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Terraced glacial outwash (fig 2, pl. 1, C)

A RAISED FLUVIOMARINE OUTWASH TERRACE, NORTH SHORE OF THE MINAS BASIN, NOVA SCOTIA[1]

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ABSTRACT

The Five Islands Formation is a late Pleistocene outwash deposit. It 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 Harbor, 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 molded into a lagoon enclosed by spits and backed by a wave-cut bluff, closely resembling the modern Advocate Harbor. 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 molds of *Portlandia glacialis*. The glaciodeltaic lithosome is disconformably overlain by a sheet of kettled glaciofluvial gravels exhibiting a relict braided pattern on its surface. The marine lithosomes are designated the Advocate Harbor Member; the fluvial lithosome is designated the Saint's Rest Member. The top of the marine member rises from mean sea level at Saint's Rest to over 40 m. at Advocate Harbor.

Formation of the terrace started with dissipation of the ice, tentatively placed in Port Huron time of the classical sequence. Outwash deltas replaced ice in the valleys of the north shore as the rising sea level flooded them as far as the Cobequid scarp. When the rate of uplift exceeded eustatic sea-level rise, the deltas emerged and underwent first dissection, then burial under south-spreading alluvial fans based at the foot of the Cobequid scarp. Deposition was complete by Valders time of the classical sequence, since ice-wedge casts correlated with this time penetrate both units.

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. J. W. 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. This paper establishes the terrace as a formal lithostratigraphic entity, indicates criteria for distinguishing between marine and fluvial lithosomes in order to determine the extent of marine overlap, and considers the late Pleistocene history of the region.

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 upfaulted 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 m. above sea level. Two major wind gaps, the Parrsboro gap and the Folly Lake gap, divide the Cobequids into three segments. The gaps are at least partly of glacial origin. The south face of the Cobequids is precipitous, cut by steep gorges, and is remarkably straight for long distances (pl. 1,*A*). It is the scarp of the Cobequid fault, one of the major structural features of the Maritime Appalachians.

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 (figs. 2, 9). Consequent and subsequent valleys in the sedimentary upland contain remnants of

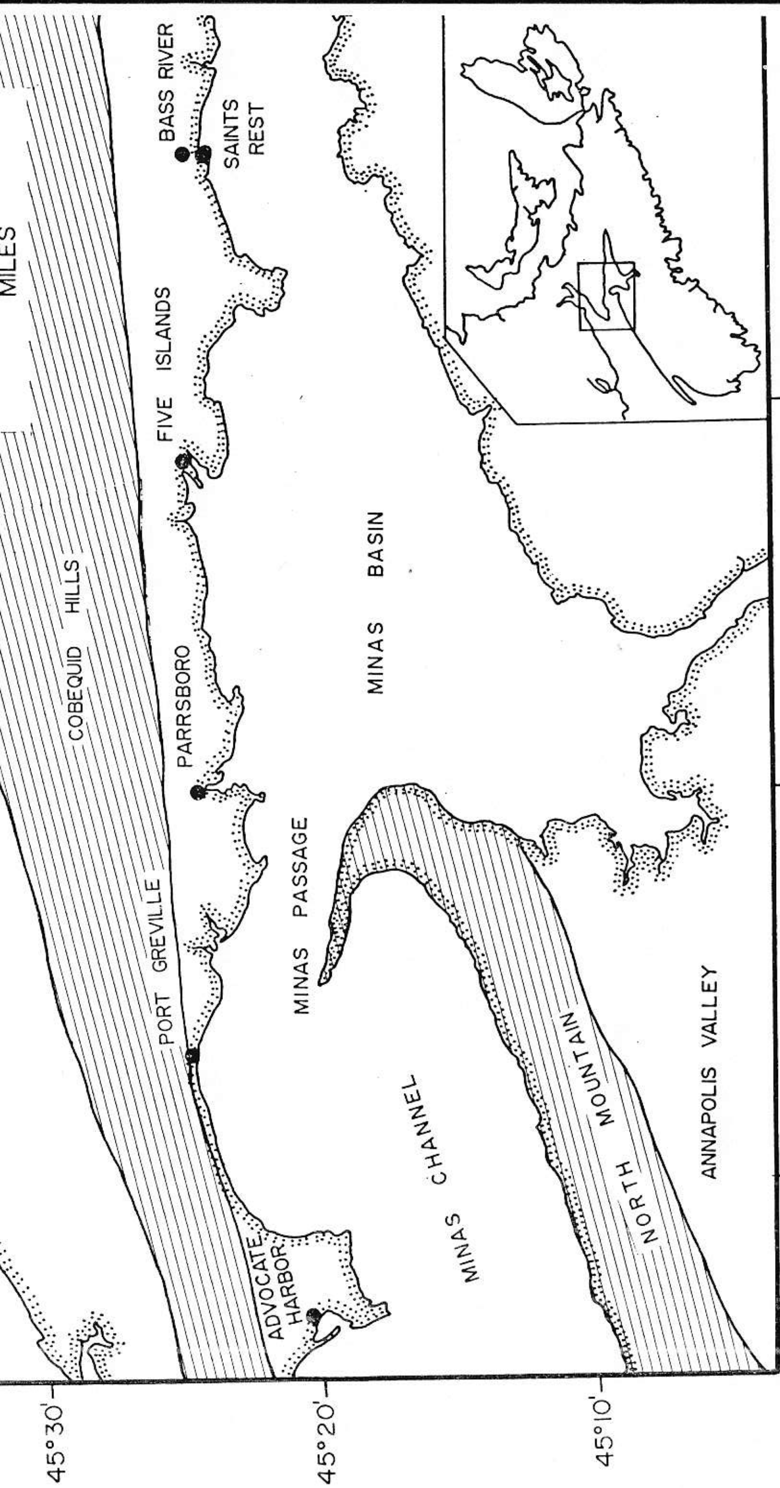


FIG. 1.—Location map for the Minas Basin. Shaded areas are uplands

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 Harbor (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 for cliffs composed 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 cm. median thickness [Ingram, 1954]) to medium bedded in the sand and gravel bodies (10–30 cm. median thickness) (see fig. 3 and pls. 1,*B*, and 3). Bedding shows continuity for up to 100 m.

Medium- to large-scale, high angle, planar cross-stratification (McKee and Weir, 1953) or *a* 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, 1890) (see pl. 1,*C*). 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 and interfinger with thin-bedded foreset sands and pebbly sands which are inclined at 20–30 degrees. At Port Greville, foreset sand and gravel beds

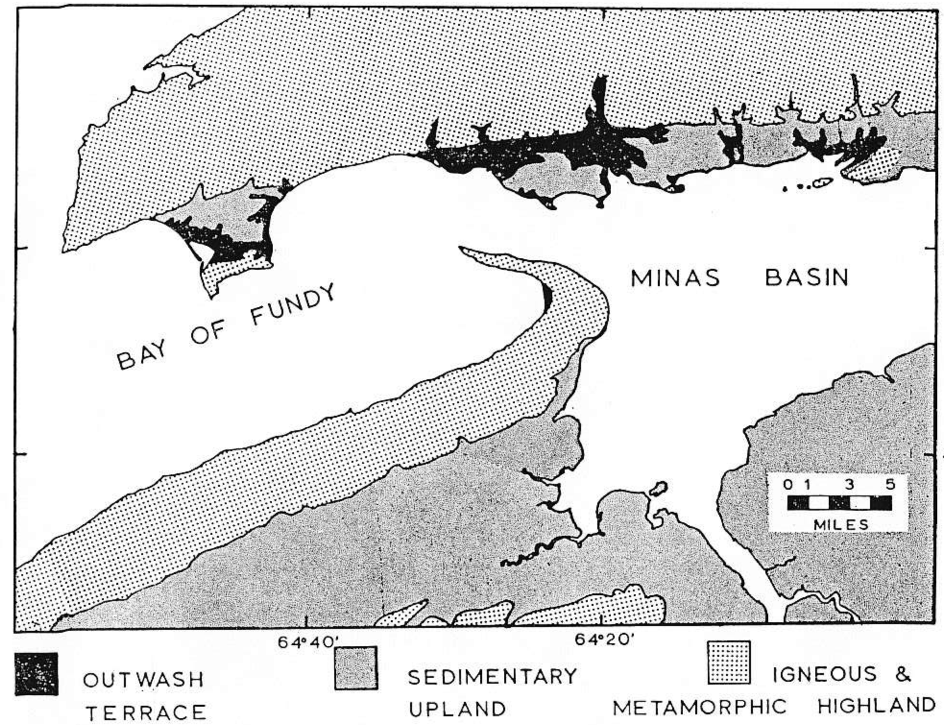


FIG. 2.—Geomorphic provinces of the Lower Minas Basin

ut into very thinly bedded, lami- massive, silty, red clays. At Port two to three deltaic lobes are ne above the other. Locally chaotic these lobes appear to be ice-contact structures.

ory structures in the deltaic litho- ude rhythmic alternations of grad- and clay, slump zones, convolute and asymmetric ripples with wave- up to 50 cm. (pl. 2,*A*). At Five molds of the euryhaline pelecypod *a glacialis* (Gray) were found 966, p. 55).

areal and stratigraphic position, nd lithology of this unit clearly that it was deposited as a series of l marine outwash deltas in the f the north shore valleys. The well- topset-foreset-bottomset structure of the deltas shows that the 14-m. tide range of the present basin was greatly reduced at the time of deposition. Modern deltas of the Minas region (pl. 2,*B*) undergo dissection at each low tide, and consist only of very gently dipping topset beds, spread in some cases over half a kilometer of tide flat.

