A COMPARISON BETWEEN THE LATE WISCONSINAN HISTORY OF SOUTHWEST AND NORTHEAST EMERALD BASIN

by

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ABSTRACT

A ridge comprised of multiple till separates the Late Wisconsinan glaciomarine sediments of SW and NE Emerald Basin. Seismostratigraphic evidence from this feature indicates that the lowermost beds of Emerald Silt, facies A in NE Emerald Basin are older than those of the SW basin. The uppermost beds of facies A of the two sections appear to be time equivalent.

INTRODUCTION

Recent work by Gipp and Piper (in prep.) and Piper *et al.* (1988) constitutes a significant contribution to the chronostratigraphy and seismostratigraphic interpretation of glaciomarine sediments in SW Emerald Basin. Their dates (^{14}C AMS on mollusc shells), together with new AMS shell dates (King and Fader, 1988), conflicts with the chronology of King and Fader (1986) which suggested a long period of recession and deglaciation on the Scotian Shelf throughout much of Middle Wisconsinan time. The new data indicate a Late Wisconsinan age for the glaciomarine section (Emerald Silt, facies A and B) from both basins. However, because the Emerald Silt section represents only part of the recessional phase of shelf glaciation as evidenced by seismostratigraphic data (Mosher, 1987; Piper, 1988; and King and Fader, in prep.), the early chronology of the last major glaciation on the shelf is still not well understood.

Gipp (1988) also questioned certain aspects of the depositional environment suggested by King and Fader (1986) for the ice-proximal glaciomarine sediment (Emerald Silt, facies A). Although we agree in part with his interpretation, some of his conclusions require qualification. Part of the disagreement arises from the fact that the glaciomarine sections of NE and SW Emerald Basin are separated by a stratigraphically-complex barrier of till. Piper *et al.* (1988), and Gipp and Piper, in press, suggested that the stratigraphic sections of facies A, Emerald Silt are equivalent on either side of the barrier. It is the purpose of this study to demonstrate that the sections are not completely equivalent.

The bathymetry of NE and SW Emerald Basin is shown in Figure 1, together with the location of piston cores and the relevant geological elements.

DIVISION OF GLACIOMARINE SECTIONS WITHIN EMERALD BASIN

Figure 2 (in pocket) is a high resolution seismic reflection profile across a ridge of till which separates the glaciomarine (Emerald Silt) and overlying marine (LaHave Clay) sections of SW and NE Emerald Basin. Thus, correlation of these sections cannot be achieved directly from seismic reflection profiles.

The seismic fabric of the ridge comprises incoherent reflections which regionally characterize glacial till. The interpreted till can be separated into two ridges, A and B, on the basis of a contrast in fabric density or grey-level. The "denser" ridge, A, is draped by a thin blanket of Emerald Silt, facies A which appears to correlate with the lower part of the facies A section in NE Emerald Basin. Between kilometre marks 6.0 and 6.9 the till of ridge A and its overlying blanket of Emerald Silt, facies A, dips below the till of ridge B indicating a difference in age between the two ridges.

In SW Emerald Basin the younger till (ridge B) interdigitates with the Emerald Silt, facies A to form a till tongue in the lower portion of the section. Ridge B may be a continuation of the Sambro Moraine along the basin flank. The upper section of facies A occurs as a time-transgressive onlap along the upper surface of the till where the individual beds of Emerald Silt blend gradationally with the till at several horizons along the contact. This relationship is interpreted to represent a retreating ice margin (buoyancy line) when interpreted in terms of the till tongue model (King and Fader, 1986; and King *et al.*, 1987).

CHRONOLOGY OF LITHO- AND SEISMOSTRATIGRAPHIC EVENTS

NE Emerald Basin

Ten new ^{14}C AMS shell dates from the Late Wisconsinan and Holocene sections of NE Emerald Basin were very briefly discussed by King and Fader (1988). These dates are shown in Table I.

