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A Faunal Interpretation of Tidal Evolution in Minas Basin, Nova Scotia
Une interprétation faunique de l'évolution de l'amplitude des marées dans le bassin des Mines, Nouvelle-Écosse

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Article abstract

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A FAUNAL INTERPRETATION OF TIDAL EVOLUTION IN MINAS BASIN, NOVA SCOTIA

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ABSTRACT Interpretation of the evolution of the tidal cycle in Minas Basin and upper Bay of Fundy (Scots Bay) based on molluscan assemblages agrees well with that derived by AMOS (1978) from sedimentological evidence. Prior to about 6300 years B.P. quiet water conditions, *i.e.* with minimal or no tidal activity, prevailed. From that time, tidal range and intensity have increased to their present levels. The molluscs show this change by a change from intact specimens of deposit feeders at, or near, the base of two of the vibrocores, through a mixture of incomplete specimens and suspension feeders, to accumulations of minute, unidentifiable shell fragments.

RÉSUMÉ *Une interprétation faunique de l'évolution de l'amplitude des marées dans le bassin des Mines, Nouvelle-Écosse.* Une interprétation de l'évolution du cycle des marées dans le bassin des Mines et le fond de la baie de Fundy (baie Scots), fondée sur les assemblages de mollusques, correspond bien à celle qu'AMOS (1978) a donnée en se basant sur des preuves sédimentologiques. Avant environ 6 300 BP, les eaux étaient calmes, c'est-à-dire qu'il y avait peu ou pas de marées. Par la suite, l'amplitude et l'intensité des marées se sont accrues pour atteindre les niveaux actuels. L'examen des mollusques de deux des carottes, obtenues par vibration, confirme cette interprétation puisque l'on passe de spécimens intacts de mangeurs de sédiments, à la partie inférieure des forages, à un mélange de spécimens incomplets de mangeurs de sédiments et de mangeurs de matières en suspension, puis à des accumulations de fragments d'écailles minuscules et non identifiables, vers le sommet.

INTRODUCTION

The Minas Basin area, Nova Scotia, because of its possible involvement with tidal power development, has been the subject of various recent studies. One of these, by AMOS (1978), was concerned with the distribution and evolution of postglacial sediments and with the development of the tidal regime in the basin. Five vibrocores were obtained by Amos, three from Minas Basin and one each from Cobequid Bay and Scots Bay (Fig. 1). These cores, taken at depths between 15 and 18 m below low water in Minas Basin and Cobequid Bay, and 29 m in Scots Bay, were from 182 cm to 370 cm in length.

AMOS (1978) identified four sedimentary units in these cores ranging from watery silts and clays up through well sorted sands and poorly sorted shelly gravels to pebbles and cobbles at the top. He equated the increasing coarseness with the increase in tidal activity. At least two of the cores, one from Minas Basin and the other from Scots Bay, bottomed in glacial deposits, material from the base of these cores being radiocarbon-dated at 14,180 ± 710 years B.P. (GX-4514) and 37,000 years B.P. (GX-4522)[1] respectively. Dates for the bottoms of the other two cores in Minas Basin were 6240 ± 175 years (GX-4515) and 8665 ± 195 years B.P. (GX-4516), and for the core from Cobequid Bay, 7255 ± 250 years B.P. (GX-4938).

FAUNAL EVIDENCE

Initially, only samples taken at, or near, the base of each vibrocore were examined for faunal content. Identifiable molluscs were found only in the Minas Basin and Scots Bay cores. A single unidentifiable fragment of mollusc shell was present in the sample from Cobequid Bay (Vibrocore 2). Foraminifera were encountered in some of the samples and these plus the molluscs comprised a suite of shallow, open-water marine species (AMOS, 1978, p. 967).

More recently samples were taken from the five vibrocores at 30 cm intervals and examined for molluscs.

