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GEOLOGY OF CHARLOTTETOWN MAP-AREA, PRINCE EDWARD ISLAND

11 L/3

(Report and Map 6-1964)

V. K. Prest

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By

V.K. Prest

D E P A R T M E N T O F

M I N E S A N D T E C H N I C A L S U R V E Y S

C A N A D A

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Map 6-1964. Charlottetown map-area ..... In pocket

ABSTRACT

This report deals with the bedrock and surficial deposits of a small area on the south shore of Prince Edward Island. Bedrock is mantled throughout most of the Charlottetown area by a layer of glacial drift, a few inches to 25 feet thick. Natural rock exposures are restricted mainly to coastal areas and along some streams. Bedrock is terrestrial Upper Pennsylvanian and Lower Permian red sandstones, siltstones, and claystones, essentially flat-lying except near a northeast-trending domal structure centred in Hillsborough Bay. Bedding is extremely variable in most exposures. The drift mantle is mainly basal till with related patches of ablation till and of ice-sloughed debris. Minor glacio-fluvial deposits are poorly developed in valleys in the western part of the area. Glacial striae in Charlottetown area suggest that in late Wisconsin time ice flowed from dispersal areas in Cape Breton Island to the east, in the Cobequid Mountains to the south, and in central New Brunswick to the west. Deglaciation resulted in ice stagnation and accumulation of debris on the surface. There is no evidence of early post-glacial marine overlap in this area, although evidence of overlap has been recognized at the western end of the Island. There are no mineral deposits of economic interest, nor any noteworthy sand and gravel deposits. The land is used chiefly for agricultural purposes, but the parent soil materials are not rich soil or soil-forming types, and require constant chemical treatment to compensate for mineral deficiencies.

GEOLOGY OF CHARLOTTETOWN MAP-AREA, PRINCE EDWARD ISLAND

INTRODUCTION

Charlottetown map-area is situated in the south-central part of Prince Edward Island (hereinafter referred to as the "Island") and includes the city of Charlottetown. A cursory examination of this area was made by the writer in 1953 at the start of a comprehensive geological study of both bedrock and surficial deposits that has continued to the present and is now nearing completion. The 1953 work in this area was primarily aimed at outlining the bedrock structure in the vicinity of Hillsborough Bay. Thereafter mapping of the surficial deposits was undertaken in Tignish map-area; the report on the Tignish area provides some general information on the fossils found in the Island 'red beds' and the problems that arose as to the age of the strata (Prest, 1962). Since that report was written the age of the 'red beds' has been more clearly established through the study of vertebrate fossils (Langston, 1963) and of spore and pollen grains (Barss, Hacquebard, and Howie, 1963) from certain parts of the Island including Hillsborough Bay.

The map accompanying this report was largely compiled by the writer during parts of the field seasons 1962 and 1963. It embodies some of the writer's earlier observations around Hillsborough Bay as well as those of G. H. Crowl from the peninsula east of Charlottetown, which Crowl studied when mapping the Mount Stewart area to the northeast (Crowl, 1960). The eastern side of Charlottetown area adjoins the Montague area on which the surficial geology has been published (Frankel, 1960).

Those unacquainted with Prince Edward Island are apt to think of it as a very low-lying pastoral area, yet it has a maximum elevation of 475 feet. Parts of Charlottetown area rise to 375 feet within 2 1/2 miles of the sea. Near Charlottetown itself the hills are subdued but near the eastern side of the map-area one hill, only 1 1/4 miles from Hillsborough Bay, has an elevation of 300 feet. Local relief in the more hilly northwestern corner of the map-area is about 200 feet from creek bottom to adjacent hill-tops. The present topography pre-dates the last (Wisconsin) glaciation. There is scant evidence of major glacial scouring and the stream pattern is in no way related to such action.

The bedrock of Charlottetown map-area is almost everywhere mantled by a layer of drift from less than a foot to about 25 feet thick. Where the drift mantle is generally less than about 2 to 3 feet

thick, the area concerned has been mapped as bedrock. Natural rock exposures are restricted mainly to the coastal bluffs; to a lesser extent they occur in or along streams and especially at the spring-heads. They are very rare elsewhere though a few were encountered on farmland. The most prevalent inland exposures are roadside cuts and borrow-pits where rock has been removed during road construction or for 'fill'.

