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Current Transport and Deposition of Foraminiferal Tests, Planktonic Organisms and Lithogenic Particles in Bedford Basin, Nova Scotia *

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Introduction

The size of Foraminifera tests and the possible entrapment of air or some other gas make them most susceptible to erosion and transport by currents. This is especially true of abandoned foraminiferal tests which are no longer inhabited by the living animal. The pseudopodia of the living animal are employed to gather food and to anchor the Foraminifera to the sediment surface so that successful erosion requires much stronger currents than those required to initiate movement of an abandoned test. Numerous investigators have provided evidence of the redistribution of living specimens and abandoned tests of Foraminifera through comparison of the living and dead assemblages. Shallow-water species have been observed by Phleger (1957) in sediment cores obtained seaward of the Mississippi delta. He suggests that the tests may have been carried somewhat beyond the limit of turbidity flows because of their slow settling velocity or that they may have been put into suspension by wave action when they contained protoplasm, and were carried seaward by currents. Living specimens of shallow-water benthonic Foraminifera have been reported by Phleger (1951) in offshore plankton tows in the northwestern Gulf of Mexico and Murray (1965) recovered numerous abandoned tests from tows in the English Channel. Murray surmised that wave-base turbulence of bottom sediments had thrown the Foraminifera into suspension and that turbulence had enabled those of the size range 0.15 to 0.20 millimetres to rise to the surface waters of the Celtic Sea. Transport of benthonic Foraminifera in Hudson Bay (Leslie, 1965) and along the coast of Nova Scotia (Bartlett, 1964) has also been reported.

Previous investigations have not clearly defined the degree of activity of transporting mechanisms, or if there is any selectivity by currents with respect to the species being eroded and transported. Murray (1965) has noted, however, that smaller specimens were preferentially removed from the source sediments in the English Channel and that subsequent deposition of these transported tests altered the composition of the death assemblages both by removal and by addition of new material. In some studies living Foraminifera are observed in non-typical environments and the question of recent transport versus adaptation on the part of the species must then be resolved.

Preliminary trials of a sediment trap in the Bedford Basin (Fig. 1) have provided evidence suggesting that turbidity currents are responsible for the transport of foraminiferal tests in this body of water. The trap is being developed as part of a continuing study of the production rate of planktonic Foraminifera and to obtain semiquantitative data regarding the degree of foraminiferal transport at certain nearshore locations.

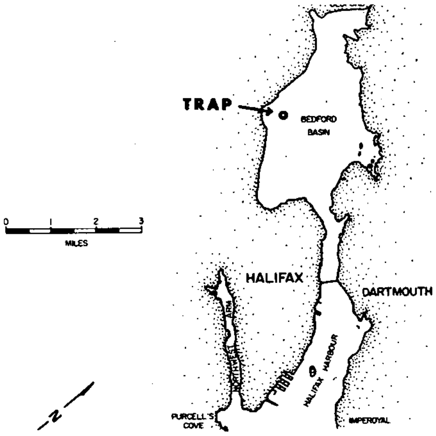

Fig. 1 - Map showing Bedford Basin and location of sediment trap during trial period.

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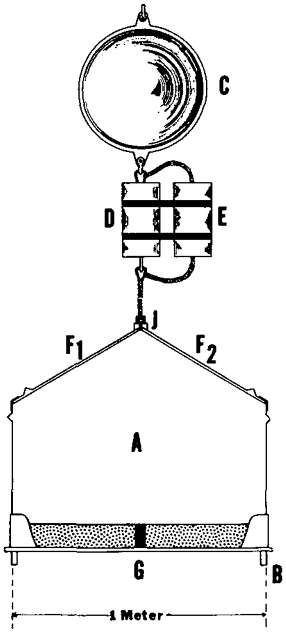

Fig. 2 - Side view of trap in closed position. Downward movement of trap enclosure (A) toward base (G) activates arms that open doors F_1 and F_2.

