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Carboniferous Stratigraphy and Sedimentology of the Chignecto Bay Area: Southern New Brunswick

van de Poll, H.W.

Trip A-4, by H. W. van de Poll, University of New Brunswick

CARBONIFEROUS STRATIGRAPHY AND SEDIMENTOLOGY OF THE CHIGNECTO BAY AREA: SOUTHERN NEW BRUNSWICK

INTRODUCTION

The purpose of this field excursion is to examine the vertical and lateral facies transitions from an upper Mississippian marine evaporite succession (Windsor Group) to a lower Pennsylvanian continental fluvio-paludal sequence (Cumberland Group) and to reconstruct the apparent tectonic palaeo-physiographic and climatic conditions under which the transition has taken place. Copper, silver, vanadium, mercury and to a lesser extent lead, of the so-called "sedimentary" type are widely associated with these strata.

A brief discussion of the Carboniferous geology of the Maritime Province is presented here to emphasize the evolutionary history of the basin and its stratigraphy.

PREVIOUS WORK

The first geological map of New Brunswick was published by James Robb in 1849-50, and shortly after, the Carboniferous subdivisions appeared in their proper stratigraphic order when Sir William Dawson issued his first edition of "Acadian Geology" in 1885. Following the passage of the Confederation Act in 1867, the Geological Survey of Canada expanded its geological coverage to the Maritime Provinces.

The most important advances in the local Carboniferous stratigraphy, however, were not made until after the turn of the century as a result of the palaeobotanical studies by W. A. Bell of the Geological Survey of Canada. Bell, until his death in 1968, devoted more than 50 years to geological work in the Maritimes. He introduced the present Carboniferous stratigraphic subdivisions and correlated them with those of the United States and Europe. In 1914, Marie Stopes published her classic work on the flora of the Saint John "Fern Ledges" and demonstrated their striking similarity with the Westphalian flora of the European coal measures.

Subsequent regional palynological studies by P. A. Hacquebard, S. Barss and D. Donaldson of the Geological Survey of Canada were particularly successful in assigning otherwise non-