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BEDROCK GEOLOGY

Age Relationships

The bedrock of Charlottetown map-area, except for Governor Island, is of early Permian age (Langston, 1963)[1] and hence is about 200 million years old. The rocks of Governor Island are somewhat older as they lie stratigraphically beneath the Permian rocks and are related to the upper part of the Pennsylvanian System, and specifically to rocks of Stephanian age (Barss et al., 1963). The writer considers the red beds at Crown Point to be the close stratigraphic equivalent of the known Lower Permian beds at Gallows Point (Montague map-area), and that the thickness of the red bed sequence between Crown Point and Governor Island is about 2,000 feet. This section beneath Hillsborough Bay must, therefore, include the contact or time-boundary between the Pennsylvanian and the Permian; judging by the similarity of the beds near Gallows Point and on Governor Island, the boundary may well be transitional.

Rock Types

The bedrock types in Charlottetown map-area are predominantly sandstone, siltstone, and claystone, in that order of abundance. Locally there are discontinuous lenses of claystone breccia. The most prominent breccia horizon is at the base of the sea-cliff east of Seatrout Point, at the entrance to Charlottetown Harbour, where it occurs as a bed 1 foot to 5 feet thick; which is traceable for several hundred feet. This is the most continuous breccia layer seen on the Island.

No conglomerate was seen in the map-area, and only one exposure of conglomeratic sandstone was encountered. This is on a point on the south shore of Eliot River causeway. There angular pebbles of hard stones (acidic lava, porphyry, and quartzite) up to 1/4 inch in size comprise a few per cent of the rock. A mere scattering of hard pebbles was seen in sandstone exposed in the road-side drainage-cuts at the bend in the road 1 1/2 miles north of New Haven. An occasional hard or foreign pebble occurs in the claystone breccia in some places. All the rocks mentioned above are terrestrial in origin.

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[1]Names and dates in parentheses refer to publications listed in the References.

In general the Island rocks are a dull brownish red owing to the presence of a ferruginous cement; when dry they fall within the Munsell colour range 10 R 4-5/2-4, but damp claystones may be as dark as 10 R 3/6. The sandstones become greyish as the carbonate content increases and locally are as light as 7.5 YR 7-8/0-2. The claystones, however, retain their red colour even though the carbonate content is so high that they effervesce vigorously in dilute hydrochloric acid.

At the western tip of Crown Point a bed of blue-grey freshwater limestone less than 1 foot thick can be seen on the tidal flats, and boulders of it occur in the low drift banks. It is doubtful if this thin bed has any appreciable continuity; its size and position eliminate the possibility of economic use.

Structure

The regional structure of the strata in the Charlottetown area is imperfectly known. The strata appear to be essentially flat-lying except near the shores of Hillsborough Bay, where the beds are upturned some 5 to 15 degrees and comprise the northern flank of a slightly elongate dome that trends N50°E and is centred in Hillsborough Bay. Away from the marked influence of the dome the strata are either flat-lying or very gently undulating. Their true attitude is masked by the initial or fore-set bedding dips and complex quaquaversal-type crossbedding. The lower beds in the sequence may have been deposited as channel and flood plain strata and the higher beds in the sequence as coalescing alluvial fans. The presence of mudstone units is not as helpful in recording the structural attitude of the beds as one might expect, because they fill marked 'scours' in the underlying sandy units and are themselves deeply channelled and filled by overlying sandy units. Furthermore the mudstone units are known to be surprisingly lenticular and hence major bedding planes cannot be safely projected over any distance. Disconformities between major units of beds have been noted. The structure must therefore remain obscure until the whole of the Island has been examined and at least a rough stratigraphic succession established.

SURFICIAL GEOLOGY

The drift mantle in Charlottetown map-area is mainly basal till with related patches of ablation till and of ice-sloughed debris. Next in importance are glacio-fluvial sand and gravel deposits, which occur as elongate bodies in some lowland areas, and as irregular patches on hillsides and lowlands alike. The ice-sloughed debris occurs for the most part along hill-sides associated with, or

grading downslope into sorted glacio-fluvial deposits. Some of the hill-sides are mantled by colluvium, but this cannot be readily distinguished from ice-sloughed debris, nor can the alluvium in some valley bottoms be separated from glacio-fluvial sand and gravel; colluvium and alluvium have not therefore been mapped as discrete units. Organic deposits are not common but have been mapped in a few places.

