Genesis of the Raised Fluviomarine Outwash Terrace, North Shore of the Minas Basin, Nova Scotia; A Preliminary Report *

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Abstract

A late Pleistocene outwash deposit forms a discontinuous raised terrace between the Cobequid Hills and the north shore of the Minas Basin, Nova Scotia. Three lithosomes may be distinguished. At Advocate Harbour sea bluffs and numerous sand pits expose well stratified sandy gravels and openwork gravels of the glaciolittoral lithosome. These were deposited in a wave-agitated environment similar to the modern Advocate Bay. Here the surface of the terrace is moulded into a lagoon enclosed by spits and backed by a wave-cut bluff, closely resembling the modern Advocate Harbour. Between Cape Spencer and Five Islands, river valleys are filled with a glaciodeltaic lithosome. Bottomset clay deposits and sand and gravel foreset and topset deposits contain ice contact features and, rarely, casts and moulds of Portlandia glacialis. The glacio-deltaic lithosome is disconformably overlain by a sheet of kettled glaciofluvial gravels exhibiting a relict braided pattern on its surface.

The terrace contains a record of the interaction of eustatic sea level rise and crustal uplift during deglaciation.

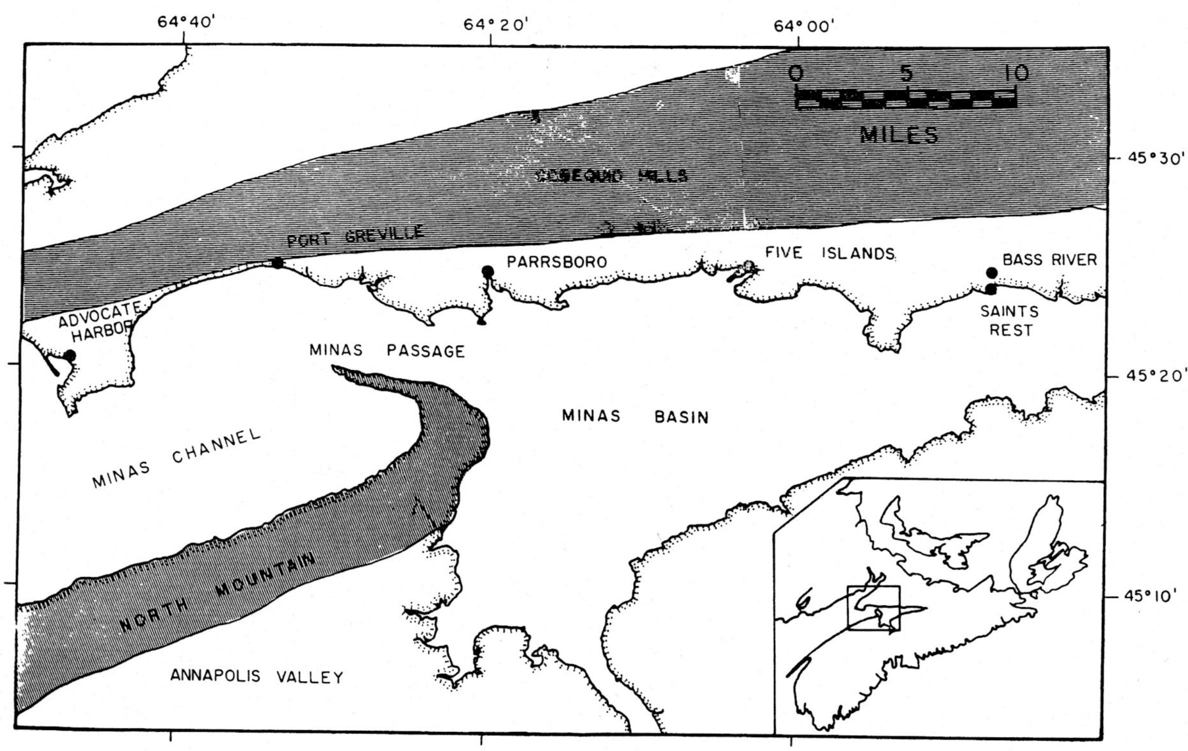

Figure 1 Location map for the Minas Basin. Shaded areas are uplands.

