *ORV Sagar Kanya*, etc. have a full-fledged core-cutting laboratory on-board for sub-sampling purpose, whereas vessels like *CRV Sagar Sukti*, *RV*

Yuzhmorgeoligiya, A. A. Sidorenko, A. Boris Petrov, etc. have no specific laboratory for core-cutting and sub-sampling. Therefore, in some vessels cutting of the core liner and sub-sampling is performed inside the laboratory, whereas in others both activities are carried out on the deck, facing inconvenience and difficulties. In such a situation, the spcl plays an important role, since the assembling and disbanding of the spcl is easy and fast. Further, the sediment properties in the spcl are protected and the chance of core shortening is remote. Important advantages of using the spcl and its comparison with the existing methods are given in Table 1.

The only drawback for the present spcl could be that, half of the core liner with sample cannot be preserved for archive purpose. Though preserving half of the core is not a common practice, the improved version of the spcl will have an option for preserving half the portion of the core liner.

A 2 m long spcl was designed and tested to obtain 1 cm sediment sub-samples from near shore. The initial test gave successful results for precise and accurate sub-samples. The spcl is light-weight, portable, reusable and requires small budget for fabrication. The sub-sampling method by the spcl is user-friendly and has many advantages over the existing ones, e.g. it requires considerably less time, less manpower and small area for sub-sampling on-board.

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Study of the Salem–Attur shear zone, east of Salem, Tamil Nadu: a new kinematic interpretation

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A study of the mylonites of the Salem–Attur shear zone at Udayapatti and Sarkar Nattar Mangalam reveals that the shear zone developed in the form of a north-easterly vergent subhorizontal thrust which has been refolded into variable attitude due to late stage folding. The subhorizontal mylonitic foliation with NE trending stretching lineation bears testimony to such an explanation. The earlier impression that the shear zone is vertical comes from the folded part of the thrust as the mylonites have assumed a vertical attitude on the limb of the fold.

THE E–W running Salem–Attur shear zone (or Moyar–Bhavani–Salem–Attur shear zone) in Tamil Nadu forms an important tectonic line in the Southern Granulite Province (inset, Figure 1). Together with the Palghat–Cauveri shear zone, it demarcates a possible suture between two geologically distinct terrains, namely the northern and southern granulite terrains of Archaean and Neoproterozoic age respectively^{1–4}. Apart from their ages, these terrains differ remarkably with regard to structural and metamorphic evolution. The northern terrain is marked by northeasterly structural grains that swing into the E–W direction along the Salem–Attur shear zone, and indicates an overall anticlockwise *P–T* path. The southern terrain, known as the Pandyan Mobile Belt, that resulted from the collision between Dharwar and Africa/Antarctica continental blocks during the Pan-African period, displays domal structures and records an overall clockwise path^{5–8}. However, Bhaskar Rao *et al.*⁹ and Ghosh *et al.*¹⁰ suggest that the boundary between these two terrains lies further

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