Basal Till

Basal till is the mixture of broken and ground-up rock and drift material deposited from the lower part of an active glacier. In Charlottetown map-area it is a brownish red (Munsell chart 10 R 5/4-6), compact, clayey to sandy till. The proportion of clay-size to sand-size 'grains' varies markedly according to the local character of the bedrock over which the glacier passed. The stones in the till, however, are mostly sandstone types even in claystone areas, as the former are more resistant to abrasion. The stones in the till range from pebble to small boulder size; large boulders are uncommon owing to the weak nature of the Island rocks.

The marked range in the proportions of clay-size to sand-size 'grains' constituting the till matrix in Charlottetown map-area makes it both possible and desirable to separate or map different phases of the basal till. Accordingly clayey, intermediate, and sandy phase tills have been mapped, and have been termed clay till, clay-sand till, and sand till respectively. The boundaries between these types, however, are gradational. Furthermore they are largely based on the general appearance of the till when inspected by the naked eye or by hand lens, and on the way it 'handles'. For instance, the clay till has a dense clayey appearance with only widely-scattered sand grains, and when moist can be readily broken into blocks. The sand till, in contrast, is an obvious aggregate of sand grains with but scant clay 'skins' around them, and it readily crumbles to a granular mass. The clay-sand till has a sandy appearance, but with readily evident clay 'skins' around the grains, and with some irregular clayey veinlets throughout. It is generally very tough when slightly moist to nearly dry, and breaks into irregular chunks.

The behaviour of the till on 'handling' varies appreciably according to the moisture content, and hence weather conditions tend to effect the field classification. The subdivision of the basal till is also affected by the proportion of silt-size grains that are present at the expense of either the clay or sand-size fractions of the matrix.

In spite of all these variables it is felt that the surficial geology map provides a fairly reliable picture of the character of the till. The type of till is important in that it has a direct bearing on the nature of the soil mantle and the use to which it may be put. It also provides an indirect picture of the kind of bedrock to be expected nearby, in this area of uncommon exposures.

In order to provide some factual data on the grain-size range in the till matrix, a wet method of screening was employed, followed by a short period of dry-screening; by this method mechanical abrasion of the soft Island stones was lessened. The -0.061 mm fraction was analyzed by the pipette method. The following size distribution appears to apply to the Charlottetown area till types:-

Clay till;	clay + silt sizes >65%, sand size <35%
Clay-sand till;	clay + silt sizes 50±15%, sand size 50±15%
Sand till;	clay + silt sizes <35%, sand size >65%

A variable proportion of the sand-size, and to a lesser extent the silt-size grains are rock rather than mineral grains.

Ablation Till and Ice-sloughed Debris

The ablation till represents the debris that accumulated on the surface of the glacial ice as it thinned, and finally was gently deposited on some parts of the upland surfaces. The ice-sloughed debris represents former englacial materials that accumulated on the ice in unstable positions and finally slid from the last remnants of ice in the valleys or low areas onto the adjoining hillsides. These deposits are characterized by great variation in sand versus clay content over very short distances, by the inclusion of lenses of variably-stratified materials, and by their general stony character. The debris may contain boulders of Island rocks several feet in diameter whereas the adjacent or subjacent till contains only cobbles or small boulders. The debris and ablation till is usually less clayey than the nearby till, suggesting the quiet or gentle removal of 'fines' by meltwater. In some places, however, the debris remains as a bouldery and clayey mixture. All these materials are difficult to recognize except along the coastal bluffs or in fresh road-cuts and borrow-pits that chance to transect them. Their thickness ranges from about 1 foot to 25 feet.