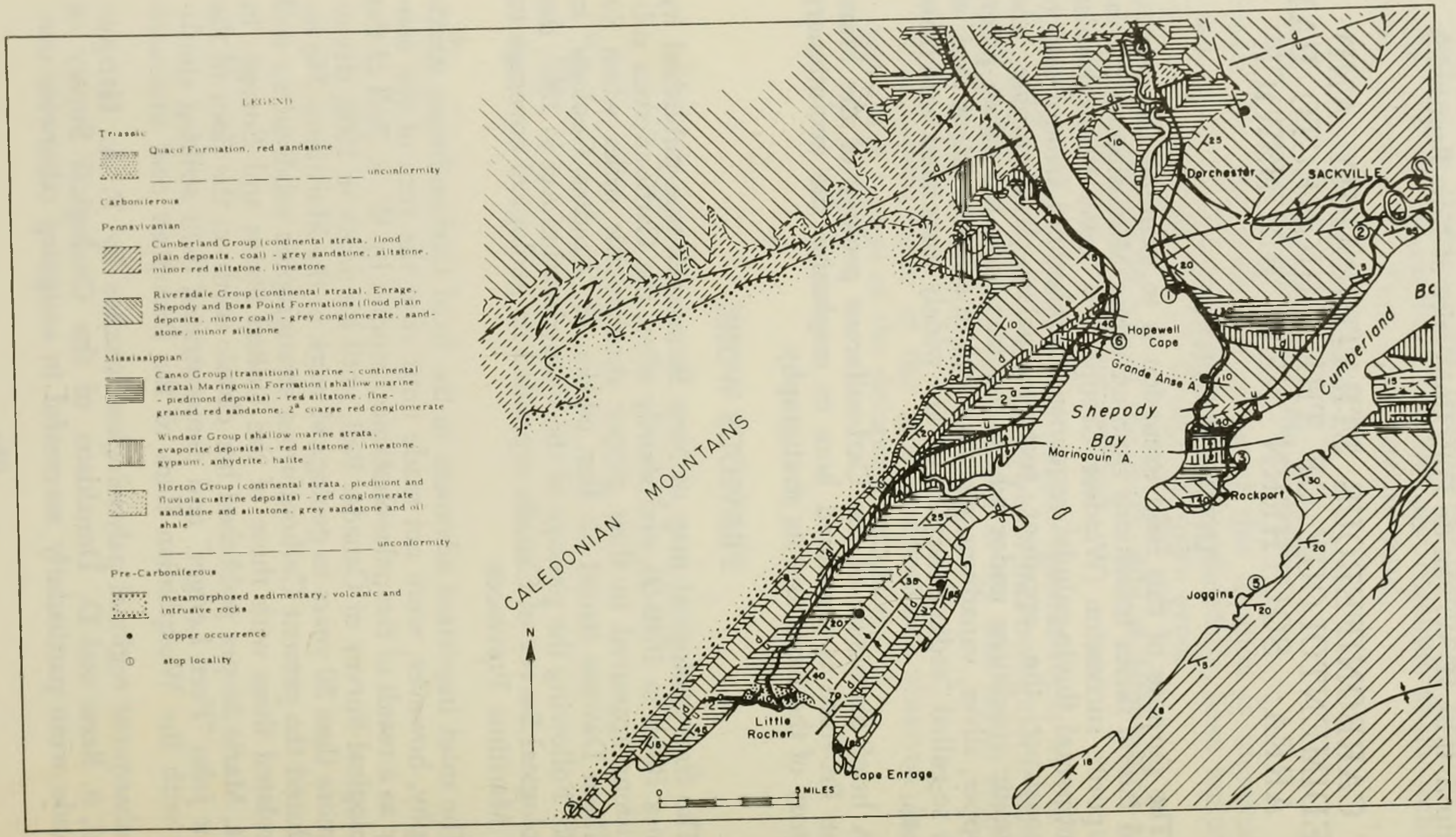

Fig. 1 Geology of the Chipucto Bay Area, N. B.

fossiliferous Carboniferous sequences to their proper stratigraphic position, and led to important modifcations of the Pennsylvanian stratigraphy.

THE DEPOSITIONAL BASIN

The term "Acadian Orogeny" as used here refers to the orogenic event during which the Appalachian Geosyncline was subjected to folding and faulting, intruded by granitic batholiths, became uplifted and was subjected to erosion by Middle Devonian times. In contrast to pre-Acadian rocks, which are mainly marine turbidites and associated volcanic rocks (flysch), post-Acadian strata are predominantly terrestrial red and grey beds in which plant fragments are common (molasse).

Early, post-Acadian deposition of molasse type sediments became firmly established by Middle Devonian time (Hacquebard, 1971) and initially was probably confined to partly connected basins.

Continued subsidence and concomittant onlap of sediments onto the surrounding foreland areas during the Carboniferous and Permian gradually consolidated to original loci of deposition into a large successor basin, of which the remains still underlie parts or all of Newfoundland, Nova Scotia, New Brunswick, Prince Edward Island, Quebec and the Gulf of St. Lawrence. The present total area of (post-Acadian) Devonian and Permo-Carboniferous strata is approximately 65,000 square miles, of which an estimated 25,000 square miles is on land (Kelley, 1967).

The destructive phase in the evolution of the basin did not take place until post-Permian times, and perhaps may not have taken place until post-Triassic times when all of the region became uplifted and subject to erosion.

The present outline of the basin therefore is the result of erosion rather than deposition. Although the original palaeogeography of the basin is not known, recent sedimentological work has shown that the present western margin of the basin in Southwestern New Brunswick was once covered by up to several thousand feet of Permo-Pennsylvanian strata (van de Poll, 1970).

Three main categories of deformed Carboniferous strata can be identified. These are:

(a.) open and closed folds, locally associated with slaty cleavage;

(b.) tilted and locally overturned strata on the flanks of salt-cored piercement anticlines, and

(c.) tilted and locally overturned strata occurring in association with post-Carboniferous faults.

Slaty cleavage is locally developed, notably in the so-called "Fern Ledges" (Westphalian B age) of the Saint John Harbour area and to a lesser extent also occurs in lower Mississippian strata of the Canso Strait area of Nova Scotia. These comprise the most extensively deformed rocks of the basin although the nature of the deformation and its significance in the tectonic development of the basin are poorly understood.

The most common type of deformed strata are tilted beds on the flanks of salt-cored piercement anticlines where dips ranging from sub-horizontal on the margin to vertical or steeply overturned in the axial regions of these structures may be observed.

Tilted and locally overturned strata associated with high angle normal or thrust faults occur subparallel to the prevailing northeasterly and easterly structural trend of the basin. These faults are of major proportions and in most instances can be traced over considerable distances into pre-Carboniferous basement rocks. The main period of post-Carboniferous fault displacement took place probably between early Permian and Triassic times (van de Poll, 1970).