1. These and other radiocarbon dates are by Kruger Labs and are based on total carbon.

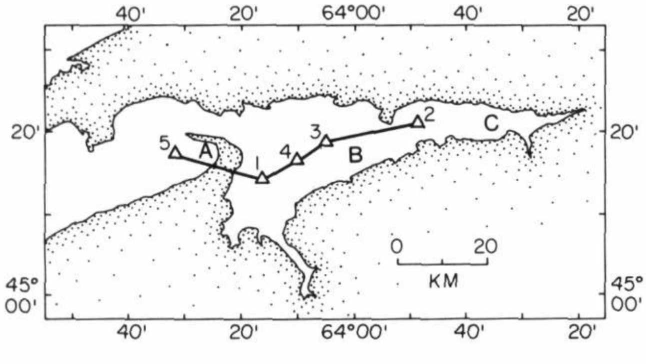

FIGURE 1. Location of vibrocores. A) Scots Bay; B) Minas Basin; C) Cobequid Bay.
Localisation des forages. A) Baie de Scots; B) bassin des Mines; C) baie de Cobequid.

Twenty-two forms have been identified to species. A further five were identifiable only to the generic level. Species identified from Vibrocores 1 and 5 are listed in Table I.

Vibrocore 2, in Cobequid Bay, yielded only unidentifiable fragments from the surface and from the 60, 150, 180 and 182 cm intervals. Samples from the 30, 90 and 120 cm levels were barren. The core in Minas Basin closest to Cobequid Bay, Vibrocore 3, was almost as devoid of molluscs. Unidentifiable shell fragments were found at the surface and at 30, 60, 90 and 287 cm below the surface. Fragments of *Mytilus edulis* Linné were present in the 90 cm sample, and fragments of *Anomia* sp. and? *Mya* sp. at the bottom of the core at 287 cm. In Vibrocore 4 also molluscs were sparsely represented. As before, unidentifiable fragments were common. They were found in the 30, 60, 90, 150, 180, 300 and 333 cm intervals. The surface sample of this core was barren. Fragments of *Macoma balthica* (Linné) and *Ensis directus* (Conrad) were identified from the 30 cm and 90 cm intervals respectively. The bottom of the core yielded a complete embryonic shell, tentatively referred to *Spisula polynyma* (Stimpson) and a single valve, also embryonic, of *Mya truncata* Linné. The molluscan evidence from these three cores is inconclusive but it does suggest considerable reworking of molluscan material from older, shallow-water deposits. Vibrocores 1 and 5 give a more comprehensive record.

Vibrocore 1, near the western end of Minas Basin, penetrated 209 cm of sediment. The sequence comprises approximately 30 cm of surficial pebbles and cobbles overlying 25 to 30 cm of sand with shells. Below this level the rest of the core is composed of clay with sand laminations (Fig. 2). The base of the core was dated at approximately 6240 years B.P., whereas a sample taken 30 cm below the top of the core gave a radiocarbon date of 7490 ± 315 years B.P. (GX-4939). The older date from near the top complements the fragmentary nature of the shells from that interval as evidence for reworking. Shells from lower in the core were a mixture of complete and broken specimens.

Vibrocore 5, from Scots Bay, was similar sedimentologically to Vibrocore 1 except for the presence of a few centimetres of sand at the bottom. This core is well documented regarding age with 7 radiocarbon dates having been determined (AMOS, 1978). As previously stated, the bottom of the core, at 370 cm, was dated at 37 000 years B.P. Complete shells were identified from a depth of 365 cm in the core, but these were not dated. The sequence of dates for the rest of the core was 7530 ± 175 years (GX-4521) at 300-315 cm, 8040 ± 360 years (GX-4520) at 212-214 cm, 6030 ± 320 years (GX-4519) at 100-120 cm, 7300 ± 350 years (GX-4518) at 30-35 cm, 9130 ± 440 years (GX-4936) at 30 cm and 735 ± 205 years (GX-4517) at 0-20 cm (AMOS, 1978, p. 973). The dates for the 100 to 120 cm and 300 to 315 cm intervals may reflect *in situ* occurrences and indicate the true sequence of events, but the other dates indicate the results of reworking. AMOS (1978, p. 972) considered that much of the sequence indicated reworking from marginal deposits.