The extreme modern tide range is a consequence of the dimensions of the Bay of Fundy, which satisfy the conditions for resonant amplification of the tidal wave's semidiurnal component. The bay averages 37 m. deep, and its critical length for resonance is 296 km., which closely agrees with its measured length of 300 km. The natural period of oscillation of the bay is about 6.29 hours, which almost exactly fulfils the conditions for semidiurnal resonance (King, 1963, p. 175). Calculations suggest that

(4)

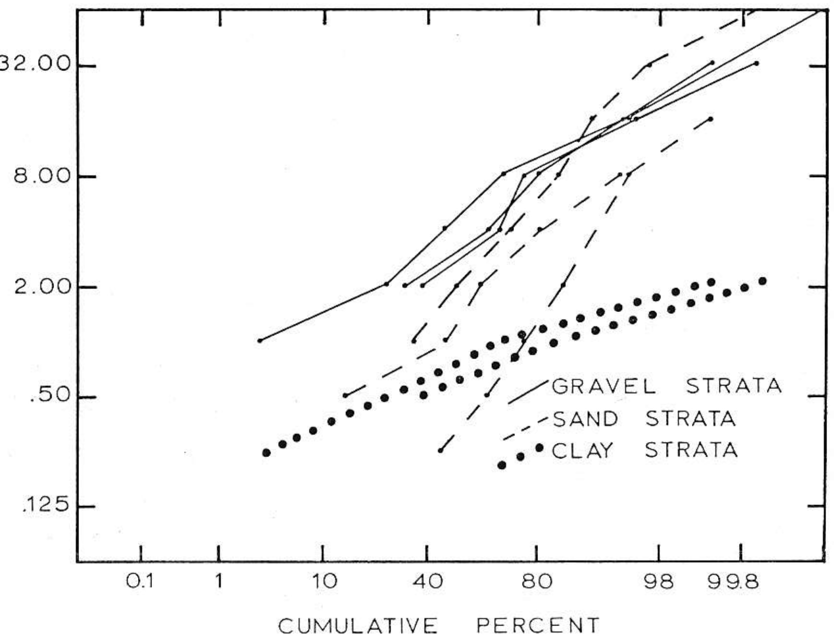


Fig. 3.—Cumulative curves of strata thickness from the glaciodeltaic lithosome

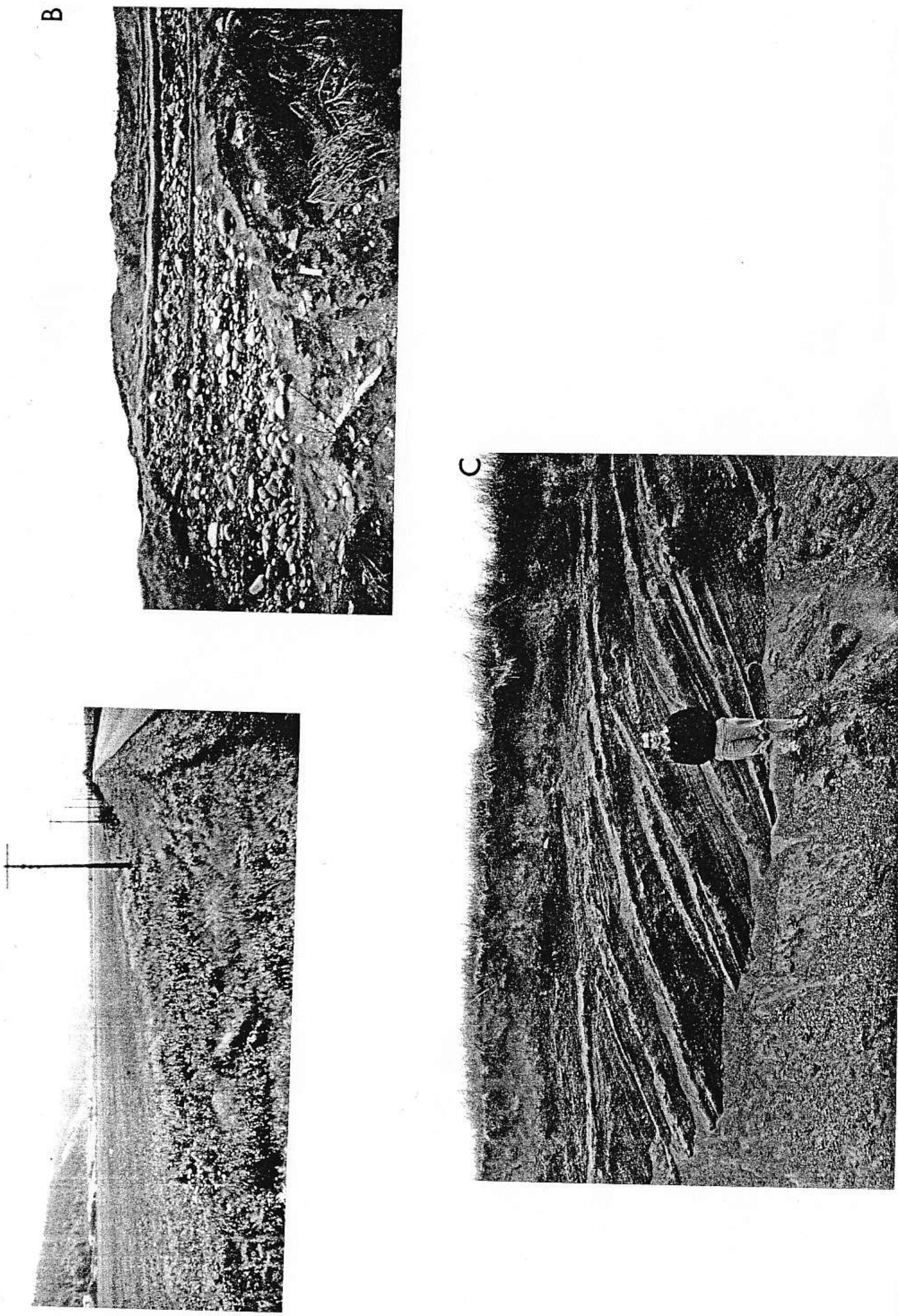


PLATE 1

outwash terrace and Cobequid scarp at Kirkhill, Parrsboro; *B*, stratified coarse gravels of the al lithosome, Bog Brook, Advocate Harbor; *C*, topset and foreset beds in the glaciodeltaic litho- elhaven, under Cape Blomidon. (Photo by D. Stanley.)

Fundy's critical length and actual length have been 95 per cent coincident only since about 7,500 B.P. (fig. 4), using Curray's (1965) curve for the Holocene sea-level rise.

GLACIOLITTORAL LITHOSOME

At the west end of the terrace, in the Advocate Harbor area, large-scale, high-angle cross-bedding is lacking, though most strata have initial dips of 10° 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. 5). The boulder beds in Bog Brook at the tip of the southern raised spit (pl. 1,*B*) are 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 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 ζ, θ, and ι cross-stratification types of Allen (1963). The upper surface of the gravels is pitted with numerous kettles. These may include kettles left by river ice and sea-drift ice as well as glacier ice. Those kettles along the present shore line are being destroyed by marine erosion (pl. 2,*C*); therefore, where these kettles occur, the

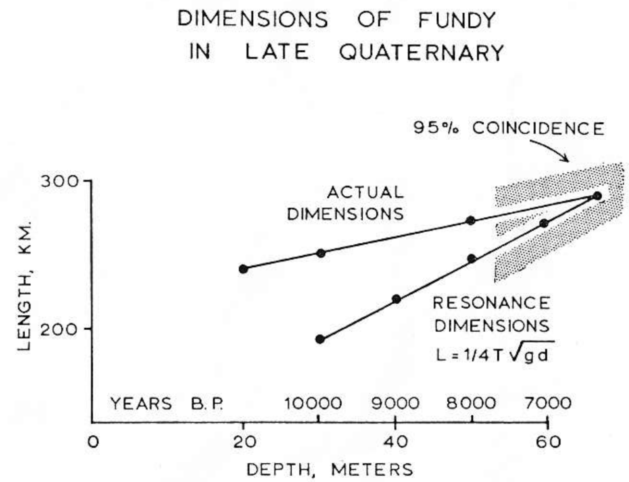


FIG. 4.—Changing length of the Bay of Fundy with post-Pleistocene sea-level rise (based on sea-level rise curve in Curray, 1965) and associated change in the length of the bay critical for resonance. Formula for critical length is from King, 1963.