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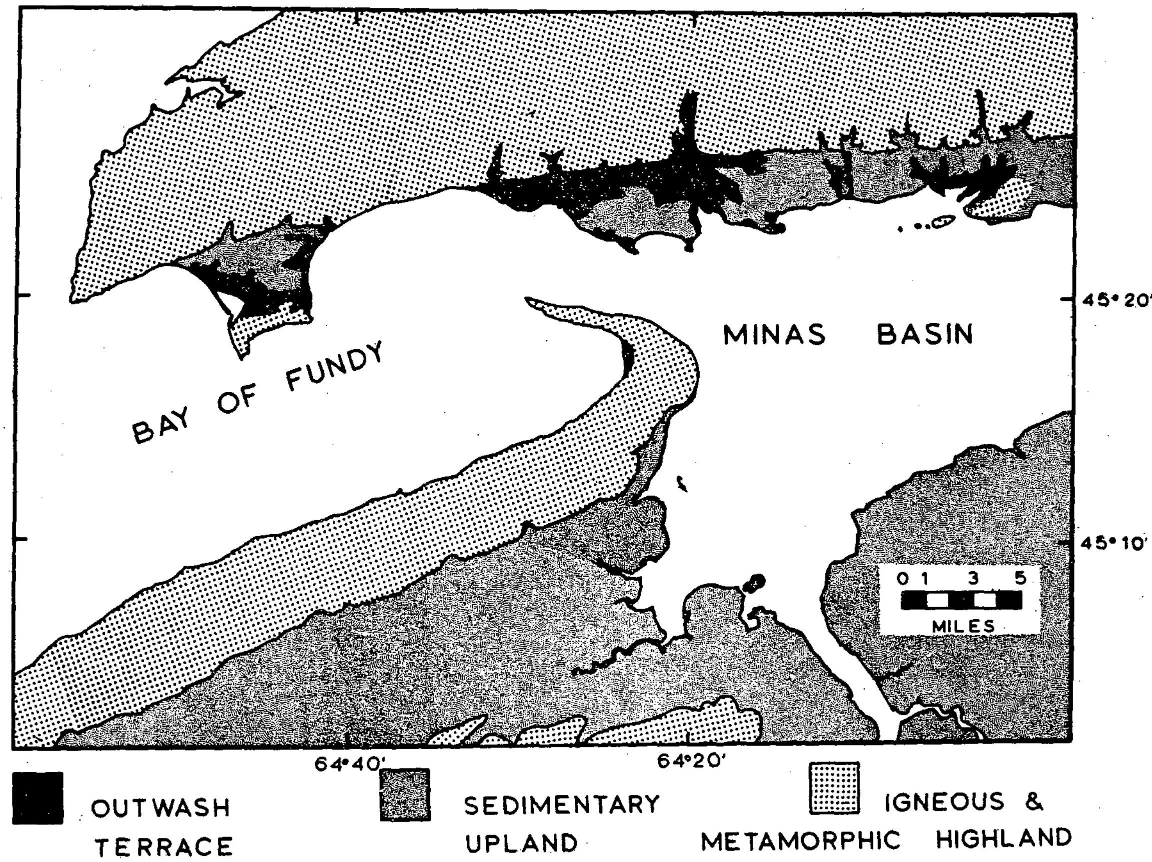


Figure 2 Geomorphic Provinces of the lower Minas Basin

Introduction

A discontinuous gravel and sand terrace on the north shore of the Minas Basin, Nova Scotia (Fig. 1) has long been thought to consist of proglacial deltas. GOLDTHWAIT (1924) has suggested that the landward margin of the terrace represents the maximum extent of postglacial marine overlap. Detailed observations indicate that these deposits do comprise a record of late-Pleistocene sea level fluctuations. However, both glaciomarine and glaciofluvial lithosomes occur in the terrace, and the two must be distinguished before the maximum postglacial marine overlap can be determined.

The north shore of the Minas Basin is divided into three geomorphic provinces for the purposes of this report. An igneous and metamorphic highland, the east-west trending Cobequid Hills, (Fig. 2) borders the area to the north. It is an up-faulted block of lower Paleozoic low-grade metamorphic rocks of the Cobequid Complex (WEEKS, 1948), and the Chignecto Granite (JACOBSON, 1955). The upper surface may be a dissected peneplain lying at about 300 metres above sea level.