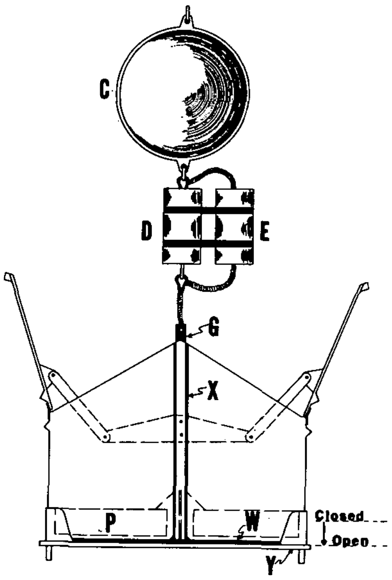

Fig. 3 - Side view of trap showing linkage used to open doors.

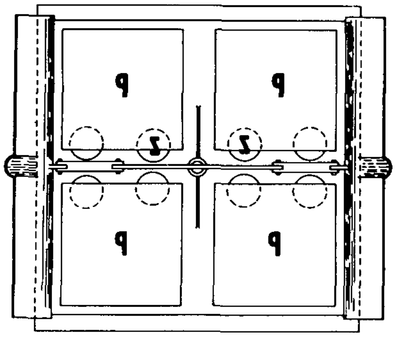

Fig. 4 - Top view of trap in open position showing collecting pans (P) and position of drain holes (Z).

Trap Construction

The sediment trap shown in Figure 2 can be lowered to the sea floor from a ship using standard hydrographic wire fitted with an appropriate messenger release. Upon reaching the bottom the trap is disconnected from the wire and allowed to settle on four two-inch diameter cylinders (B), which serve as gravity corers. Buoy (C), time-release mechanism (D), and reel of line (E), are used for recovery after some chosen length of time. A pinger and flashing neon light may also be attached to the system in order to aid in relocating the device.

The operation is as follows:

(1) The trap is positioned on the bottom. After about six hours, magnesium links fastened to the upper edge (J) of the doors (F_1 and F_2), dissolve and allow the doors to open (Fig. 2). The force to open the doors is obtained by mounting the activating linkage on a stationary rod (Figs. 2 and 3, G).

(2) As the doors are unlatched, the weighted base of the trap (W) causes it to move downward relative to rod (G); the entire trap slides on a slotted sleeve (X) opening the doors as it moves. The platform (Y) to which rod (G) is anchored is also weighted in order to stabilize the entire mechanism and to facilitate penetration of the four coring tubes into the sediment.

(3) At some predetermined time, the release mechanism (D) fires allowing the buoy (C) to ascend to the surface. The entire system can then be recovered by the attached rope stored in container (E).

In the recovery phase, tension is applied to the attached rope which causes the trap housing (Fig. 2, A) to move upward relative to shaft (G) and platform (Y). This action closes doors F_1 and F_2 before the sampler begins its journey to the surface.

The trap has been constructed using fiberglass or fiberglass-coated components wherever possible. Door hinges were made from 1/8-inch thick teflon sheets fastened with stainless steel bolts. Sacrificial anodes have been attached to those components that may be expected to corrode. The floor of the trap holds four 40 X 40-centimetre pans (Fig. 4, P) that will contain sediment and biogenic detritus settling to the bottom. There are several large drain holes (Z) in the base of the trap-housing that permit flooding when the trap is submerged and drainage when the device is removed from the water.

The system was initially submerged in the Bedford Basin for three months in order to determine relative rates of corrosion on certain parts and to assess other factors that may dictate the approximate length of time that the trap must operate in order to gather meaningful data.

Preliminary Results

The sediment and living organisms collected in the pans during the initial three-month trial period (May-July) have been examined. The volumes of wet sediment plus living organisms in three of the pans were 785, 710 and 690 cubic centimetres respectively. On an average about 0.45 cc of wet material was deposited on each square centimetre of pan surface. This relatively high sedimentation rate reflects the turbid conditions that persist in nearshore parts of the Basin and possibly the deposition of suspended material from the Sackville River. The influence of the trap-housing configuration on the sedimentation rate (under diverse current conditions) must still be assessed before any definite conclusions can be drawn regarding absolute rates of sedimentation.