Most of the molluscan species appearing in the cores are either deposit feeders or suspension feeders. Carnivores and ectoparasites were represented sparingly. Deposit feeders prefer areas of quiet waters and fine grained sediments, whereas suspension feeders are normally found in coarser sediments where waters are agitated. All species from the cores collectively indicate waters less than about 10 m deep although there is a variation in range among the species, some having a deeper lower limit than others. About half of the species, namely the pelecypods *Arctica islandica* (Linné), *Cerastoderma pinnulatum* (Conrad), *Ensis directus* Conrad, *Hiatella arctica* (Linné), *Macoma balthica* (Linné), *Mytilus edulis* Linné, *Nucula proxima* Say and *Pitar morrhuanus* Linsley and the gastropods *Cingula aculeus* Gould, *Nassarius trivittatus* (Say) and *Turbonilla interrupta* (Totten) were reported previously from Minas Basin by BOUSFIELD and LEIM (1959). They remarked that *Mytilus edulis*, a common intertidal species around the coasts of Nova Scotia, was remarkably scarce in the basin. It was of rare occurrence in the core samples also.

In Vibrocore 1 shells at the bottom (209 cm interval) consisted of a mixture of complete specimens and single valves of pelecypods. Except for a single valve of *Nucula proxima* Say, all specimens were of embryonic individuals. Numbers were about equally divided between deposit feeders and suspension feeders. However, because embryonic forms are freely transported, the assemblage is not diagnostic of the degree of current or tidal action at that time. The age of 6240 years B.P. would be feasible for an *in situ* occurrence.

TABLEAU I

Occurrence of molluscan species in Vibrocores 1 and 5

Core Interval (cm)	Sfc	30	60	90	120	150	180	205	209	365
Vibrocore 1										
Unidentifiable fragments	300 ±	100 ±	200 ±	200 ±	150 ±	75 ±	15	35	5	
Mytilus edulis Linné	0,0,3*	—	—	—	—	—	—	—	—	
Nassarius trivittatus (Say)	—	—	2,0,0	—	—	2,0,1	—	—	1,0,0	
Acteocina canaliculata (Say)	—	—	1,2,0	—	1,4,0	0,0,1	1,1,0	—	—	
Ensis directus Conrad	—	—	0,0,3	—	0,0,4	—	0,0,1	—	0,1,0	
Nucula sp.	—	—	0,0,4	0,0,1	0,0,2	—	—	—	—	
Yoldia sp.	—	—	0,0,3	0,0,2	0,0,8	—	—	—	—	
Pitar morrhuanus Linsley	—	—	0,6,2	0,3,2	0,4,2	0,0,1	—	—	—	
Pandora sp.	—	—	0,0,1	—	0,0,1	—	—	—	—	
Turbonilla interrupta (Totten)	—	—	—	0,1,0	1,0,0	—	—	—	—	
Cerastoderma pinnulatum (Conrad)	—	—	—	0,0,1	—	—	—	—	—	
Yoldia myalis (Couthouy)	—	—	—	—	0,3,0	—	—	—	—	
Yoldiella lenticula (Möller)	—	—	—	—	0,4,0	—	—	—	—	
Nucula delphinodonta Mighels and Adams	—	—	—	—	—	0,2,0	—	—	—	
Nucula proxima Say	—	—	—	—	—	—	—	—	0,1,0	
?*Limposis* sp.	—	—	—	—	—	—	—	—	1,0,0	
?*Delectopecten vitreus* (Gmelin)	—	—	—	—	—	—	—	—	0,2,0	
Amomia simplex d'Orbigny	—	—	—	—	—	—	—	—	0,7,0	
Hiatella arctica (Linné)	—	—	—	—	—	—	—	—	0,1,0	
Velutina sp.	—	—	—	—	—	—	—	—	2,0,0	
pelecypod-indet.	—	—	—	—	—	—	—	—	2,5,0	
gastropod-indet.	—	—	—	—	—	—	—	—	1,0,0	
Vibrocore 5										
Undentifiable fragments	300 ±	3	100 ±	—	50 ±					—
Cingula aculeus Gould	—	—	4,0,0	4,0,0	—					—
Nassarius trivittatus (Say)	—	—	1,0,0	1,0,0	—					1,0,0
Acteocina canaliculata (Say)	—	—	7,0,0	2,0,0	0,1,0					1,0,0
Nucula delphinodonta Mighels and Adams	—	—	0,3,4	3,7,0	0,1,0					—
Nucula proxima Say	—	—	1,16,0	0,6,0	0,4,6					4,7,0
Yoldia myalis (Couthouy)	—	—	0,1,2	—	0,1,0					—
Yoldiella frigida (Torell)	—	—	0,6,0	0,6,0	0,1,0					—
Anomia simplex d'Orbigny	—	—	0,1,0	—	—					—
Mulinia lateralis (Say)	—	—	0,34,6	0,5,0	0,5,2					—
Tellina agilis (Stimpson)	—	—	—	0,1,0	—					—
Arctica islandica (Linné)	—	—	—	0,1,2	—					—
pelecypod-indet.	—	—	—	3,4,0	—	0,1,0				
?*Yoldiella lenticula* (Möller)	—	—	—	—	0,2,0					—
?*Spisula polynyma* (Stimpson)	—	—	—	—	—					0,1,0
?*Yoldia* sp.	—	—	—	—	—					0,0,1