Two other provinces form an interlocking pattern in a strip of land between the Cobequids and the Minas Basin. An irregular sedimentary upland consists of folded Carboniferous clastic rocks, and gently tilted Triassic clastic rocks and basalts (Fig. 2). Consequent and subsequent valleys in the sedimentary upland contain remnants of terraced glacial outwash (Fig. 2).

Depositional Environments of the Terrace

General

The terrace is divided into compartments corresponding to the major valleys of the sedimentary upland. In addition, careful study of numerous exposures in the sea bluffs at Five Islands, Port Greville, and Advocate Harbour (Fig. 1) shows that there is also a vertical division into lower glaciodeltaic and glaciolittoral lithosomes, and an upper glaciofluvial lithosome. The term "bluff" is used in this report to indicate cliffs of unconsolidated material.

Glaciodeltaic lithosome

Between Spencer's Island and Five Islands (Fig. 1) the lower portion of the terrace commonly consists of masses of sand, gravel, sandy gravel, or red clay resting on red, clayey till. Its most important primary structure is stratification ranging from thin-bedded in the sand and clay bodies (10-30 cms median thickness, INGRAM, 1954) to medium-bedded in the sand and gravel bodies (30-100 cms median thickness). Bedding is continuous for up to 100 metres.

Medium-to large-scale, high-angle, planar cross-stratification (McKEE and WEIR, 1953) or alpha cross-stratification (ALLEN, 1963) is abundant. Lobate, interfingering clay, sand, and gravel bodies often have the characteristic tripartite structure of the Gilbert-type delta (GILBERT, 1902). At the Lower Five Islands sea bluffs and in the sea bluffs east of Port Greville, topset gravels (locally sands) can be seen to roll over into the interfinger with thin-bedded foreset sands and pebbly sands which are inclined at 20 to 30 degrees. At Port Greville, foreset sand and gravel beds flatten out into very thinly bedded, laminated or massive, silty, red clays. At Port Greville, two to three deltaic lobes are stacked one above the other. Locally chaotic zones in these lobes appear to be ice-contact collapse structures.

Accessory structures in the deltaic lithosome include rhythmic alternations of graded sand and clay, slump zones, convolute laminae, and asymetric ripples with wavelengths up to 50 cms. At Five Islands, moulds of the euryhaline pelecypod Portlandia glacialis (Gray) were found (BORNS, in press).

The areal and stratigraphic position, fauna, and lithology of this unit clearly indicate that it was deposited as a series of proglacial marine outwash deltas in the mouths of the north shore valleys. The well-defined topset-foreset-bottomset structure of the deltas shows that the 14-metre tide range of the present basin was greatly reduced at the time of deposition. Modern deltas of the Minas region undergo dissection at each low tide, and consist only of very gently dipping topset beds, spread in some cases over half a kilometre of tide flat.

Glaciolittoral lithosome

At the west end of the terrace, in the Advocate Harbour area, large-scale, high-angle cross-bedding is lacking, though most strata have initial dips of 10 degrees or less. Aerial photographs of the terrace surface show a series of ridges which resemble the modern spits. These enclose an emerged lagoon, backed by a wave-cut bluff similar to that behind the modern Advocate lagoon (Fig. 3). The boulder beds in Bog Brook at the tip of the southern raised spit is suggestive of the boulder gravels in the modern tidal inlet. It seems that at the west end of the terrace, open to the Bay of Fundy, wave activity reworked glacial materials to create a lagoon. The similarity between the modern lagoon and the emerged one

