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DISTURBANCES IN SOFT SEDIMENTS DUE TO PISTON CORING

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ABSTRACT

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Misinformation may arise during core description and analysis unless due attention is paid to common disturbances caused by the piston-coring mechanism. Some mid-core flow-in features can resemble slump bedding. Sandy sediment commonly migrates along the core margins as a sand—water slurry; voids are left by its removal and entirely new beds formed by its intrusion. Inclined laminae, rotated blocks and minor faults may be secondary sedimentary features caused by slumping, or artefacts of the piston-coring process. Core rotation of up to 100° has been detected by palaeomagnetic study. Variable lengths are usually missing from the upper sections of piston cores; estimation of deposition rates for the most recent sediment is therefore hazardous.

INTRODUCTION

Disturbed sediments are a common feature of piston cores. In many cases the disturbance is relatively easy to visualize and interpret. However, there are other structures which are readily misinterpreted and may lead to erroneous conclusions.

Core shortening with missing upper sections is the most commonly noted disturbance (Hvorslev and Stetson, 1946; Kullenberg, 1955; Richards, 1961; Ross and Riedel, 1967; Chmelik et al., 1968; McCoy and von Herzen, 1971). It is largely caused by down-dragging along the core margins. Vertical disturbances occur frequently in the lower sections of cores (Bouma and Boerma, 1968), and are usually caused by the sucking-up of sediment when the core is pulled out after incomplete penetration. Rotation of sediment has been noted by McCoy and von Herzen (1971).

Mass physical properties of the sediment, including shear strength, water content, porosity and unit weight, are affected by sampling disturbance to varying degrees, depending on the type of corer being used and depth within the core (Ross and Riedel, 1967; Inderbitzen, 1968).

Burns (1963) carried out laboratory experiments with a scaled-down piston corer. He concluded that misinformation was readily introduced by the mechanics of piston coring, and that it was very difficult to eliminate.

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He found that beds would either not be sampled or would be sampled in the wrong stratigraphic sequence. Squeezing out of soft sediment from between two firm layers has also been noted (Kallstenius, 1958; Chmelik et al., 1968).

Rosfelder and Marshall (1967) discussed the causes of some of the disturbances that have been described. McCoy and von Herzen (1971) have examined the operation of a piston corer in the deep sea by mounting cameras within a core head. They also briefly review earlier work on the piston-coring mechanism and various suggestions for improvement in design and techniques.

This paper aims to provide a more thorough documentation of disturbances in soft sediments due to piston coring, and also to introduce certain disturbed structures not previously described in the literature. It is hoped that it will be of use in preventing erroneous interpretations during routine core description by visual and X-radiographic techniques. The cores examined have all been collected on recent Bedford Institute of Oceanography/Dalhousie University cruises, using 2½ in. inside diameter Alpine and 3 in. inside diameter Benthos piston corers with the appropriate gravity trigger corers.

OBSERVED DISTURBANCES

Flow-in or suck-in

In 75% of the cores we have examined, flow-in occurs as a clear vertical disturbance at the bottom of the core. This is most easily recognized in the fine-grained sediments as a vertical streaking-out of interlaminated, varicoloured muds and silts (Fig.1A). It is less clear in homogeneous sediments, but may be inferred from a complete lack of structure and absence even of burrowing or mottling.

Thick, apparently massive, sands may only be interpreted as due to flow-in by measuring grain orientation in thin section (Hollister, 1967, p.244). In gravels or gravelly-sandy muds, vertical pebble orientation and streaking-out of sand lenses can often be observed in X-radiographs (Fig.1B).

Highly disturbed surface sections (200—300 cm in length) are also found. Vertical flow-in structures are not well developed, but a more random disturbance of laminae occurs (Fig.1C).

More rarely, flow-in occurs in the middle sections of piston cores. Fig.1D shows the development of flow-in at core depths of 200 to 300 cm. Flow-in of up to 200 cm has also been observed in the middle section of an 800 cm piston core.