* 1^{st} column, number of complete specimens; 2^{nd} column, number of single pelecypod valves or eroded gastropods; 3^{rd} column, number of fragments.

None of the species is indicative of the colder conditions prevailing during and immediately after the withdrawal of glacier ice from this area. A sample from 205 cm below the surface yielded only minute unidentifiable fragments. Molluscs were scarce at 180 cm with only two specimens of *Acteocina canaliculata* (Say), one complete and one eroded, and one fragment of *Ensis directus* Conrad. *A. canaliculata* is probably a carnivore and *E. directus* is a suspension feeder. There were also about a dozen unidentifiable fragments in this sample. The nature of the material would suggest that it was not in place. At 150 cm below the surface complete or minimally worn specimens were present in conjunction with about 75 minute, unidentifiable fragments. The complete specimens consisted of two juvenile *Nassarius trivittatus* (Say). This interval probably represents a continuation of agitated-water conditions. Only unidentifiable fragments were found at 30 cm and

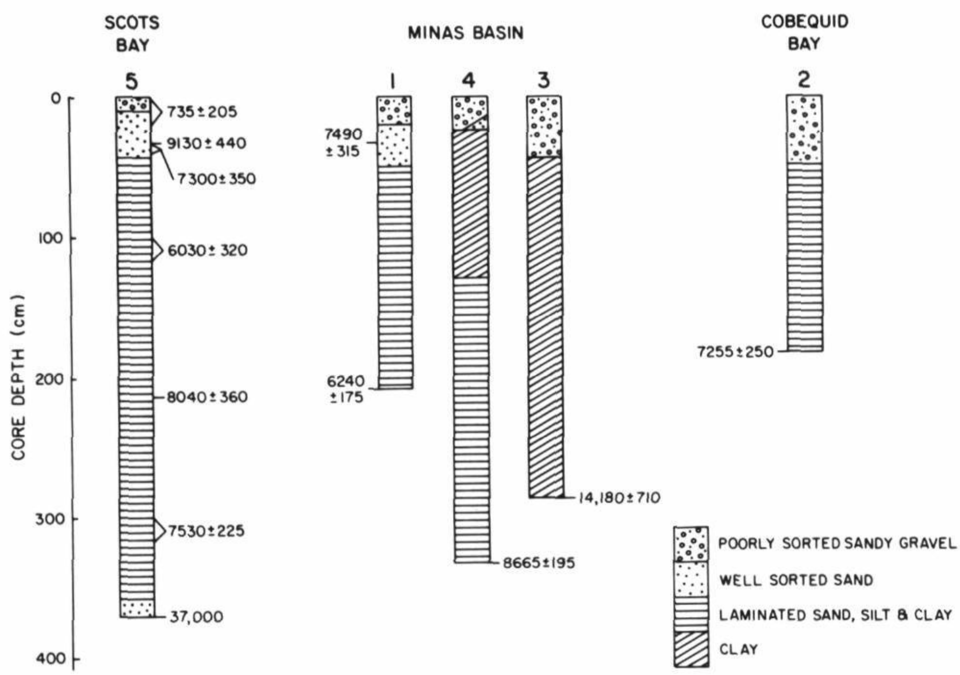

FIGURE 2. Sediment sequence in the cores and location of radiocarbon dates.
Ordre d'apparition des sédiments à l'intérieur des carottes et localisation des dates au radiocarbone.

the date of 7 490 years B.P. shows this material definitely to be redeposited. The deposit-feeding molluscs throughout much of the core where other evidence points to disturbed conditions were probably reworked from older deposits formed before the onset of recognizable tidal activity. AMOS (1978, p. 970) has determined 6300 ± 1100 years B.P. as a reasonable date for the start of pronounced tidal activity. The surface sample from this core, although it contained several minute fragments of *Mytilus edulis*, yielded mainly unidentifiable fragments, again evidence for strong currents.

Outside of Minas Basin, in Scots Bay, somewhat different conditions prevailed. The bottom of Vibrocore 5, at 370 cm, was dated at 37,000 years B.P. No molluscs were present in this sample. However, the assemblage from 365 cm showed a definite resemblance to that from the interval in Vibrocore 1 dated at 6240 years B.P. Thus these shells are apparently of postglacial age and young enough to be more recent than the immediately postglacial cold period. Unidentifiable fragments were absent from the sample. Complete specimens of *Nassarius trivittatus* and *Nucula proxima*, both