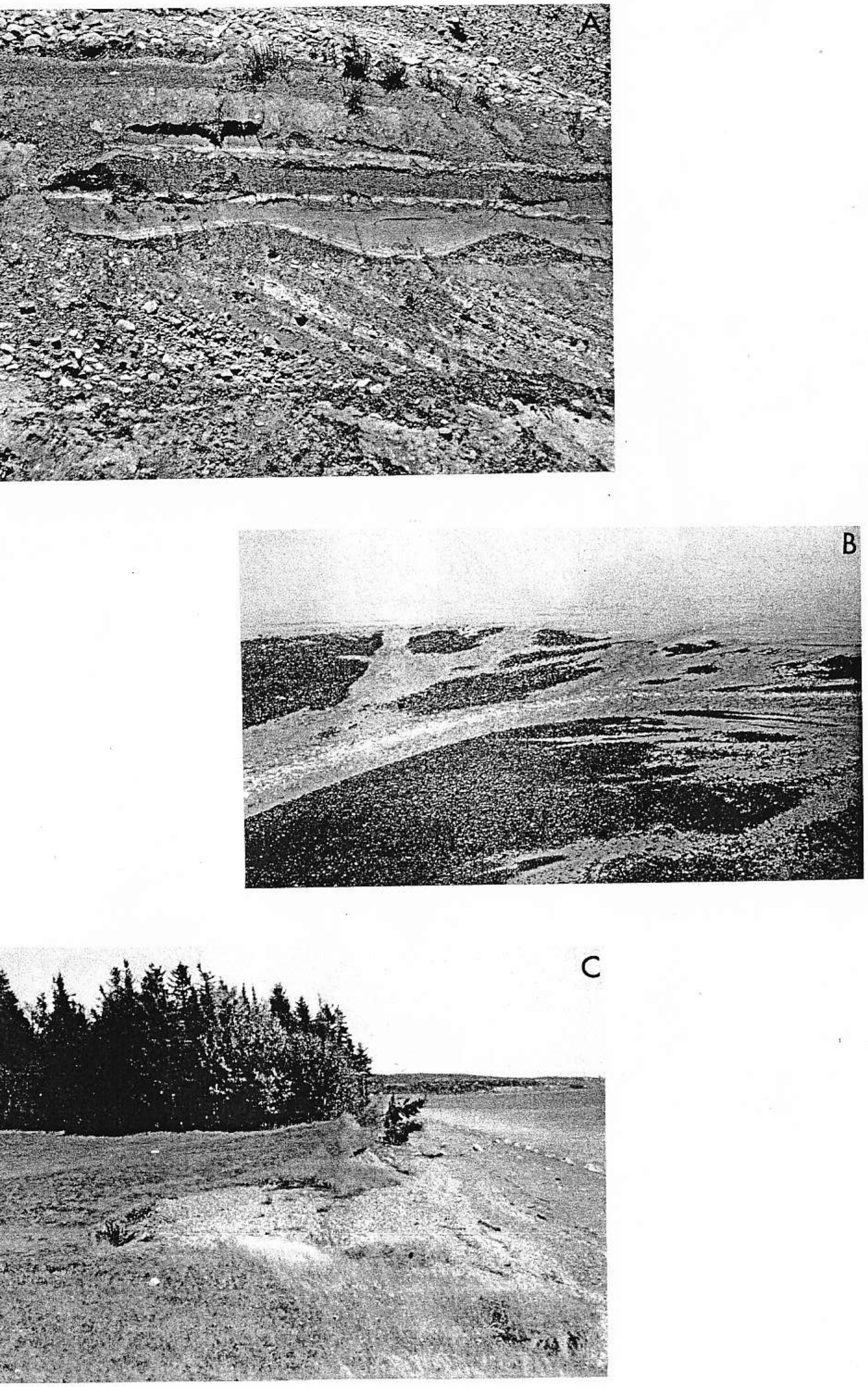


PLATE 2

A, stratification, cross-stratification, and large ripples in the glaciodeltaic lithosome at Wards Brook; *B*, a modern delta in Scots Bay, Minas channel, building out as the tide drops down the beach face; *C*, kettle at Saint's Rest, being breached by the sea, and filled with beach material.

a has not been higher than at present
nce kettle development (Borns, 1966, p.
). Aerial photographs of the Parrsboro
ea reveal a relict pattern of braided chan-
ls radiating from the Parrsboro gap (fig.
, indicating that sea level has not been
gher than this surface since it formed.

The contact between the glaciofluvial hosome and the underlying glaciomarine hosomes is sharp, being some millimeters ick (pl. 3). 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. The relief on this surface is 6 m. Although it is difficult to be certain, this disconformity may be the same one observed in sub-bottom profiles of the Minas Basin (fig. 12).

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

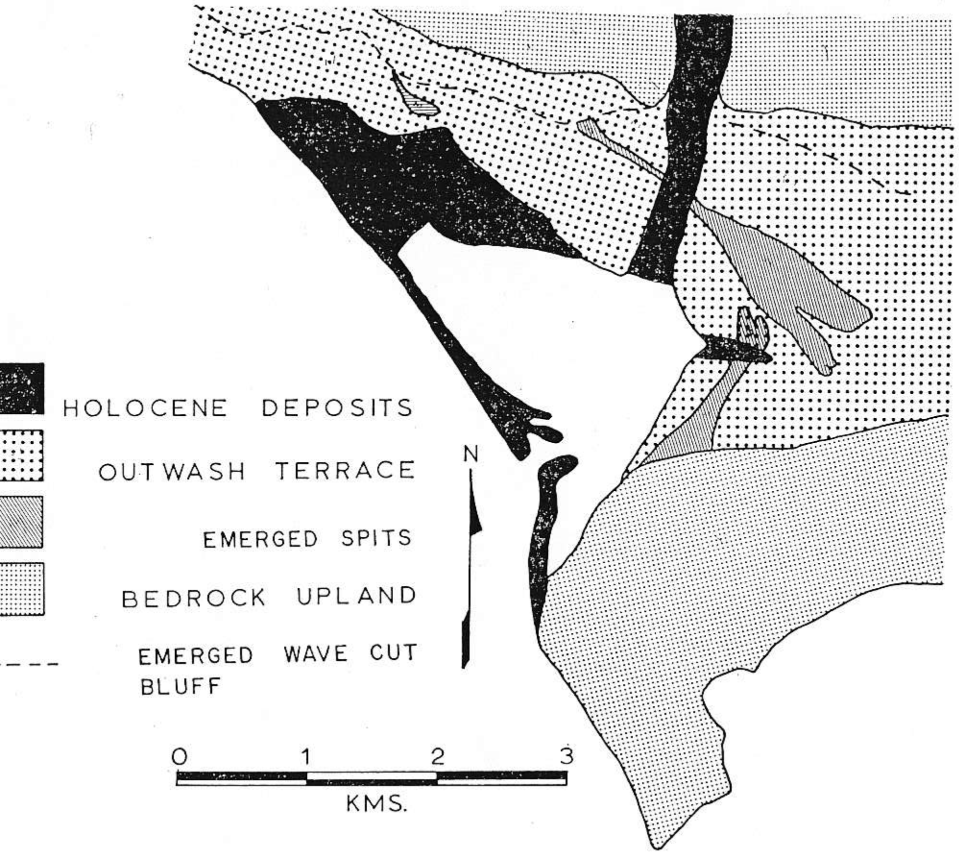
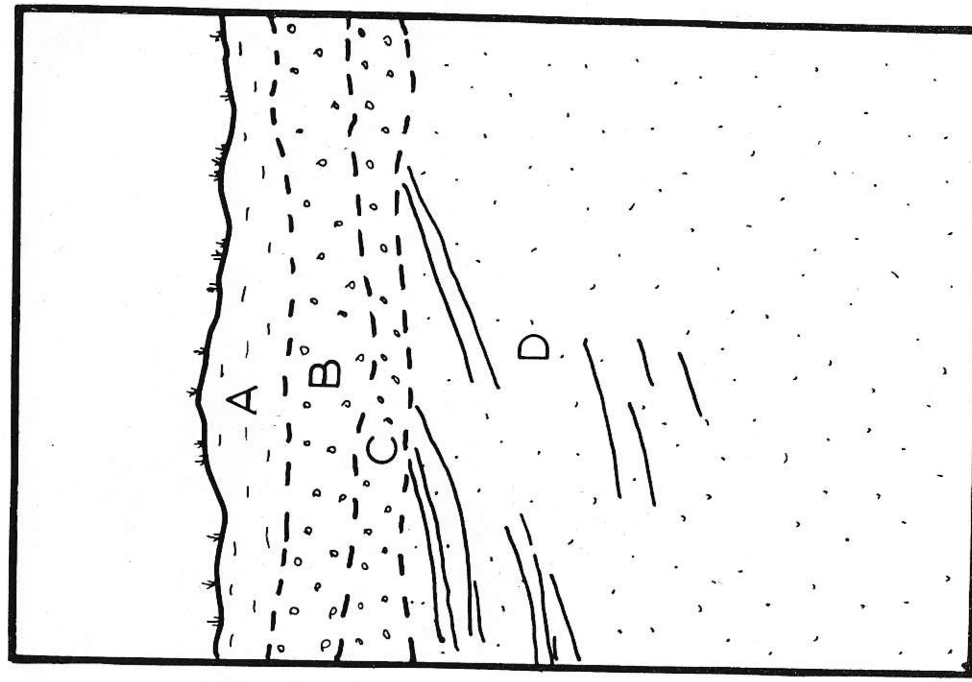