Flow-in is most probably due to incomplete penetration of the piston corer followed by the sucking-in of the sediment during withdrawal (Bouma and Boerma, 1968). Cores from fairly hard substrates commonly have up to 600 cm of flow-in in the bottom half of a 1200 cm piston core. Similar disturbances at the surface or at intermediate depths are probably caused by incomplete penetration and slight separation of the sediment during withdrawal. Material is then drawn up the sides and into the void from deeper within the core.

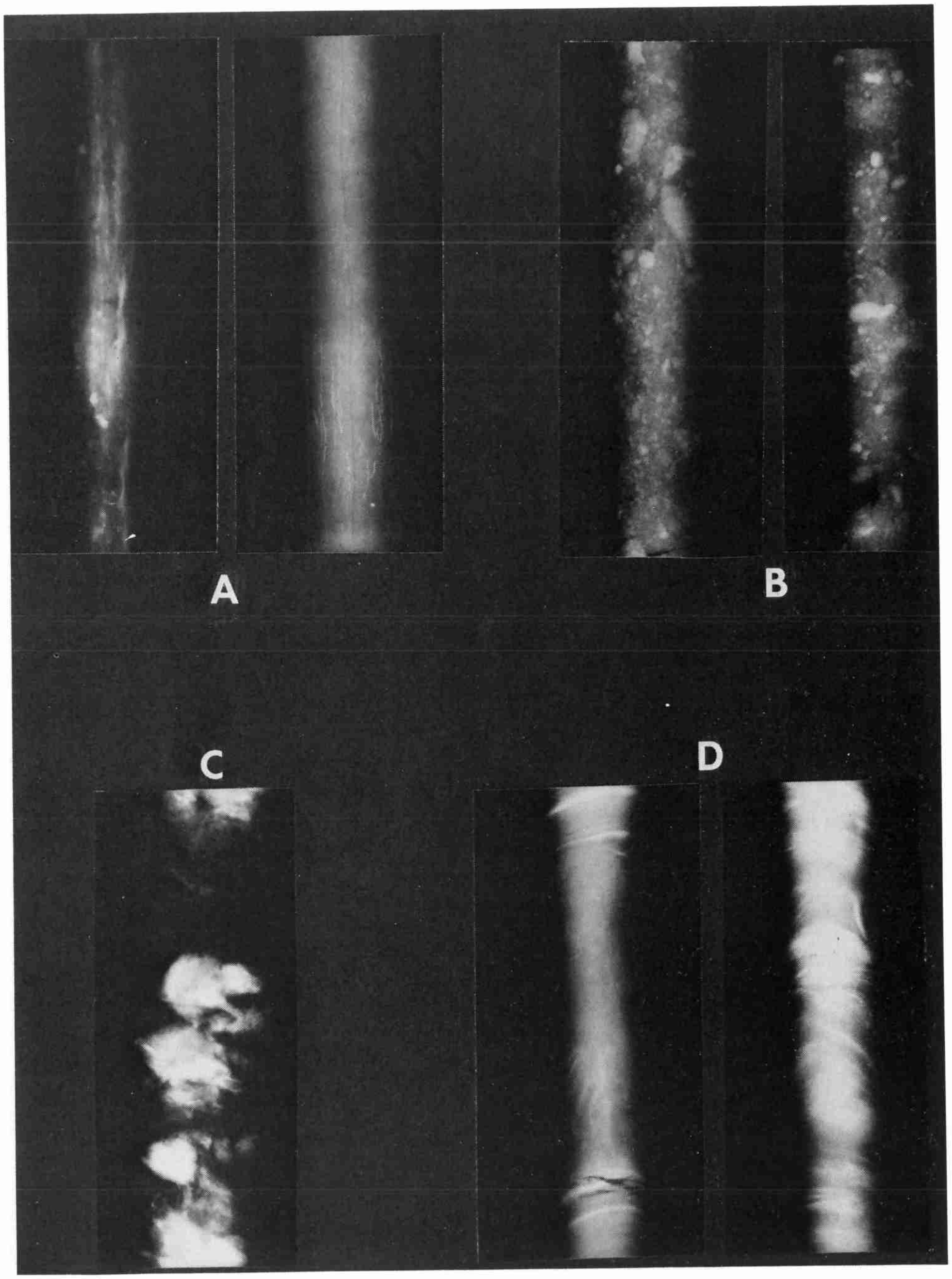

Fig.1. X-radiograph prints of flow-in structures. A. Vertical streaking in fine-grained sediment. B. Vertical clast orientation in left-hand photo, normal orientation in right-hand one. C. Disturbed upper section of core. D. Incipient flow-in in middle of core.