TABLE I - ^{14}C AMS Shell Dates for Glaciomarine and Marine Sediment from NE Emerald Basin

Core # and Depth Below Seabed (cm)	Formation	Species	Age (a B.P.)
79-011-1 (27)	LaHave Clay	not identified	6130 ± 150
79-011-1 (338)	LaHave Clay	not identified	7740 ± 170
79-011-1 (557)	LaHave Clay	*Yoldia thraciae formis*	9450 ± 100
79-011-1 (701)	Uppermost Emerald Silt, facies B	*Nucula tenuis*	10580 ± 110
79-011-1 (815)	Emerald Silt, facies B	not identified	18206 ± 350
82-003-4s (210)	Emerald Silt, facies B	*Nucula proxima*	13550 ± 150
82-003-6s (285)	Emerald Silt, facies B	*Portlandia arctica*	14250 ± 130
79-011-10 (552)	Uppermost Emerald Silt, facies A	*Portlandia arctica*	14600 ± 150
79-011-10 (386)	Uppermost Emerald Silt, facies A	*Portlandia arctica*	14680 ± 120
79-011-11 (495)	Uppermost Emerald Silt, facies A	*Portlandia arctica*	14850 ± 170

In Figure 3 the new dates are plotted against the total glaciomarine sequence determined on the basis of seismostratigraphy. Through the use of seismic control, the thickness above the basal till section was corrected for variations in local sedimentation rate between the various core sites, (King and Fader, 1986). With the exception of one date (18.0 ka) the plot shows very little scatter through the uppermost 40 m of the section, and indicates a slight increase in sedimentation rate with increase in depth. The 18.0 ka date appears to be erroneous. Litho- and seismostratigraphic events are superimposed on the plot.

The plot of Figure 3 is used to date the top of the ice-proximal beds (Emerald Silt, facies A) at 14.5 ka which represents the time of major ice withdrawal from the central shelf area. It also dates the uppermost till tongues at the flank of the adjacent bank at 15.0 to 15.5 ka.

The overlying ice-distal deposits (Emerald Silt, facies B) occur within the time interval of 14.5 and approximately 10.0 ka. During this interval of approximately 4500 years, the glacial margin may have been located along the inner shelf, and possibly sourced the ice-distal deposits of the central shelf.

Seismostratigraphic evidence indicates a widespread erosional unconformity over large areas of the basin and the removal of variable thicknesses of the glaciomarine muds. The unconformity was formed during late Emerald Silt, facies B time (King and Fader, 1988). The unconformity can also be traced to the adjacent bank areas where it occurs close to the present seabed. The erosional event occurred sometime between the dates of 9450 ± 100 and 10580 ± 110 a B.P. (Table I), or approximately 10.0 to 10.5 ka using Figure 3 as an aid in estimation. King and Fader (1988) interpreted the unconformity as being glacial in origin, and identified several glacial deposits associated with it. They correlated the short glacial interval with the Younger Dryas event of northwest Europe. The chronology of events are summarized in Table II.

Table II - Estimated Chronology for Late Wisconsinan and Early Holocene Events in NE Emerald Basin

Chronology	Stratigraphic Horizons and Events
9450 ± 100 a B.P.	Lowermost dated beds of LaHave Clay, 50 cm above base
Approximately 10.0 ka	Base of LaHave Clay and beginning of Holocene
Approximately 10.0 - 10.5 ka	Formation of glacial erosional surface and glacial deposits on the banks during the Younger Dryas event. Equivalent to unconformity near the top of Emerald Silt, facies B in the basin
10580 ± 110 a B.P.	Uppermost dated beds of Emerald Silt, facies B, 75 cm below unconformity near top of unit
Approximately 14.5 ka	Top of Emerald Silt facies A and base of Emerald Silt, facies B, representing the time of departure of the major Late Wisconsinan glaciation from the central Scotian Shelf.