Glacio-fluvial Deposits

Glacio-fluvial deposits in Charlottetown map-area are relatively unimportant parent materials for the development of the

Island soils. They are more common in valleys in the western part of the area though they are perhaps more readily distinguished in the vicinity of Clyde River and Cornwall. Though these deposits could be classified as esker, crevasse-filling, kame, valley train, and outwash, their forms are only observed with difficulty on the ground and seldom distinguishable on airphotos. In other words they tend to blend into the landscape and may often be discovered only upon examination of the 'soils' themselves. The eskers, for instance, are generally only about 10 feet high. The materials range from relatively well-sorted sand through gravels into rather bouldery material, including some ill-sorted debris. The ill-sorted debris is included in this grouping only where associated with sand and gravel of some specific glacio-fluvial feature. The glacio-fluvial deposits are in large part associated with ice-sloughed debris, and together these deposits form a complex anastomozing pattern in some of the stream valleys. Only in the Clyde River-Cornwall area does the glacio-fluvial and debris complex lap over from one small valley to another, though this is a common phenomena in eastern Prince Edward Island (Crowl, 1961; Frankel, 1960).

Organic Deposits

Black muck and peaty muck are uncommon soil types in Charlottetown map-area and the mapped muck deposits are restricted to the part east of Hillsborough River. Salt marsh is more prevalent, occurring at several places around Hillsborough Bay and the adjoining inlets. A section through the marsh made by a power shovel across North Creek (Queens Arm) a short distance north of the map boundary revealed the following materials:

High Tide Level ----------Growing vegetal layer
0 to 3 or 4 feet of ---------- Vegetal muck (tidal flats accumulation)
6 to 16 feet of ----------Grey organic clay containing marine shells as well as pieces of wood, leaves, cones and other debris
2 to 4 inches of ----------Grey-white sand

'Hardpan' reported (a trace of red, clay-sand till was seen on the power shovel dump).

GLACIAL AND POST-GLACIAL HISTORY

The last (Wisconsin) continental ice-sheet covered the whole of Prince Edward Island at its maximum development.

Glaciation of Charlottetown map-area is revealed by the mantle of glacial till that rests on the bedrock in most places. Glaciation is also indicated by glacial striations or scratches, known as striae, which may be observed on the bedrock surface where the till mantle has been newly uncovered by shoreline erosion or by construction projects; once exposed the striae are generally destroyed by weathering within a year or so. The glacial till is derived from the local 'Island' bedrock; only a very few cobbles and boulders of far-travelled, hard, 'foreign' stones are present in or on the till.

Direction of Ice-movements

The glacial striae observed in Charlottetown area are believed to be related to late Wisconsin ice-movements when three major ice-lobes were deploying in the Prince Edward Island region. These were from dispersal areas centred in Cape Breton Island (Prest, 1957), the Cobequid Mountains (Flint, 1957), and central New Brunswick (Flint, 1953, 1957). In the case of the Cobequid 'centre' it may well be that late dispersal was not from these mountains (hill-tops generally between els. 1,000 and 1,200 feet), but rather from the lowland to the north of the Cobequids as a mere freshening of a late ice remnant. The writer believes that Cape Breton ice glaciated the eastern part of the Island, and New Brunswick ice the western part. The Cobequid Mountains (or the lowland north of it) supplied ice that moved northward to the Island shores in the neighbourhood of Hillsborough Bay and for a time held off the major eastward- and westward-moving ice-lobes. When both the 'Cobequid' and Cape Breton ice-lobes had receded, the New Brunswick ice was able to push eastward along Northumberland Strait toward Wood Islands.

In Charlottetown map-area a 'Cobequid' ice-lobe is believed responsible for nail-head striae[1] trending N10°W that were observed a short distance west of Canoe Cove. These striae were crosscut by others trending at N40°E related to a glacial lobe from New Brunswick.

Nail-head striae on the shore between Kelly Point and the Hillsborough causeway, and striae in a borrow-pit near Hillsborough corner, together with ice-flow features in the till near Mount Herbert and Bunbury are considered by the writer to have been formed by northwestward-moving ice from the Cape Breton dispersal area. There is as yet, however, no clear-cut proof that Cape Breton ice glaciated this part of the Island.

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[1]Nail-head striae are not infallible indicators of ice-movement directions, but they appear to be generally reliable for the Island.