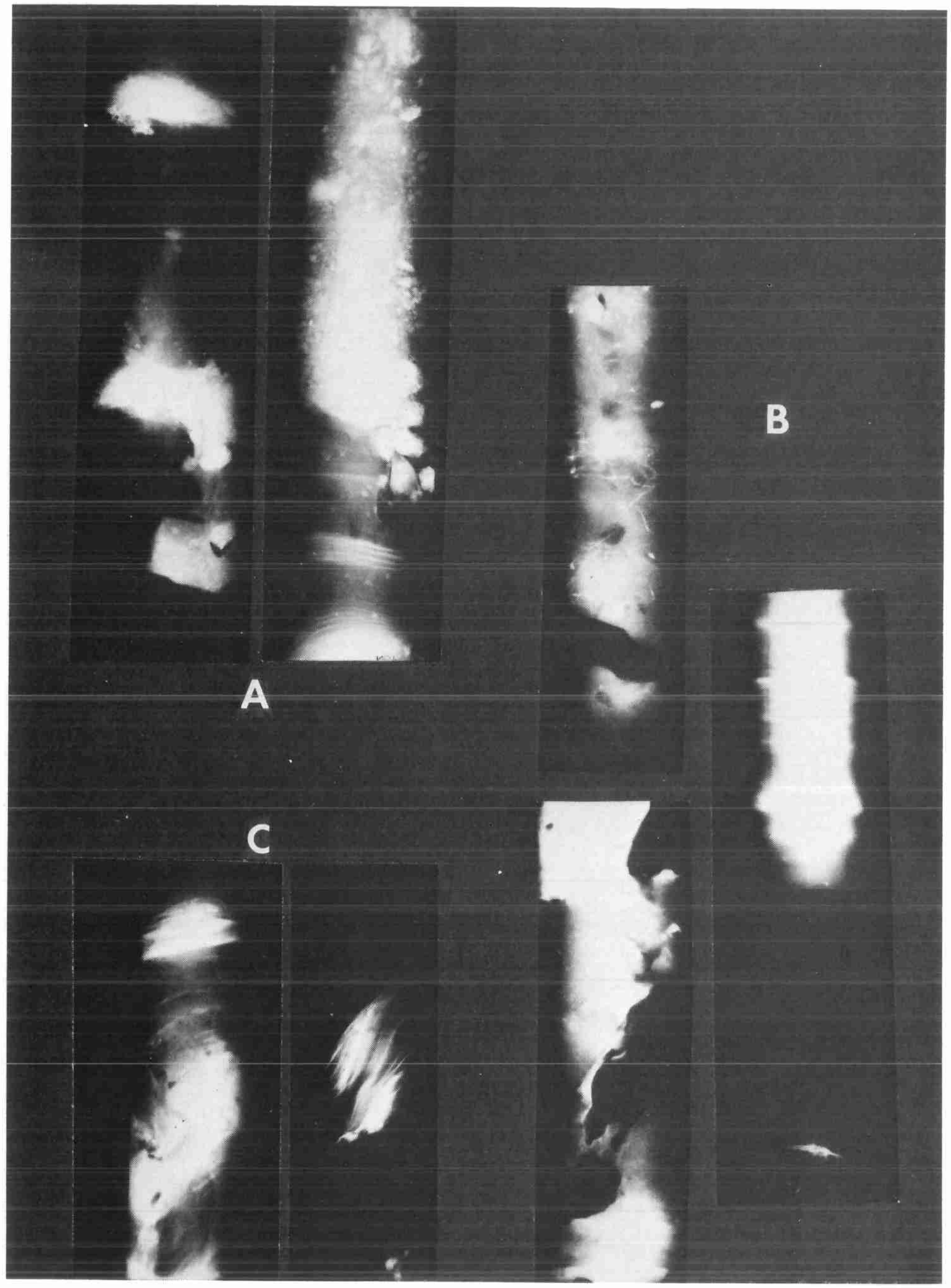

Fig.2. X-radiograph prints of sand-flow structures. A. Sand-flow at base of thin sand and thick gravelly-sandy-mud beds. B. Voids, formerly with sand beds. C. Disturbed internal structure of thin sands.