Fig. 5.—Surficial geology of Advocate Harbor area

PLATE 3



Left: Glaciodeltaic foresets and topsets of the Advocate Harbor Member disconformably overlain by the
nt's Rest glaciofluvial gravels. *Right:* Tracing of the photograph. *A*, soil zone; *B*, Saint's Rest Member;
topset gravel, Advocate Harbor Member; *D*, foreset sand, Advocate Harbor Member.

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CRITERIA FOR DISTINGUISHING BETWEEN MARINE AND FLUVIAL LITHOSOMES

GENERAL STATEMENT

Identification of marine and fluvial lithosomes is essential if conclusions are to be drawn concerning the extent of marine overlap and crustal emergence. If all outwash surfaces in the Minas Basin region are assumed to represent marine surfaces when in fact fluvial surfaces are present, errors of up to 25 m. will occur. Criteria have been developed which serve to distinguish between marine and fluvial lithosomes at those exposures on the north shore of the Minas Basin where both lithosomes are present and well exposed. Firm identification is not possible at some other less well-exposed outcrops. These criteria are based

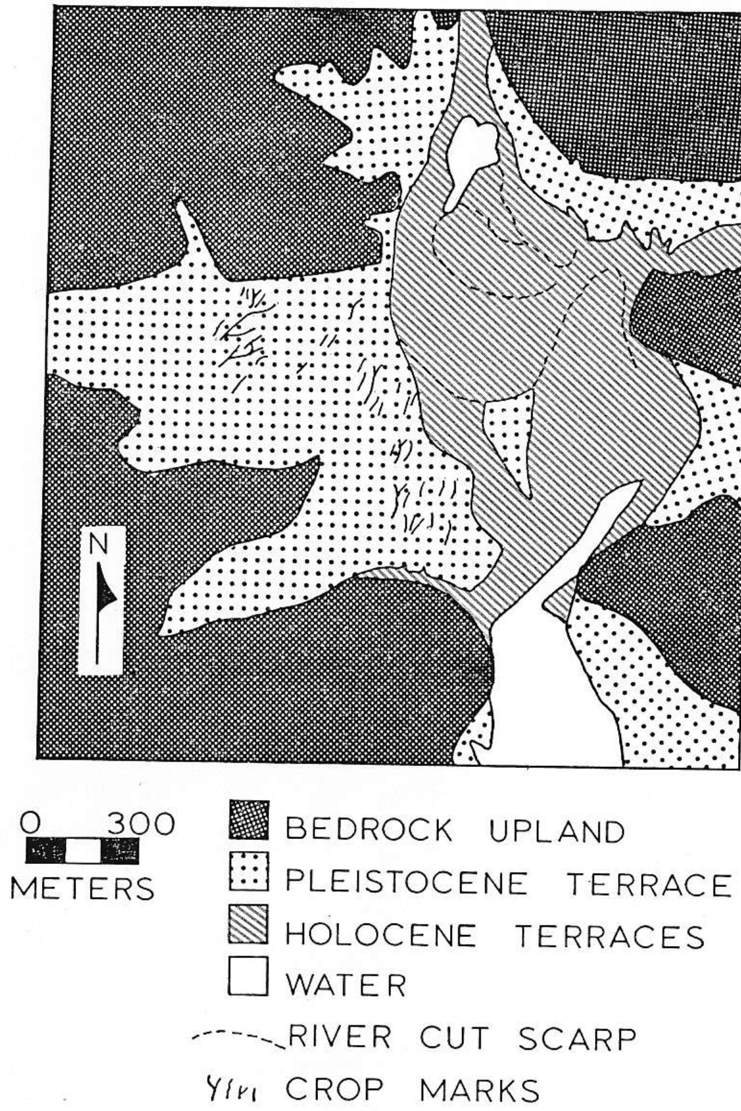

Fig. 6.—Surficial geology of Parrsboro area.

on the outwash regime of the north shore of the Minas Basin during the late Pleistocene and are not necessarily applicable to deposits of other times and places. One criterion, the size-frequency distribution, is a direct consequence of the nature of the depositing medium, fluvial or marine. Other compositional criteria yield direct information only on the nature of the source area. Where all features occur together, however, the deposition medium and source area can be seen to have changed at the same time, so the compositional features also serve to distinguish the two lithosomes.

SIZE-FREQUENCY DISTRIBUTIONS

At Wards Brook, Port Greville, Five Islands, and Advocate Harbor (fig. 1), size-frequency distributions within sedimentation units are a useful criterion. Here the upper gravel is a "chink-filled" sandy gravel. The underlying gravels are also mainly sandy gravels, but 3–15 per cent of the beds are of openwork gravel, with no sandy matrix. These distributions may be seen in analyses of randomly selected samples (figs. 7, 8). Pettijohn (1957, p. 245) has noted that rapidly aggrading fluvial gravels are typically bimodal, containing both gravel and sand; there is little chance in this depositional environment for a separation of the two size fractions. Nearshore marine gravels, on the other hand, are often openwork, since the back-and-forth motion of wave agitation tends to winnow out the sand.

COMPOSITIONAL PARAMETERS

Pebble counts and examination of the associated sands show that, at many exposures, glaciomarine and glaciofluvial lithosomes may be distinguished on the basis of particle composition. The difference is most marked at localities such as Lower Five Islands, where the terrace rests on the sedimentary upland and is backed by portions of the Cobequid Hills containing the Chignecto granite (figs. 9, 10). Here the upper unit is rich in granite and, to a lesser extent, in metamorphic clasts but is poor in sedimentary clasts (fig. 10). Its matrix is an arkosic sand. The percentages are reversed in the lower unit; sedimentary clasts from the underlying sedimentary upland are dominant, while igneous and metamorphic clasts from the Cobequids are rare. The associated sands are lithic. It is possible that the bulk of the meltwater and associated sediments were derived from the margin of the wasting ice rather than from farther back in the ice; the lower unit would then reflect a period when the ice margin rested on the sedimentary lowland; when the upper unit was deposited, the ice margin would have been up in the Cobequids, and meltwater streams would have been insulated from the sedimentary source by a blanket of deltaic materials. Regardless of the cause, this feature is extremely noticeable at Port Greville and Five Islands; the abrupt change in lithology serves to distinguish the upper and lower lithosomes even when the two are paraconformable gravels (pl. 3).

The composition of the fine fraction of the two lithosomes also tends to differ. The lower sands contain lamina of red clay (5R 3/4 when wet) and, in lenses of openwork gravel, the clasts tend to be coated with this material. Clays in the upper unit are commonly a dark yellowish-brown (10YR 4/2). The red pigment of the lower lithosome appears to be derived from the dusky red shales of the underlying Carboniferous and the red-brown Triassic claystones. Some of it may have been sea-borne material which settled out during the winter freeze-up. The yellowish-brown fines of the upper lithosome were clearly derived from the drab stony tills of the Cobequid Upland.