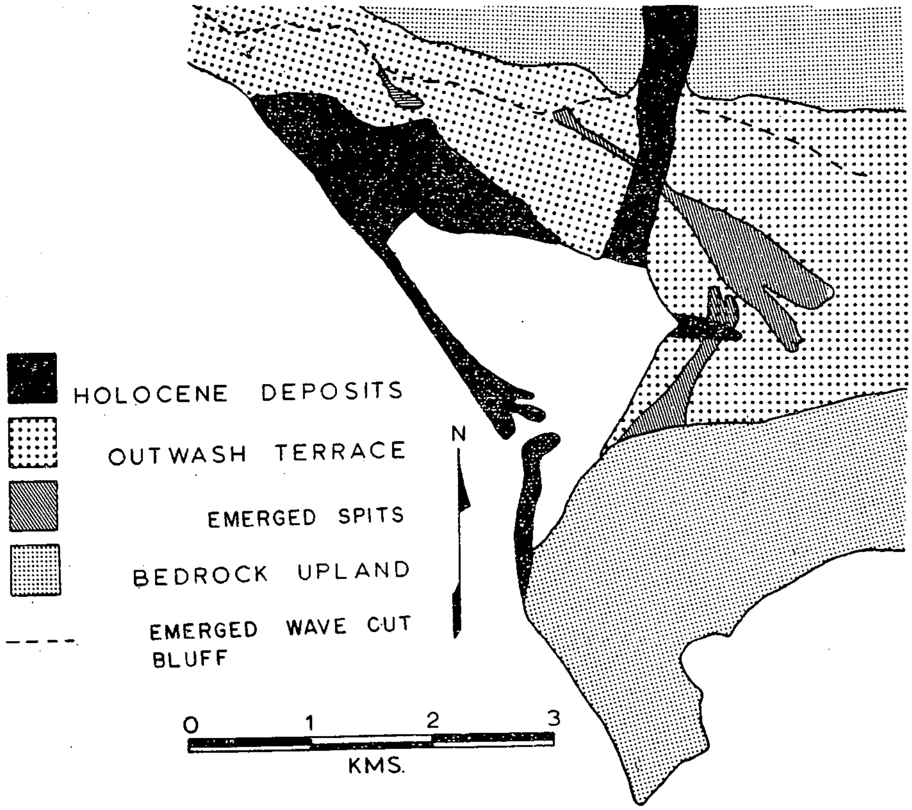
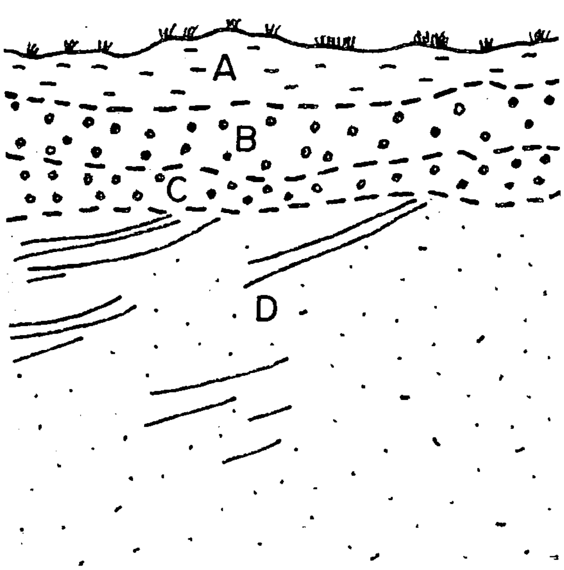


Figure 3 Surficial Geology of the Advocate Harbour Area



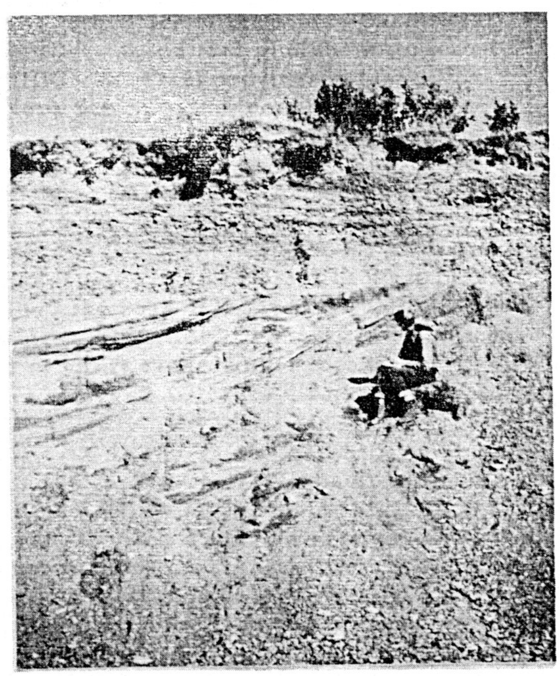


Figure 4 Foresets and topsets of the glaciomarine unit disconformably overlain by glaciofluvial gravel, C: Topset gravel, D: Foreset sand

suggests that factors governing wave attack and longshore drift have not changed since the late Pleistocene.