Sand-flows

A number of disturbances can be related to sand-flow at some stage of the piston-coring operation.

Thin (1—5 cm) sand beds are often partially disturbed near their bases or tops, and may be drawn into sand lenses along the margins of the core (Fig.2A), or intruded into the surrounding mud to produce separate irregular layers. Complete removal of a sand bed is not uncommon. The resulting void may be lined with fine sand, but does not necessarily represent the original layer thickness (Fig.2B).

In some cases sand-flow from thick sand units may produce entirely new sand beds. Fig.3A shows a thick Pleistocene sand from the Scotian Rise

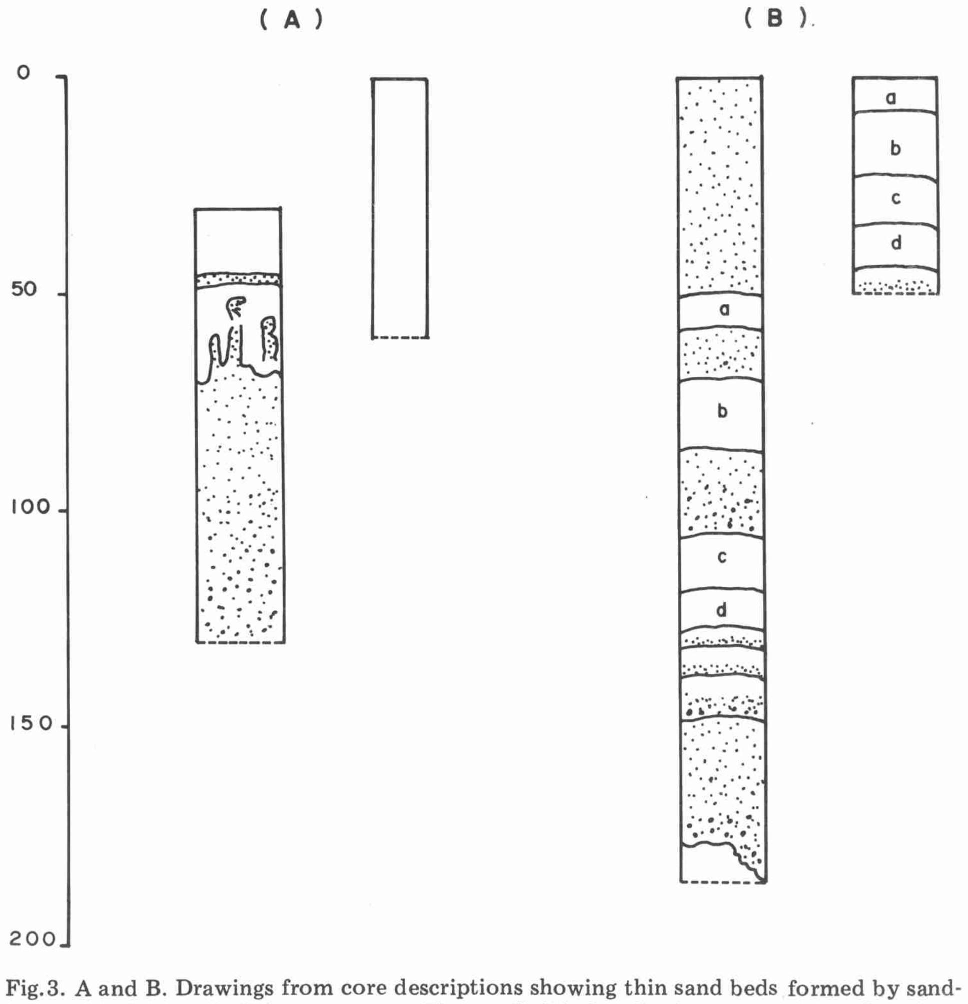

Fig.3. A and B. Drawings from core descriptions showing thin sand beds formed by sand-flow-from thick underlying sequences. The small right-hand columns represent the trigger weight cores. White=mud; stippled=sand.