NOMENCLATURE

Three well-defined lithic units exist in the outwash terrace on the north shore of the Minas Basin. Textural and compositional criteria serve to differentiate these units, while their depositional environment is indicated by primary structures. Further work may show that these or similar units

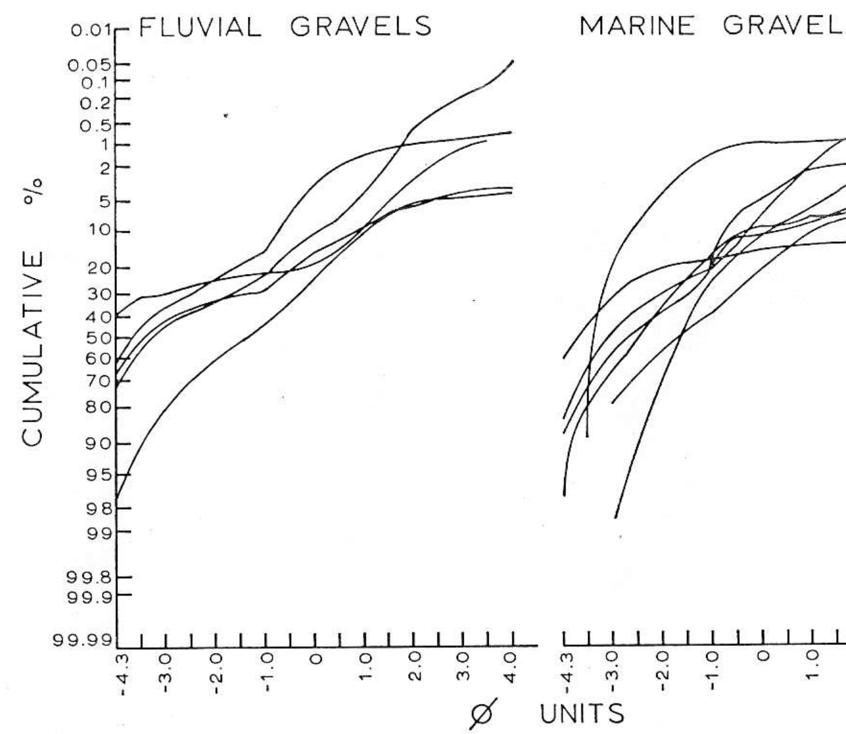

FIG. 7.—Cumulative curves of size-frequency distributions of fluvial and marine grave[ls from the out]wash terrace from the north shore of the Minas Basin. Gently inclined curves are sandy gra[vels; curves with] pronounced knee are openwork gravels.

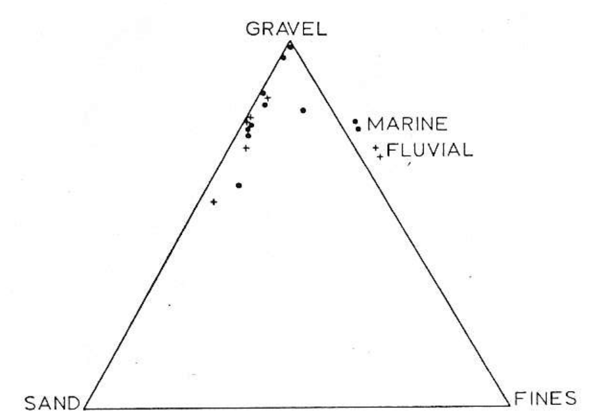

FIG. 8.—Gravel-sand-fines diagram from marine and fluvial gravels

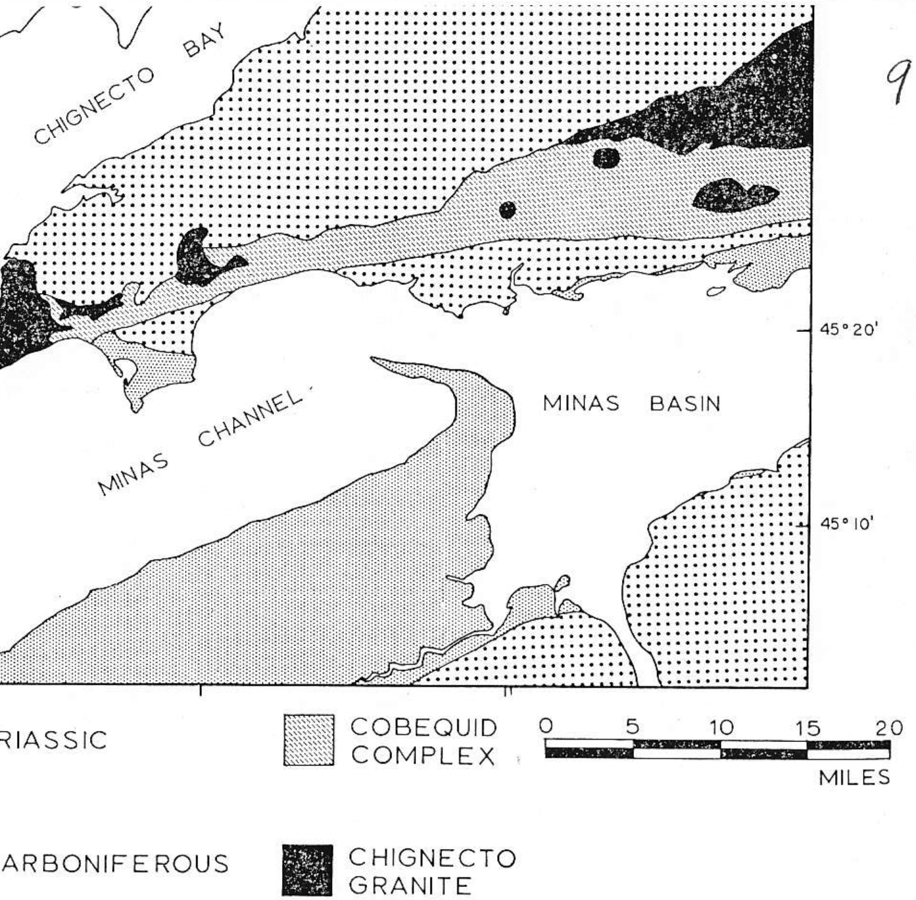

FIG. 9.—Generalized geology of Minas Basin area

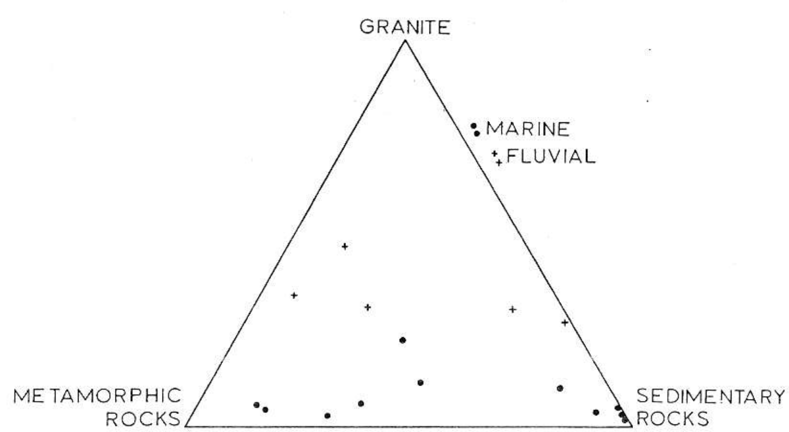

FIG. 10.—Composition of marine and fluvial gravels

may exist elsewhere in the Atlantic provinces, hence formal names are proposed. The terrace deposit is designated the Five Islands Formation, after the sea bluffs between the Harrington and North Rivers at Lower Five Islands, Colchester County, Nova Scotia, where both units are well developed. The upper unit is designated the Saint's Rest Member, after the point of land east of Bass River. Here the massive phase is well exposed in the low sea bluff by the lighthouse; kettles and river terraces are present on the surface above. A second outcrop facing the Bass River estuary reveals the less common well-bedded phase resting on red till. The lower marine lithosomes are designated the Advocate Harbor Member, after the glaciolittoral sea bluffs running from the wharf at Advocate Harbor toward the mouth of Bog Brook (fig. 1). An important reference locality is the sea bluffs between Port Greville and Fox Point where the glaciodeltaic lithosome is well exposed.