Glaciofluvial lithosome

A third lithosome of sandy gravel overlies the marine lithosomes. Stratification is often more poorly developed in this lithosome, though exposures near the mouths of Bumper Brook and Bass River are exceptions to this rule. Imbrication is well developed, even when stratification is not. Occasional to frequent lenses of sand show a cut-and-fill relationship to the enclosing gravel, and an internal festoon stratification similar to the zeta, theta, and iota cross-stratification types of ALLEN (1963). The upper surface of the gravels is dimpled with numerous kettles. These may include kettles left by river ice and sea drift ice as well as by glacier ice. Kettles along the present shoreline are being destroyed by marine erosion; therefore, where these kettles occur, the sea has not been higher than it stands now (BORNS, in press). Aerial photographs of the Parrsboro area reveal a relict pattern of braided channels radiating from the Parrsboro gap, indicating that sea level has not been higher than this surface since it formed.

The contact between the glaciofluvial lithosome and the underlying glaciomarine lithosomes is sharp, being a matter of millimetres thick (Fig. 4). Where the underlying glaciomarine lithosomes have an initial dip, the contact is an angular unconformity, and it is probably a disconformity at most other points. There is six metres of relief on this surface.

The braided upper surface of this lithosome, its kettles, and cut-and-fill stratification indicate a glaciofluvial origin.

Formation of the Terrace

Formation of the outwash terrace on the north shore of the Minas Basin was the consequence of the dissipation of the late Pleistocene ice, plus the interaction of Pleistocene sea and land level changes. HICKOX (1962) provides evidence for a late glacial residual ice cap in southern Nova Scotia. The ice therefore, must have dissipated first in the Gulf of Maine, then in the Bay of Fundy. By the time the ice front had receded to the Lower Minas Basin, the sea, rising in response to the melting of continental ice sheets, had reached this area. As ice tongues dissipated in the valleys of the sedimentary upland, they were replaced by prograding deltas as far north as the Cobequid Scarp (Fig. 5A). The upper surfaces of the deltas rose with sea level until a thickness of over 60 metres of stratified sands and gravels was attained. At this point, the zone of most rapid uplift, moving inland with the front of the dissipating ice (FERRAND, 1962), reached the north shore of the Minas Basin and the rate of uplift exceeded the rate of sea level rise. The upper surfaces of the deltas emerged and were dissected to a minimum extent of six metres of relief.

Subaerial alluvial fans, which had begun to develop when the dissipating ice bared the Cobequid Scarp, prograded across the rising deltaic plain (Fig. 5B) and buried the dissected delta surfaces. Thus, at any time during emergence, the proglacial outwash plain of the Minas Basin's north shore consisted of two regressing facies separated by a zone of erosion. The subaerial fans of the Cobequid Scarp encroached on the zone of dissection of the older marine plain; the zone of dissection in turn encroached on the deltas which were following the retreating shore-