All the remaining observed striae are believed related to the New Brunswick ice-lobe. The variation in the trend of these striae is considered to reflect the declining influence of the 'Cobequid' ice-lobe and gradual domination of the New Brunswick lobe in Northumberland Strait. Thus in the south-central part of the Charlottetown area there are striae trending at N32°E to N45°E. Others at N55°E to N60°E may reflect a more easterly shift as the Cobequid ice waned. Still others at N65°E to N80°E have been observed cutting the northeast-trending striae. The N65°E to N80°E striae are the most prevalent in the area and have been found both along the coast and far inland. The cluster of striae near Battery Point, due south of Charlottetown, with bearings of N78°E to N92°E are believed related to the main New Brunswick ice thrust, but it was not found possible to determine the actual 'sense' of the movement involved here.

Glacier Stagnation

As the Wisconsin ice-sheet waned under the influence of a warming climate, the sea encroached on the Island shores and finally severed the active New Brunswick and Cape Breton ice-lobes from their former dispersal areas. The Island ice-cover then stagnated, and melting processes became dominant. Cracks and tunnels in the ice led meltwaters laden with clay, silt, sand, and cobbles into the valleys. Most of the finer material was transported to the sea, but the coarser sediment was deposited in or along the valleys or on other lower ground. Much englacial debris was not removed by meltwaters but accumulated on the ice surface. As the ice-cap broke up into innumerable smaller bodies some of the debris slid or sloughed off the ice onto lower ground or along valley walls. Some of it sloughed into cracks or crevasses in the ice to remain as small irregular ridge-like bodies when the confining ice melted. Finally as the last ice masses melted away locally, the remaining debris settled on the underlying surface as a non-sorted to ill-sorted mass termed ablation till.

Post-glacial Events

There is no evidence of early post-glacial marine overlap in Charlottetown map-area. All coastal bodies of sand or gravel at elevations less than 25 feet appear to be either of glacio-fluvial or alluvial origin. At the present time the sea is slowly encroaching on the Island shores seemingly in response to a general rise in the Atlantic level. This is causing considerable erosion of the soft Island rocks. At the same time there is an infilling of the head ends of Hillsborough inlets, as the relatively thick marine muds at North Creek

(Queens Arm) appear to indicate. On the western boundary of the map-area, southwest of Victoria, a peat-muck deposit with plentiful small tree roots is presently subject to tidal flats erosion, indicating a rise in sea-level since the deposit was formed.

Inland, in post-glacial time, heavy vegetation stabilized most of the land surface and black muck and other organic materials accumulated locally. The peat-muck deposits east of Charlottetown are probably only a very few feet thick. Very small deposits along the south coast in the western part of the area were only 1 foot to 2 feet thick, as compared to peat deposits elsewhere on the Island of about 20 feet.

ECONOMIC GEOLOGY

There are no mineral deposits of economic interest in the 'red beds' of Charlottetown map-area, nor are there any noteworthy sand or gravel deposits. Some of the sandstone horizons provide good road-bed material. Some claystone and fine siltstone beds may prove useful in the future for the manufacture of common red brick and tile (Prest and Brady, 1964). Soft weathered claystone may in a few places provide raw material for hobby-type pottery work.

The parent materials of the soils constitute the only geological units that are important to the economy. The main soil-forming material is glacial till and the more clayey phases of this till provide the better soil. In general, the more sandy till, the well-sorted glacio-fluvial materials, and the bedrock do not lend themselves to the development of good farmland, though this tendency can be offset by the addition of both lime and fertilizer coupled with good farm practice. Some good farms have been maintained where bedrock is at the surface or involved in the soil profile, but these are chiefly in areas where claystone and siltstone are prevalent.

The parent materials of soil, whether till or bedrock, are not rich 'soil' or soil-forming types. Some of the virgin soil in woodland areas does constitute an excellent soil, but for the most part the soils require constant additions of lime and fertilizer to make up for mineral deficiencies. All the parent soil materials will maintain a good forest cover. Some of the stream valleys support good stands of timber, which take care of the fuel supplies of the surrounding farms, and should be carefully maintained. Many farms or parts of farms have been abandoned and 'second' growth has taken over. The quality of wood in these places could be improved by early thinning-out. The wooded stream valleys enhance the beauty of the Island, cut down on soil erosion, help maintain stream flow, and provide tourist parks and picnic spots, all valuable assets where mineral deposits are lacking.

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