deposit-feeders, indicate quiet waters. Part of the record from this core was missing and the next shell-bearing sample was from 120 cm below the surface. AMOS (1978, p. 973) gave two dates for this part of the core, 75300 ± 225 years (GX-4521) for 300 to 315 cm below the surface and 8040 ± 360 years B.P. (GX-4520) for the 212 to 214 cm interval. Although there is a possibility that the lower date does represent a slightly older time (7530 + 225 = 7755; 8040 − 360 = 7680) it is more likely that the juxtaposition of dates is real and reflects deposition of reworked material between 315 and 212 cm in the core. At 120 cm, deposit-feeding molluscs were dominant. There were no intact specimens although single valves of pelecypods were present. However, fragmentary material outnumbered the single valves. A date of 6030 ± 320 years B.P. (GX-4519) was obtained (AMOS, 1978) for the interval between 100 and 120 cm. Physical evidence suggests that the molluscs from the 120 cm interval were redeposited from probably nearby older deposits but were not strongly reworked. The same remarks apply also to the 90 and 60 cm intervals. Tidal currents were seemingly less intense here than in the confines of Minas Basin over much of the span of this core. Only minute, unidentifiable fragments were found in the 30 cm and surface samples, suggestive of stronger current action. Complete specimens of *Macoma balthica* (Linné) had been taken from the surface sample previously (AMOS, 1978, p. 974) for radiocarbon dating. The shells gave an age of 735 ± 205 years B.P. (GX-4517). AMOS decided that the shells had probably been picked up from shallower waters by winter ice about 735 years ago and dropped at the site of Vibrocore 5 during spring thaws.

CONCLUSIONS

AMOS (1978) had concluded, on the basis of radiocarbon dating and the sedimentological record, that prior to 6300 ± 1100 years ago tides in Minas Basin and upper Bay of Fundy were minimal. Subsequently, tidal range and related currents began to increase to their present levels. Molluscan evidence parallels that of the sediments in showing an initial quiescent period followed by increasing current activity. Amos was able to deduce current velocities on the basis of change in sediment characteristics. Such determinations, however, are beyond the scope of the faunal evidence. Nevertheless, molluscan and sedimentary evidence are compatible with regard to the onset and relative increase of tidal activity.

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