Figure 3 shows that the lower 40 m of succession also comprises Emerald Silt, facies A. Only the upper 20 m portion of the facies A section has been sampled by piston cores, and the AMS chronology has not yet been established. The stratigraphic position of the stacked till tongue succession which interdigitates with this glaciomarine section farther up on the basin flank is also indicated on the diagram, as well as the lift-off moraines which occur at the surface of the basal till unit.

SW Emerald Basin

Piper *et al.* (1988) and Gipp and Piper (in prep.) obtained ^{14}C AMS dates on mollusc shells from four long cores in SW Emerald Basin. Several of the cores penetrated the entire sediment sequence to the basal till, and the dates show a constant increase in age with depth in the seismic stratigraphy. They used sequence analysis in their stratigraphic interpretation, and recognized six units numbered 0 to 5. Units 0 to 2 correspond to Emerald Silt, facies A of King and Fader (1986), 3 and 4 to Emerald Silt, facies B, and 5 to LaHave Clay. For purposes of comparison their dates are shown in Table III.

TABLE III - ^{14}C AMS Dates for Glaciomarine and Marine Sediment from SW Emerald Basin (Gipp and Piper, in prep.)

Core # and Depth Below Seabed (cm)	Depositional Sequence	Species	Age (a B.P.)
86034-25 (192)	4	*Nuculana delphinodonta*	13740 ± 220
87003-2 (754)	3	*Macoma calcarea*	14430 ± 300
87003-2 (1190)	3	*Nucula tenuis*	14870 ± 280
86034-23 (60)	3	*Portlandia arctica*	14960 ± 240
87003-6 (922)	2	*Portlandia arctica*	15060 ± 310
87003-2 (1380)	2	*Portlandia arctica*	16000 ± 320
86034-23 (339)	2	*Nucula proxima*	16690 ± 310
86034-25 (681)	1	*Portlandia arctica*	17380 ± 300

Discussion

An age of 17.5 to 18.0 ka was estimated for the top of the till in SW Emerald Basin (Gipp and Piper, in prep.), based on an extrapolation of a constant sedimentation rate below the deepest date of 17380 ± 300 a B.P. No dates are available in NE Emerald Basin for the base of the section, but the seismostratigraphy across the till barrier separating the SW and NE basins indicates that the basal recessional Emerald Silt section of NE Emerald Basin is older. An estimate of 20.0 ka for the time of lift off may be reasonable.

Evidence for a grounded ice margin on the southern flank of SW Emerald Basin is indicated by the shallowest till tongue of the basin which has an extrapolated age of 15.0 ka (Gipp and Piper, in prep.). This compares favorably with estimated dates of 15.5 to 15.0 ka for the two uppermost till tongues of NE Emerald Basin. The best indicator of ice withdrawal in the area is provided by the cessation of ice-proximal (Emerald Silt, facies A) deposition. Estimated dates for the top of facies A of 15.0 ka for

SW Emerald Basin (Table III), and 14.5 ka for NE Emerald Basin (Fig. 3 and Table II) are in good agreement.

The sequence 3 (Emerald Silt, facies B) dates of SW Emerald Basin do not depict the age of the upper boundary of the ice-distal deposit, but all fall within the age limits suggested for this unit in NE Emerald Basin. The unconformity at the top of facies B over much of the eastern portion of NE Emerald Basin is not conspicuous in SW Emerald Basin suggesting that the succession is complete to the Holocene boundary at the base of the LaHave Clay which is dated at 10.0 ka for NE Emerald Basin.

In general, the uppermost chronology of the Emerald Silt for the two basins is very similar, but the lowermost appears to be older for the NE basin. The thickest succession in the SW basin is approximately 20 m while that of the NE basin sometimes exceeds 90 m but varies over a wide range.

DEPOSITIONAL ENVIRONMENT OF ICE-PROXIMAL DEPOSITS

King and Fader (1986) originally related deposition of the ice-proximal Emerald Silt, facies A Formation to raindown from a pinned ice shelf, but the model was later modified by King *et al.* (1987) and the draped stratigraphic style and rhythmically banded beds were attributed to deposition from overflow plumes. This eliminated the basic requirement for an ice shelf. The possibility for having open water conditions greatly simplified the explanation for a rich fauna in the glaciomarine succession.