overlain by Holocene hemipelagic mud. This layer apparently contains a 5-cm sand bed which, on careful inspection and comparison with the trigger weight core, is seen to derive from the underlying sand. Fig.3B is a similar example from Baffin Bay in which three new sand beds have been formed at up to 100 cm above a graded sand turbidite. The trigger weight core compares exactly with the mud units above the turbidite sand of the piston core, but contains no interbedded sands. Even when sand beds are neither formed nor destroyed their relative mobility may result in considerable disturbance of the internal structure (Fig.2C).

Sand—water slurries formed during penetration of the piston core, and their subsequent movement during retrieval and shipboard handling, are the most likely causes of sand-flow disturbances.

Disturbed laminae

There are a wide range of minor disturbances which may be encountered in fine-grained, laminated sediments. It is not always clear which of these are true primary or secondary sedimentary features, and which result from the piston-coring mechanism.

Sometimes, laminae are almost perfectly horizontal. More frequently they are bent down at the core margins, and the degree of bending may vary considerably within a single core section (Fig.4A). The bending is caused by frictional drag between sediment and core liner; the degree of bending being related to sediment lithology and/or variation in speed of piston-core penetration and withdrawal.

Overturned laminae (Fig.4B) are found in one core from a steep channel margin on the Laurentian Fan. This structure may be indicative of sediment slumping; however, it is located directly above flow-in at the bottom of the core and may therefore be interpreted as incipient flow-in.

Laminae are frequently inclined to the horizontal at angles anywhere between 5 and 60° or more. In some Baffin Bay piston cores the inclined laminae appear to be part of cylindrical blocks of sediment which may have rotated about a vertical axis in the liner (Fig.4C). Piper (1975) describes a similar feature in semilithified DSDP cores. On the Laurentian Fan inclined laminae are most common in cores from steep channel margins, and are better interpreted as true sedimentary structures related to slumping. In addition, the inclined laminae themselves are bent down at the core margins, indicating that the deformation was prepiston-coring.

Minor faults

Minor faults are commonly encountered in some cores. These faults (between 5 and 30 cm in length) may be steeply or gently inclined, and offset the laminae by 5—10 mm (Fig.4D). In some cases, where the faults are bent down at the core margins or when they are associated with inclined laminae on a channel margin, they may be interpreted as precoring structures.