The Five Islands Formation extends along the sedimentary upland from Advocate Harbor to Truro, where it merges with the valley train of the Salmon River. To the south and west, it passes beneath the sea to merge with the outwash sheet which floors much of the Bay of Fundy (Swift and Lyall, in preparation) (see figs. 11, 12).

STRATIGRAPHIC POSITION

The stratigraphic position of the Five Islands Formation may be summarized as follows. Livingstone and Livingstone (1958) conclude from their study of pollen that the last ice sheet to cover the Gillis Lake area, Cape Breton Island, Nova Scotia, was of Cary age. Borns (1965) tentatively correlates the last ice sheet in the Minas Basin area with the one that built the end moraine system that extends for approximately 160 km. along the coast of Maine and New Brunswick, from Cherryfield, Maine, at least as far as St. John, New Brunswick. At St. John, the moraine has been dated at 13,325 ± 500 B.P. (Walton, Troutman, and Friend, 1961), or during Port Huron time of the midcontinental sequence. Borns (1965) describes ice-wedge casts at Five Islands which penetrate both members. He tentatively correlates them with the Valders readvance of the midcontinental sequence. Valders time is therefore the lower limit for deposition of the outwash, which is probably best correlated with the Port Huron recession of the midcontinent.

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. 13, *top*). The upper surfaces of the deltas rose with sea level until a thickness of over 60 m. 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 (Farrand, 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 6 m. 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. 13, *middle*) 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 en-

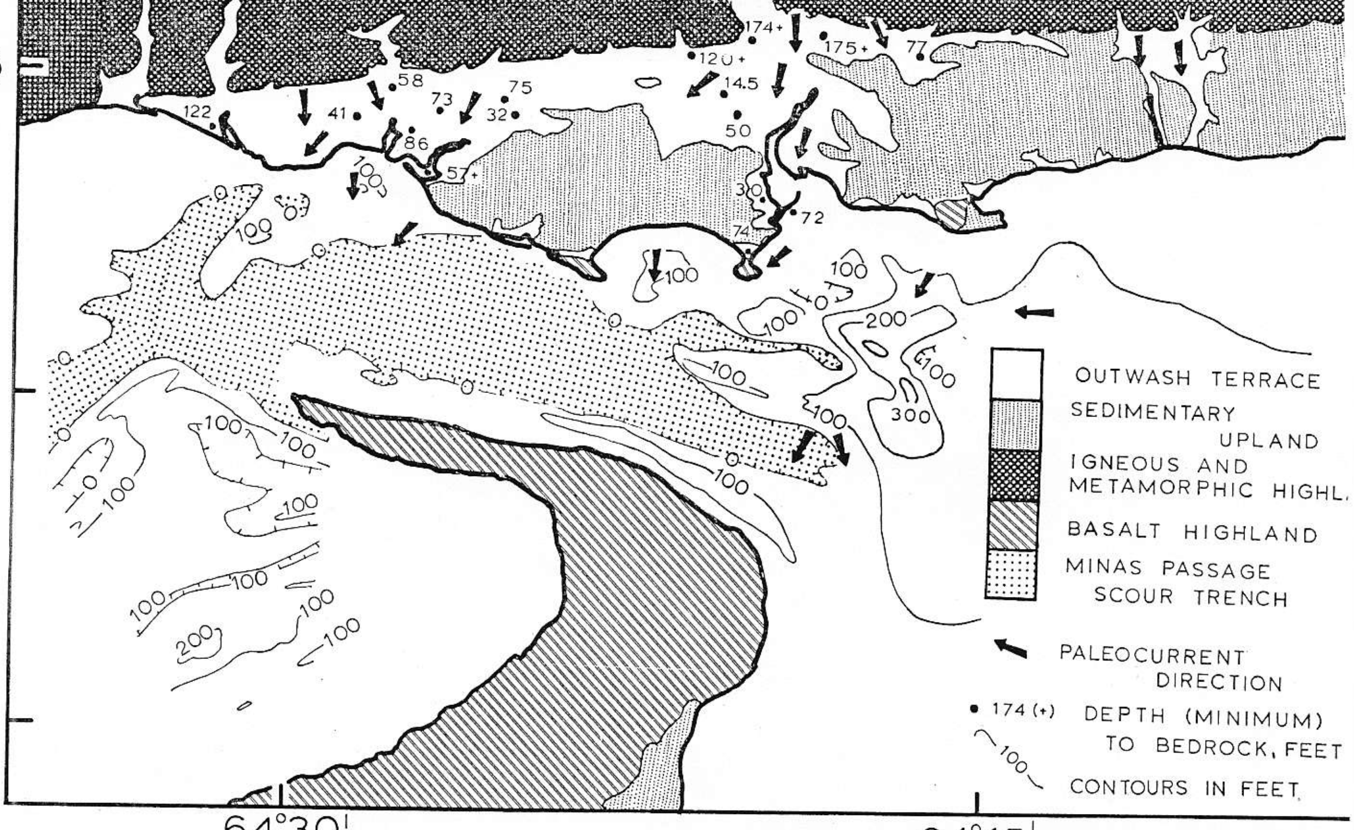

FIG. 11.—Isopach map and current directions of proglacial streams, Minas Basin. Isopach data from Huntec Limited of Toronto; released by the Atlantic I opment Board of Canada.