Gipp (1988) noted the occurrence of buried erosional features 2 to 5 m deep and 30 to 100 m long within the succession of Emerald Silt, facies A which he interpreted as relict iceberg scours. He also recognized the need for reevaluation of the original King and Fader (1986) ice model. Although the buried iceberg scours are common in SW Emerald Basin, they have as yet not been recognized in NE Emerald Basin.

Gipp and Piper (in prep.) also reported the occurrence of mollusc shells throughout the Emerald Silt, facies A sequence which further attests to open water conditions for SW Emerald Basin. In NE Emerald Basin, King and Fader (1986) noted the absence of shells in the deeper areas of the succession which they were able to sample. A decreasing trend was also noted in the foraminiferal abundance. The marked decrease in fauna with depth opens the possibility for the presence of a pinned ice shelf during the early stages of lift-off in NE Emerald Basin. The abundance of lift-off moraines at the base of the section, as well as, the confining topographic configuration surrounding the basin, are also important considerations in evaluating the possibility of an early ice shelf. Also, the occurrence of a subglacial lake, maintained by a meltwater supply from grounded ice at the basin flanks, may have been possible during the early stage of recession in NE Emerald Basin.

CONCLUSIONS

Several important differences exist between the SW and NE Emerald Basin glaciomarine sections which were not recognized by Gipp and Piper (in prep.), Gipp (1988) and Piper *et al.* (1988):

1. The lower part of the Emerald Silt sections are not entirely equivalent in time and ice lift-off appears to have occurred earlier in NE Emerald Basin.
2. Present sampling control indicates that a faunal assemblage was not present during early Emerald Silt, facies A time in NE Emerald Basin; however, it should be noted that the sample suite was obtained in close proximity to the ice margin and conditions may have been different in the central area of the basin.
3. A pinned ice shelf may have been present in NE Emerald Basin during early deposition of the glaciomarine section.

We concur with the conclusions of Piper *et al.* (1988) and Gipp and Piper (in prep.) that the Scotian Shelf was glaciated during Late Wisconsinan time, and have contributed additional supporting evidence. In addition, we believe that a terrestrial ice cap was established for a short time within the interval of 10.5 to 10.0 ka (King and Fader, 1988) which was equivalent to the Younger Dryas period of climatic cooling.

We also suggest that the revised till tongue model (King *et al.*, 1987) is compatible with the evidence for buried iceberg scours in SW Emerald Basin and we recognize that the ice shelf model originally proposed by King and Fader, 1986 required revision.

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FIGURE CAPTIONS

Figure 1. Location map.

Figure 2. High resolution seismic reflection profile across till barrier separating NE and SW Emerald Basins.

Figure 3. Chronology of Emerald Silt and LaHave Clay in Northeast Emerald Basin.