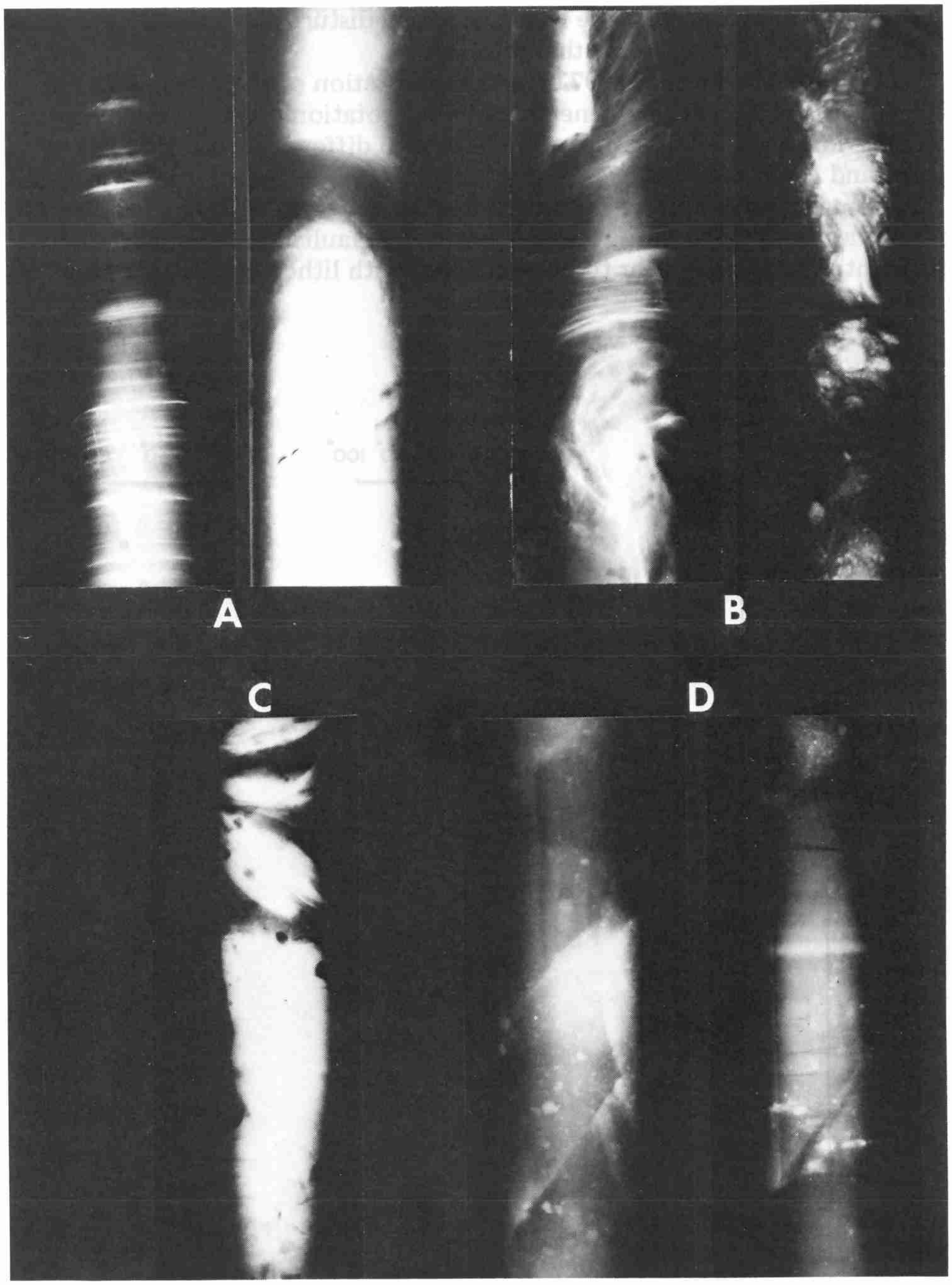

Fig.4. X-radiograph prints of disturbed laminae and minor faulting: A. Bending-down of laminae at core margins. B. Overturned laminae. C. Rotated blocks of inclined laminae D. Microfaults.

In other cases they may be the result of coring disturbance caused by rotation, uneven vertical motion or another mechanism.

McCoy and von Herzen (1971) note that rotation of the piston corer by 20—60° is common during penetration. Such rotation might be expected to produce low-angle or subhorizontal faults with differential rotation of the upper and lower sections.

Paleomagnetic studies of Scotian margin cores reveal evidence for piston-core rotation of up to 100°. Possible horizontal faults acting as planes of differential rotation appear to be coincident with lithological boundaries (Fig.5).