A portion of the sample was dried, weighed,and then ignited in a muffle furnace for three hours at a temperature of 500°C in order to destroy any organic matter. The sample weight after ignition indicated that about 0. 48 per cent organic matter was present in the sample. The inorganic constituents were composed of 16 per cent sand, 61 per cent silt and 23 per cent clay-sized lithogenic particles respectively.

A study of the sediment samples showed the presence of living and abandoned tests of Foraminifera including: Buccella frigida, Eggerella advena, Elphidium clavatum, E. incertum, E. subarcticum, Pateoris cf. hauerinoides, and abandoned tests of Elphidium sp. , Lagena semilineata, Spiroplectammina biformis and Trochammina squamata.

The diameters of the observed specimens of benthonic Foraminifera range between 0. 14 and 0. 66 millimetres. Hjulström (1939) has noted that the lowest fluid velocities required for the initiation of particle movement occurs for those particles with diameters that fall within the 0. 1 to 1. 0 millimetre range; foraminiferal tests are consequently most susceptible to erosion and transport by currents. This susceptibility is further enhanced when the tests contain a small amount of air, which reduces their envelope density in water. The presence of significant numbers of both living and abandoned foraminiferal tests in the trap samples shows that transporting mechanisms are active in the Bedford Basin and that these mechanisms are responsible for the displacement of significant numbers of both living and dead specimens of certain species from their normal environment. The absence of living specimens of certain species found in the trap may be indicative of a selectivity brought about by a combination of factors (e. g. mode of attachment, envelope density and shape etc.).

A microscopic examination of the sediment samples from the trap revealed that the zooplanktonic component of the sediment was almost exclusively represented by a large number of empty lorica of tintinnids identified as Parafavella sp. , Helicostomella subulata, H. fusiformis and Tintinnopsis sp. , the first two being most abundant. The phytoplankton in the sediment samples was represented mostly by large, thick-walled and pale yellow naviculoid diatoms like Gyrosigma, Navicula, Amphora and Pinnularia. Of these, Gyrosigma was present in highest numbers and included a few motile forms. No centric diatoms were observed in the sediment sample. Silicoflagellates were represented by a single species identified as Distephanus speculum.

The presence of these planktonic organisms in the trap sediment also lends some degree of support to the current transport hypothesis. The summer phytoplankton in Bedford Basin is characterized by a high incidence of armoured dinoflagellates belonging to genera Certaium, Peridinium and Dinophysis (Prakash, unpublished records). During the period of trap experiment the plankton was dominated by Ceratium longipes and to a lesser extent by several species of the diatom, Chaetoceros. None of these phytoplankters were ever found in the sediment samples examined. On the other hand, empty lorica of the tintinnids Parafavella sp. and Helicostomella subulata which were observed in large numbers in the trap sediment, were generally absent from the plankton during the period of the trap experiment. Tintinnids in the Bedford Basin usually accompany or follow the dinoflagellate bloom and are found in large numbers in the surface layers during August and September. Although Helicostomella subulata made a modest appearance in the plankton in July, the absence of the dominant tintinnid Parafavella sp. from the plankton during the period of trap experiment leads us to believe that the tintinnid lorica found in the sediment samples belonged to the population from the previous biological season. This disparity between the planktonic organisms present in the water column during the three month period and those found in the trap sediment suggests fairly active lateral transporting mechanisms in the Bedford Basin.

Future research will require the determination of the degree and frequency of transport of benthonic Foraminifera in areas selected for ecological studies of these protozoa. This, in turn, will enable greater precision in the interpretation of cored samples that have been obtained for paleoecologic and (or) paleoclimatic studies.

Acknowledgements

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