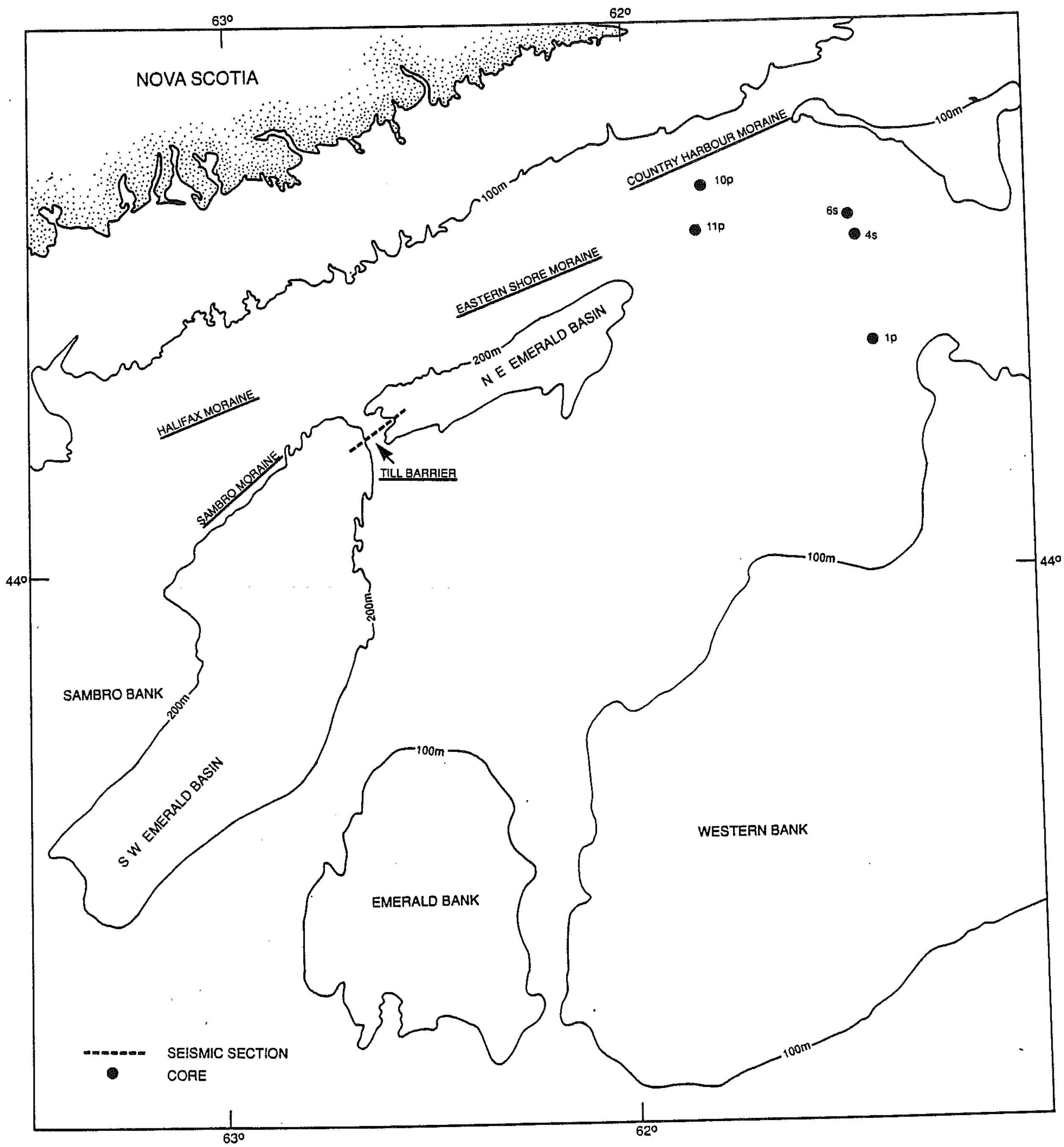
63°
62°
NOVA SCOTIA
100m
COUNTRY HARBOUR MORAINE
10p
11p
6s
4s
EASTERN SHORE MORAINE
1p
200m
N E EMERALD BASIN
HALIFAX MORAINE
SAMBRO MORAINE
TILL BARRIER
44°
100m
200m
SAMBRO BANK
200m
S W EMERALD BASIN
100m
WESTERN BANK
EMERALD BANK
100m
SEISMIC SECTION
CORE
63°
62°