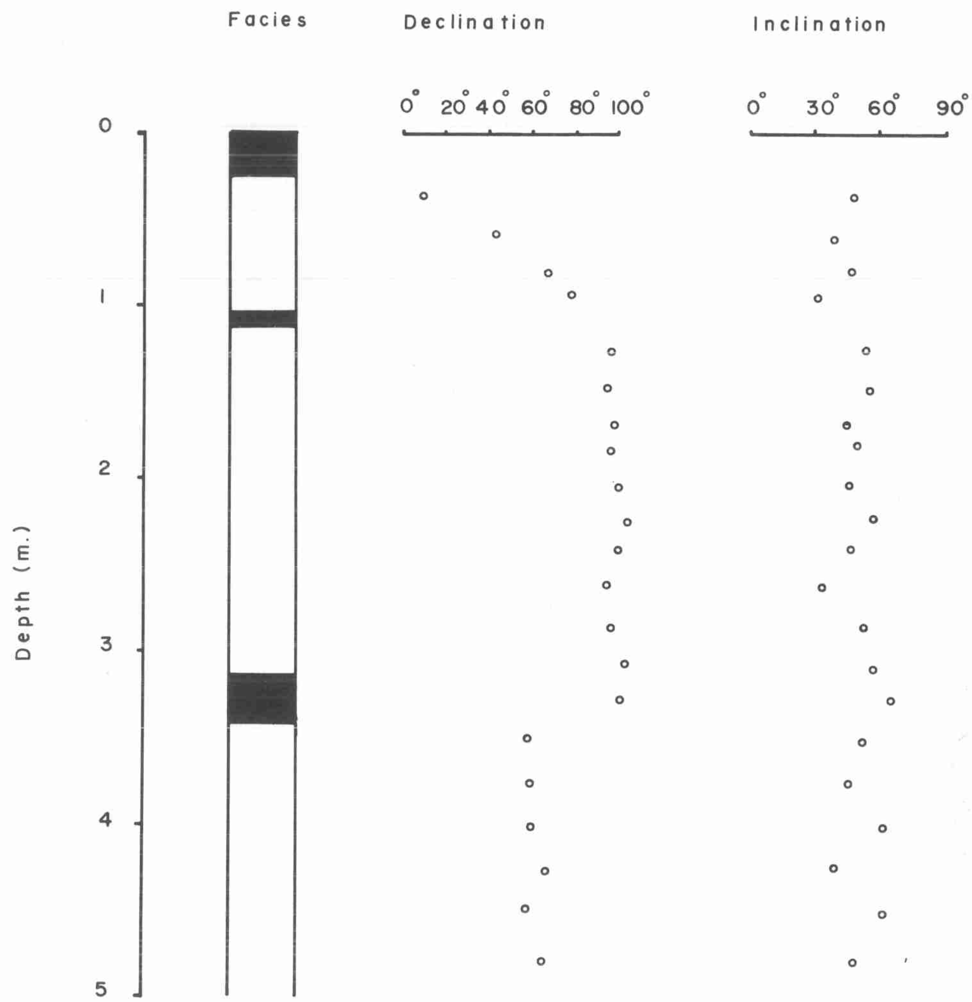

Fig.5. Palaeomagnetic measurements from a Scotian Margin core. Note the 100° rotation of the top metre of sediment, and the sharp break in declination coincident with a facies change at about 340 cm depth.

Missing top, disturbed margins

One notable shortcoming of the piston-coring process is that the sediment—water interface is commonly destroyed. This can be compensated for by using a short gravity corer as a trigger weight. Comparison of the two cores then gives an estimate of the amount of section missing from the piston core.

In 70% of the cores we have examined we find more than 20 cm of section to be missing. In some cases up to 200 cm of missing section has been noted. In addition, the top 5—50 cm of core may be considerably disturbed owing to mixing with the overlying water during retrieval and handling.

McCoy and von Herzen (1971) summarize the various factors responsible for this type of core shortening and disturbance. The chief causes are the impact of penetration and the improper adjustment of the amount of slack attached to the piston corer.

The outer margins of piston cores are always disturbed to a greater or lesser extent. The outer rim of sediment may be drawn many metres down-core because of frictional resistance during penetration. The thickness of this disturbed zone varies between 1 and 6 mm. In some cases a vertical streaked pattern of marginal disturbance can be detected on X-radiographs, superimposed on the normal horizontal layering.

DISCUSSION

The disturbances outlined above are all common features in soft sediments of piston cores. In many cases there is little danger of misinterpretation; however, attention is drawn to the following:

(1) Some incipient flow-in features may be similar to slump bedding.

(2) The interpretation of sand beds and their internal structures must always be made with caution. Voids may represent missing sand layers; while firm and even slightly graded sand beds may be artefacts of the piston-coring process.

(3) Inclined laminae, rotated blocks and minor faults may all result from piston coring. A careful examination of these features and their environment of occurrence is necessary for correctly interpreting their mode of formation.

(4) Estimates of the thicknesses of the most recent sediment layers and/or of rate of deposition should not generally be made from the tops of piston cores. Sampling should avoid the disturbed margins.

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