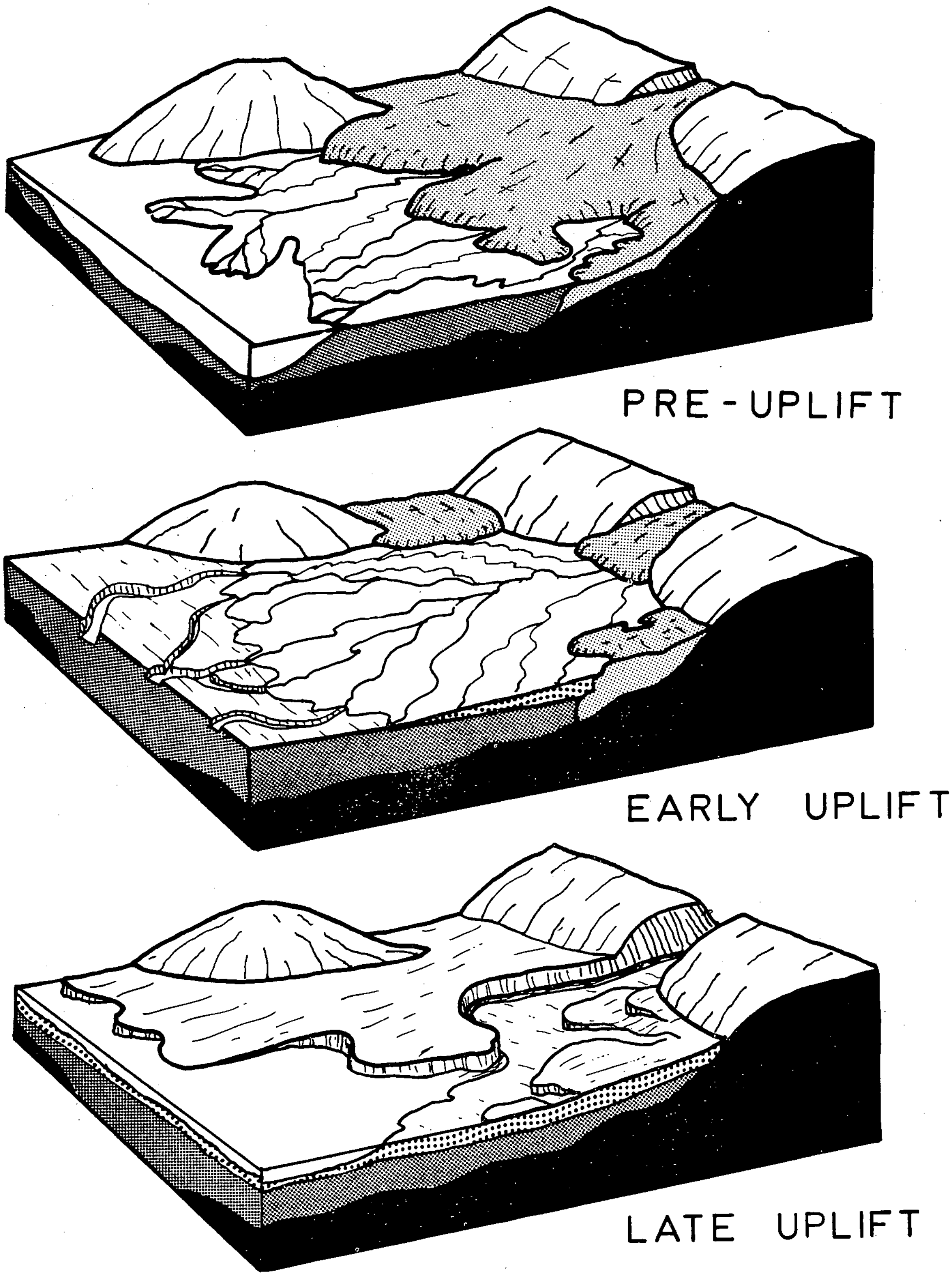


Figure 5 Evolution of the outwash terrace on the north shore of the Minas Basin. A: Growth of marine deltas B: Uplift and erosion of marine plain; growth of subaerial fans based on Cobequid Scarp C: Modern Terrace after uplift, dissection, and sealevel rise.

line. Such a scheme of regressing facies is the only depositional model which adequately explains the ubiquitous disconformity between the upper and lower units.

As the peak of outwash aggradation passed and the terrace continued to emerge, the outwash plain underwent a second, more severe dessection in which the rivers entrenched themselves to depths probably in excess of 30 metres, and the present river terraces were cut. Finally, emergence diminished to a negligible rate and the sea advanced to its present position (Fig. 5C). The concomitant rise in fluvial base level caused a last period of aggradation, confined to the floors of the entrenched river valleys, and their drowned mouths.

Status of The Study

This is a preliminary report of observations and interpretation of the terrace based on field work during the summer of 1965. Field and laboratory studies are continuing in order to better differentiate marine and alluvial deposits, assess the significance of the Terraces tilted surface, and place it within the late Pleistocene stratigraphic framework. The project is part of a larger investigation supported by NSF grant number G-S-359 awarded to the Robert S. PeaBody Foundation for Archeology for the excavation of the Debert Paleo-indian Site. Much of the work of D. J. P. Swift was supported by N. R. C. grants A, -1948 and A-2686, and the Nova Scotia Research Foundation.

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