FIGURE 1

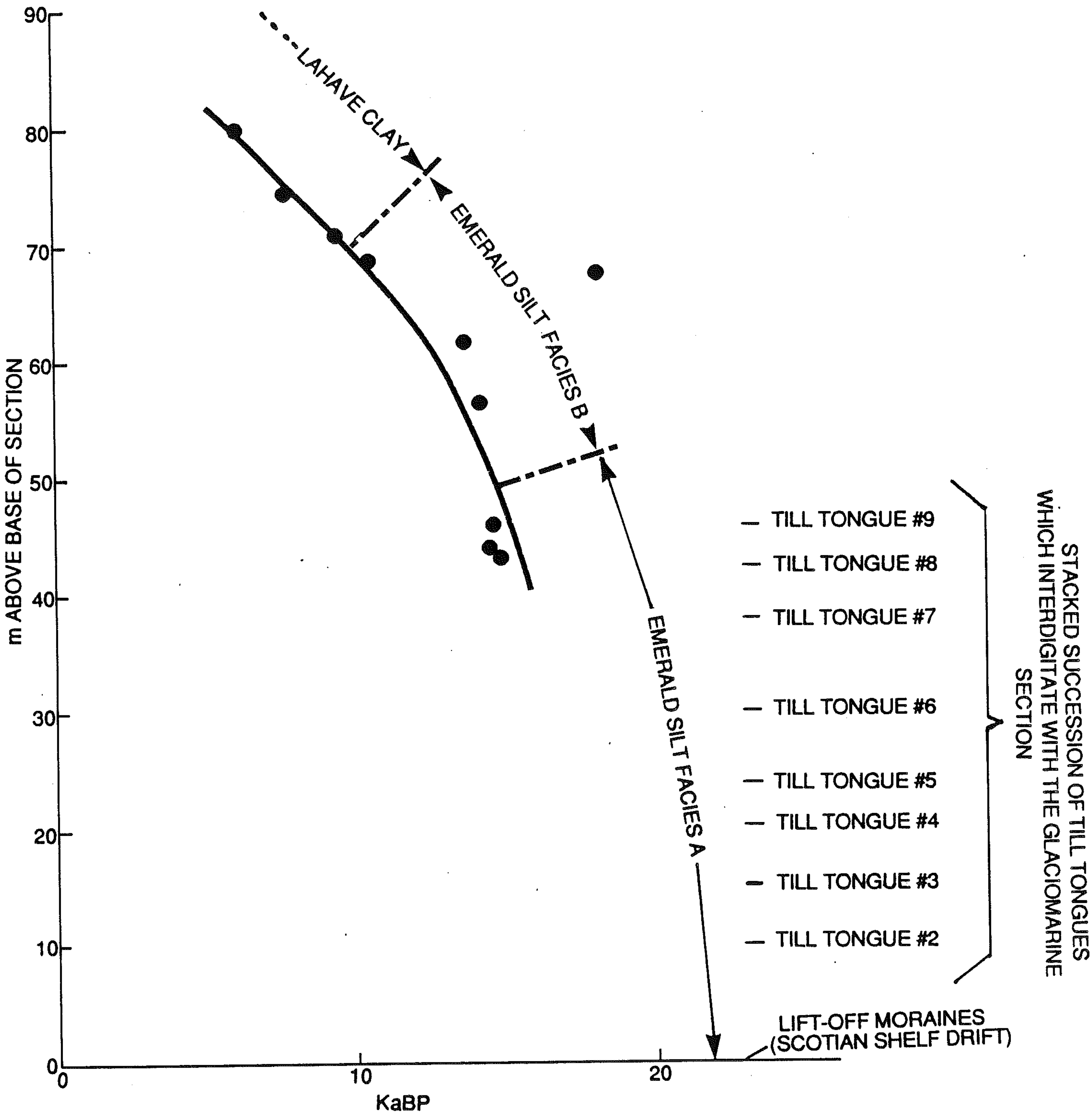
90
80
70
60
50
40
30
20
10
0
m ABOVE BASE OF SECTION
0
10
20
KaBP
LAHAVE CLAY
EMERALD SILT FACIES B
EMERALD SILT FACIES A
TILL TONGUE #9
TILL TONGUE #8
TILL TONGUE #7
TILL TONGUE #6
TILL TONGUE #5
TILL TONGUE #4
TILL TONGUE #3
TILL TONGUE #2
STACKED SUCCESSION OF TILL TONGUES WHICH INTERDIGITATE WITH THE GLACIOMARINE SECTION
LIFT-OFF MORAINES
(SCOTIAN SHELF DRIFT)

FIGURE 3