Development

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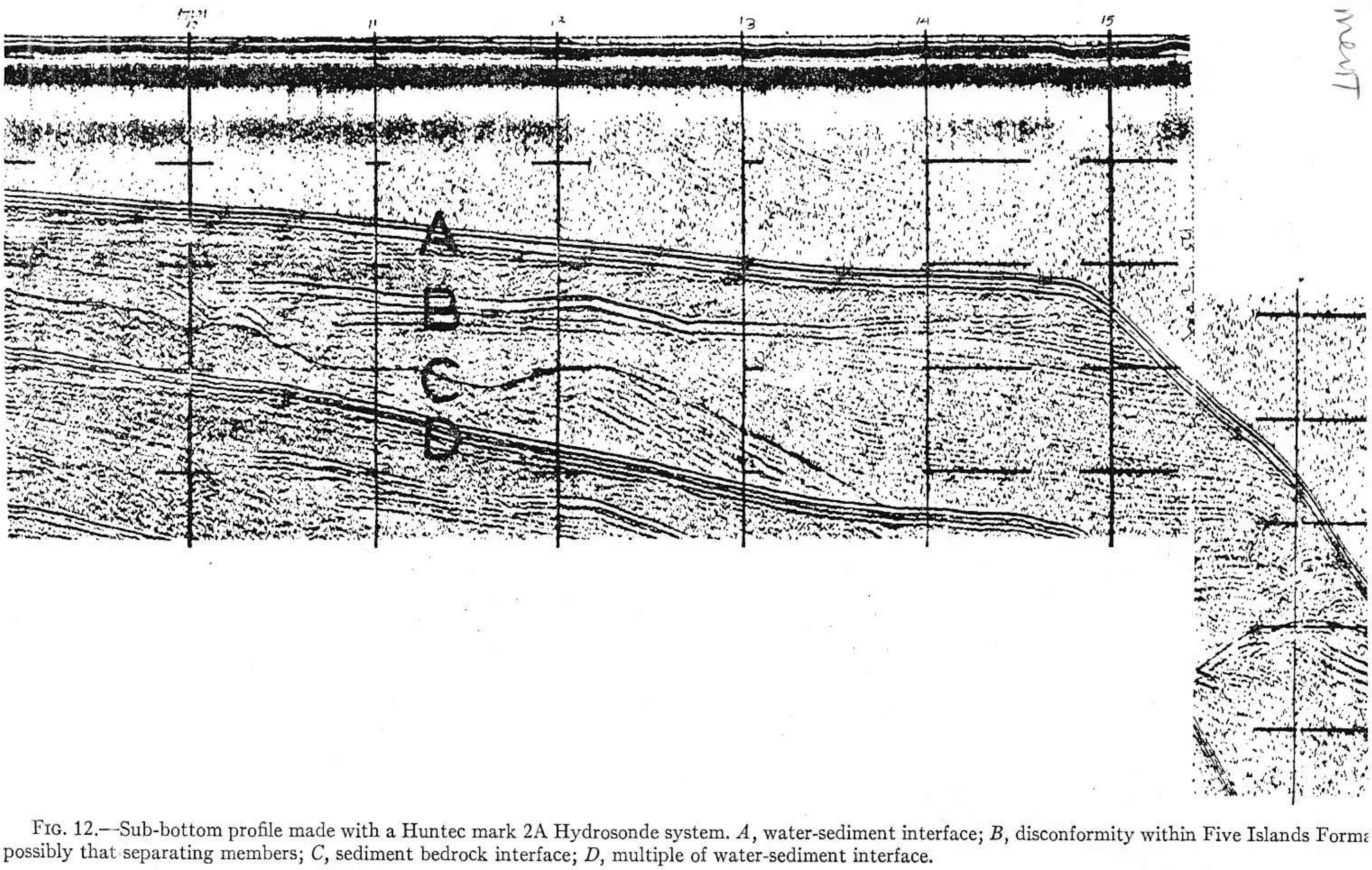
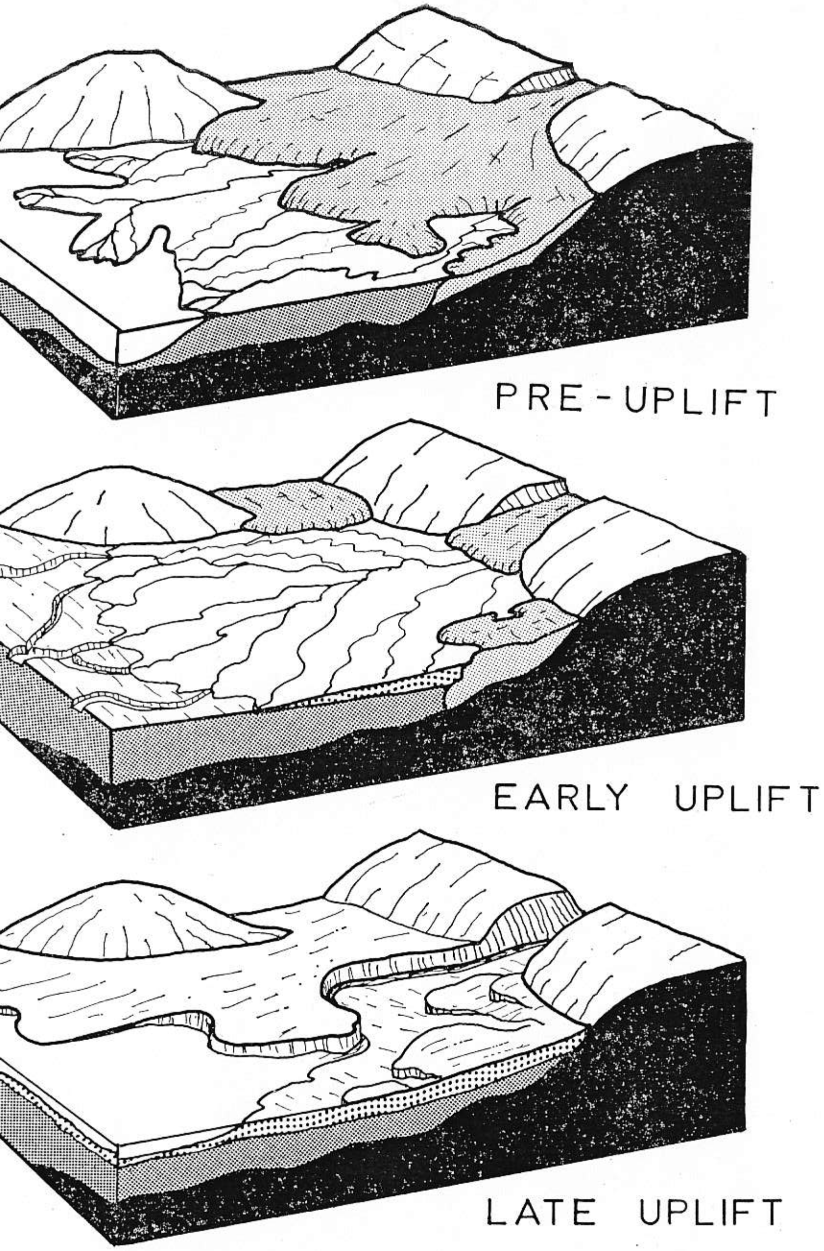


FIG. 12.—Sub-bottom profile made with a Huntec mark 2A Hydrosonde system. *A*, water-sediment interface; *B*, disconformity within Five Islands Forma possibly that separating members; *C*, sediment bedrock interface; *D*, multiple of water-sediment interface.



lution of the Minas north shore outwash terrace. *Top*, growth of marine deltas; *Middle*, of marine plain—growth of subaerial fans based on Cobequid scarp; *Bottom*, modern ter- lissection, and sea-level rise.

croached on the zone of dissection on the older marine plain; the zone of dissection in turn encroached on the deltas which were following the retreating shore line. Such a scheme of regressing facies is the only depositional model which adequately explains the ubiquitous disconformity between the Advocate Harbor and Saint's Rest Members.

eskers (J. Jones, Nova Scotia Department of Mines, personal communication). If the Annapolis Valley was such an outlet, then the Minas passage (fig. 1) must have been clogged by drift or ice.

As the peak of outwash aggradation passed and the terrace continued to emerge, the outwash plain underwent a second, more severe dissection in which the rivers en-

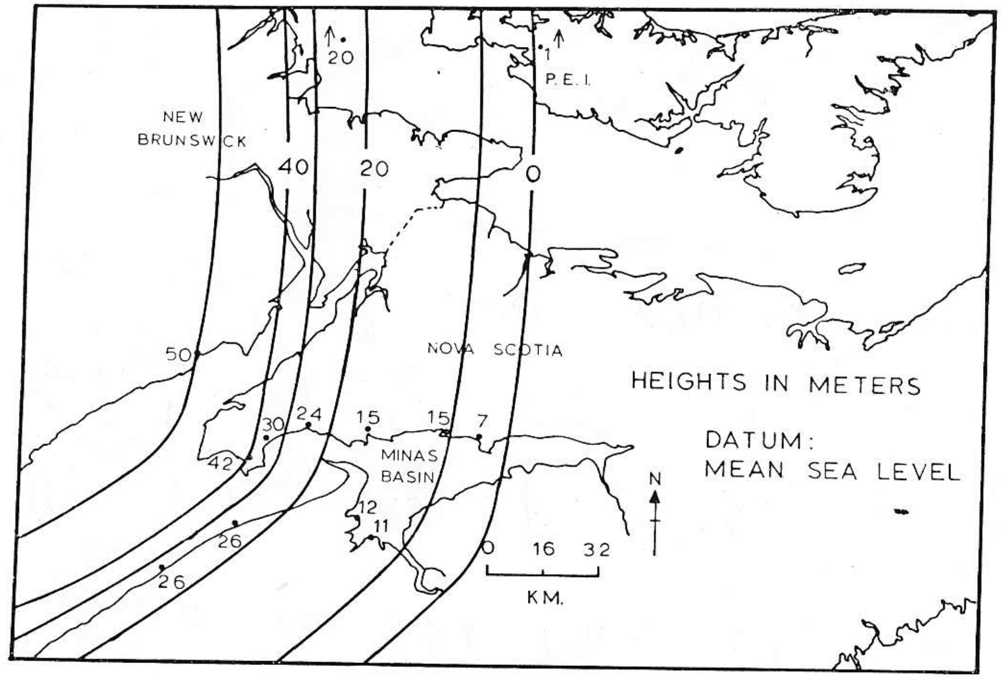


FIG. 14.—Isobases of postglacial emergence Prince Edward Island data from Prest (1962, 1964); data for the south shore, Bay of Fundy from Hickox, 1962. Modified from Borns, 1966.

Eventually a graded subaerial outwash plain extended across the Minas Basin. Sub-bottom profiles of outcrops at the north end of the Annapolis Valley suggest that, as proposed by V. Prest, Geological Survey of Canada (personal communication), the valley may have at some point served as an outlet for meltwater of the Minas Basin either as a spillway or as a marine strait. However, no marine deposits have been found at altitudes higher than 12 m. above ean sea level on the north end of the valley. Linear sand bodies at higher altitudes, interpreted by Churchill (1923)

trenched themselves to depths probably in excess of 30 m., and the present river terraces were cut. Finally, emergence diminished to a negligible rate, and the sea advanced to its present position (fig. 13, *bottom*). 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.

EMERGENCE

GENER

Contours of minimum postglacial emerlevel of the contact between the Saint's Rest and Advocate Harbor Members and, at Advocate Harbor, the altitude of the base of the raised sea bluff. Data from Hickox (1962) and Prest (1962, 1964) are included. The data are affected by errors of both procedure and interpretation.

PROCEDURAL ERRORS

Altitudes of marine–non-marine contacts were determined at the bluffs, wherever possible. Here the last high-tide line on the beach serves as a field datum as determined from *Atlantic Coast Tide and Current Tables*, 1966 (Canadian Hydrographic Service). The bluffs are steep, so that hand leveling with a Jacob's staff yields a minimal error of about 3 per cent (Robinson, 1959). The error accompanying the relating of field datum to mean sea level via the tide tables is estimated to be ±1 m.

INTERPRETIVE ERROR

The most satisfactory basis on which to measure altitudes of emerged strand lines is probably a series of wave-cut and wave-notched rock sea cliffs (Zeuner, 1961). Due to the short duration of the sea stand in question, the short wave fetch of the Minas Basin, and the prograding nature of the late Pleistocene coast, these features are lacking; and even wave-cut sediment terraces, less satisfactory since prone to subsequent erosion, are present only in the Advocate area. Strand-line measurements of the Minas Basin's north shore must be based on the altitudes of the distal portions of marine deltas. Such surfaces do not commonly lie at mean sea level, but a short distance below it, the amount depending on stream discharge, wave attack, grain size, distance from shore, and other factors. In the Five Islands Formation, error from this source probably ranges from 0 to 2 m. The range was selected after consideration of such modern sand and gravel deltas as the Middle River delta in Bras D'Or Lake, a large landlocked marine embayment on Cape Breton Island, Nova Scotia.

error stems from the fact that, as indicated on previous pages, the top of the Advocate Harbor Member was eroded prior to the deposition of the Saint's Rest Member. In order to minimize this error, each locality was carefully examined before measurements were attempted so that the point where the contact is highest could be selected. These points are usually on the flanks of the bedrock valleys which the deltas occupy. It is believed that here the contact is more a depositional hiatus than an erosional unconformity. Deeply incised channels containing the Saint's Rest Member are largely confined to the valley axes. The effects of channeling on measurement of terrace altitudes may be seen at the sea bluff by the lighthouse, Upper Five Islands (Station *M*, fig. 15).

SIGNIFICANCE OF EMERGENCE

Figures 14 and 15 indicate that the surface of the marine terrace climbs from mean sea level at Saint's Rest to over 40 m. at Advocate Harbor. The contact between the Advocate Harbor and Saint's Rest Member at Saint's Rest (zero isobase relative to mean sea level) lies halfway down the beach at low tide, and is usually covered by a veneer of beach gravel. However, at the World War II observation tower 1 km. west of Economy, the zero isobase relative to storm high tide is well exposed. Here the contact between the Saint's Rest and Advocate Harbor Members is also the break in slope between the beach and the wave-cut bluff. As has been indicated by King (1965) and earlier workers, the isobases give only a minimum figure for postglacial uplift of the crust because the sea has been rising since the uplift has been accomplished. Also, the zero isobase does not define the eastward extent of ice-induced warping; considerable uplift was undoubtly completed in Nova Scotia east of the zero isobase prior to the formation of the Minas Basin's north shore terrace.

The diachronous nature of the landward-shifting zone of maximum uplift and the

Atlantic provinces further complicate the interpretation of figure 14. Two strand-line altitudes in figure 14 are taken from Hickox (1962). Hickox reports a proglacial marine delta at Margaretsville; the delta, however, has been overriden from the south by an ice advance which Hickox correlates with the Valders readvance of the midcontinental sequence. Hickox thinks that the deltas were built during the advance; the delta would then be younger than the deltas of

the sequence of events during degla has been misunderstood. Should t napolis Valley readvance of Hickox to a cold period earlier than Valder then the wave-cut terrace of the Fundy's south shore could be tent correlated with the constructional terrace of the Minas north shore.

Finally, it should be pointed ou figure 14 would be influenced by a tonically induced postglacial crustal

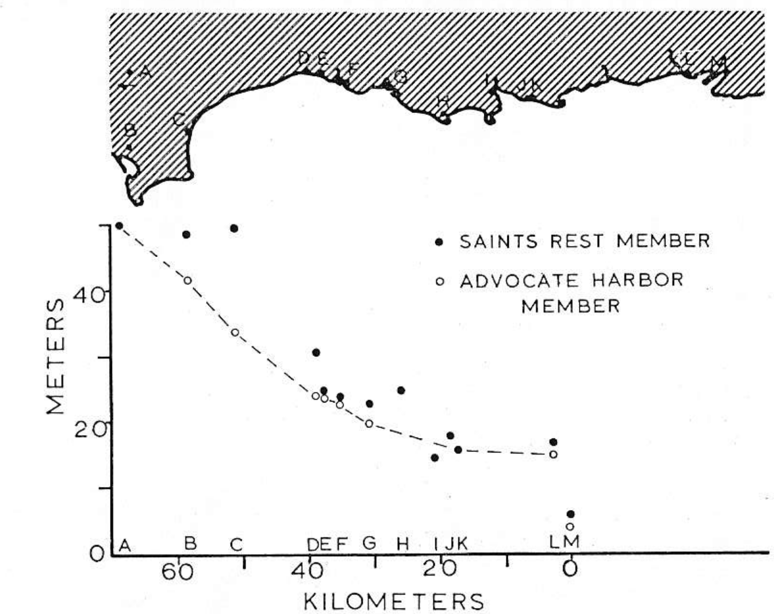


FIG. 15.—Plot of terrace elevations from the Minas Basin's north shore, against east-west comp distance between stations.

the Minas Basin's north shore, for which the authors suggest a Port Huron age. Hickox, however, does not obtain his strand-line data from the overriden delta but from a discontinuous terrace cut into the drift of the Fundy south shore. This destructional land form presumably is younger than the constructional features of the postulated ice cap of Valders age and therefore considerably younger than the Minas Basin's north shore deltas. Thus, either figure 14 presents a composite picture of several events of late Pleistocene time or else the

ments, as well as those relating to de tion. Rates of modern sea-level cha Newfoundland as great as 70 cm. p tury (Jenness, 1960) must be attribu tectonic crustal warping, and Harris Lyon (1963) have presented eviden both positive and negative crustal ments in the Minas Basin between B.P. and 3,000 B.P.

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SEDIMENTOLOGY OF CARBONIFEROUS CEMENTSTONE FAC BRITISH ISLES AND EASTERN CANADA[1]

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ABSTRACT

Distinctive facies of dark-gray lutite with interbedded cementstone (calcilutite) layers ar with laterally and vertically interfingering fluvial facies in Carboniferous fault-block troughs (on both sides of the Atlantic. The repetition of internally laminated cementstone with gray lu salinity changes in portions of the depositional basin. Laminated cementstone beds of dolom cracks were probably deposited as carbonate (calcite?) mud that may have subsequently bee dolomite during a desiccation stage. Laminated cementstone beds of calcite may have been de buried subaqueously. Nodular cementstones seem to be of secondary origin.

These facies were deposited in a marginal marine to restricted marine environment in the I but are non-marine in eastern Canada.

INTRODUCTION

Dark-gray and maroon calcareous lutite with interbeds of light-gray calcite and dolomite lutite (defined as cementstone facies) was first noted in Lower Carboniferous rocks by Young (1867), and has subsequently been found to be widespread over the Midland Valley of Scotland and its extension in Northern Ireland (Freshney, 1961, and previous work cited therein). Similar facies had been earlier but less adequately defined from southeastern New Brusnwick (Gesner, 1847), and they were recently found by Belt to be widespread over much of eastern Canada, although they form less than 30 per cent of the total lacustrine deposits there. These facies are closely associated with marginal marine and non-marine rocks in Carboniferous rift valleys, and although they vary somewhat in age from place to place, they are remarkably similar in lithology. Cementstone facies are also found in the classic Triassic rift valley of Connecticut and Massachusetts (Chicopee Shale, Emerson, 1898). As sedimentologic description of this rock type has not been widely reported p and as the authors of this paper h similar conclusions independentl posite sides of the Atlantic, a jo was considered desirable.

The precise age of the rock unit in the cementstone facies has not b determined; tentative ages are figure 1. Microspores form the bas recent age assignment for the uni ern Canada (M. S. Barss, perso munications, 1960–67), although invertebrate, fish, and megapla blage earlier supported the view. stone facies in the British Isles a ered to be mainly pre-middle V possibly Tournaisian, although th is still meager (Freshney, 1961, South of the Midland Valley, in t umberland basin (fig. 2), similar fa in the same stratigraphic positi (and presumably interfingered wi Old Red Sandstone facies and flu stones and beneath well-dated ma stones (Craig, 1957). Thus, exce northern portion of the Northu basin, the cementstone facies of th Isles are confined to the Scottish Valley and its extension into Ulste ern Ireland). The cementstone eastern Canada are confined to th Basin and its extension in northe foundland (fig. 3). Thus, in all

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