STRATIGRAPHY

The Carboniferous succession of Atlantic Canada is subdivided into six major stratigarphic units as follows:

Pictou group	Westphalian C – lower Permian
Cumberland group	Westphalian A – B
Riversdale group	Namurian C – Westphalian A
Canso group	Upper Viséan – Namurian
Windsor group	Viséan
Horton group	Upper Devonian – Tournaisian
– – – – – – –	Major Unconformity
Metamorphic	Basement Complex

Horton Group – The Horton Group comprises a succession of red and grey conglomerate, sandstone and siltstone locally with intercalations of volcanic rocks. The sequence overlies pre-Carboniferous basement with a pronounced angular unconformity and conformably underlies basal limestone of the Windsor

Group. In Southeastern New Brunswick the Horton Group includes lacustrine oil shales containing plant and fish remains.

Horton strata were originally designated by their characteristic lower Mississippian (Tournaisian) flora but more recently the age limits of the group have been extended from late Early Devonian to Viséan (Hacquebard, 1971). According to Bell (1960), the Horton flora appears of approximately the same age as the Pocono flora of the Appalachian region of the United States.

Windsor Group — The Windsor Group is the only known marine sequence in the Carboniferous section of Atlantic Canada and has been subdivided on lithological and faunal evidence into two zones and five subzones.

Each subzone is characterized by a cyclic repetition of strata involving a basal limestone overlain by red lutite, an evaporite sequence and again red lutite. In ascending order the subzones are designated as subzones A B, C, D and E and as originally defined by Bell (1929) each subzone was regarded as a chronostratigraphic unit containing a restricted suite of fossils.

More recently, however, it has been suggested (Schenk, 1967) that the Windsor subzones represent repeated wedges of marine transgressions. In his facies model Schenk (1967) proposed that each marine incursion is characterized by a carbonate zone, representing offshore and lagoonal conditions which terminate landwards against a lutite-evaporite succession of intertidal and/or salt-flat origin. The lutite-evaporite succession in turn is interpreted to be followed at its distal end by a continental red alluvial fan, or fanglomerate.

Windsor strata in Southern New Brunswick demarcate the western limit of the marine transgression and are represented by subzones A, B and the lower part of C (Gussow, 1953). They are conformably overlain by redbeds of the Canso Group (Maringouin Formation in New Brunswick) which are equivalent to Windsor subzones D and E in Nova Scotia.

Canso Group — The Canso Group represents the facies transition from marine to continental sedimentation and lies stratigraphically between the marine strata of the Windsor Group and the fluvial continental beds of the Riversdale Group.

The Canso Group is primarily characterized by red lutites in which small-scale primary sedimentary structures predominate. The unit grades laterally into marginal conglomerates of near-

source derivation and closely resembles a marine regression bahada-playa sequence expanding in the wake of the retreating Windsor sea towards the east.

Riversdale Group — As originally defined (Bell, 1944), the Riversdale Group was primarily distinguished by its Westphalian "A" flora except in the type section in Nova Scotia which is unfossiliferous (Kelley, 1967). Subsequent work, however, has shown the Riversdale type section to include time equivalent strata to the Canso Group (Hacquebard, 1971). As a result it has become desirable to redefine the Riversdale Group (Kelley, 1967) and to restrict the term to a sequence of mainly grey fluvial strata in which plant fragments are common, lying above the bahada-playa succession of the Canso Group and below the fluvio-lacustrine coal measures of the Cumberland Group.

The expanded Riversdale Group now includes, in addition to the Enragé and Boss Point Formations, the Shepody Formation, which was previously assigned to the Canso Group, and is subdivided as follows:

Boss Point Formation — mainly grey fluvial sandstone, subordinate red siltstone (floodplain type), basal quartz pebble conglomerate (rounded clasts), plant fragments very common.

Enragé Formation — red siltstone (transitional floodplain-playa type) and red and grey fluvial sandstone, basal quartz-pebble conglomerate (sub-rounded clasts), few plant fragments.

Shepody Formation — grey fluvial sandstone and interbedded red siltstone (playa type), plant fragments locally common.

The lower contact of the Shepody Formation is characterized by the first appearance of grey or red fluvial sandstone (conglomerate) overlying playa red siltstone (sandstone or fanglomerate) of the Canso Group.

In contrast to the subangular, poorly-sorted Canso conglomerates, the Riversdale conglomerates are characterized by a predominance of stable components (quartz and quartzite), better sorting and roundness of the clasts.

Cumberland Group — Rocks of the Cumberland Group overlie Riversdale strata conformably and include the Joggins section in western Nova Scotia. The succession consists of red and grey sandstone, siltstone, minor grey limestone and includes the well known coal seams of Springhill and Joggins.

Cumberland strata were previously thought to be unconformably overlain by, or in faulted contact with, strata of the younger Pictou Group, but more recent work has indicated the presence of a conformable transition of strata throughout the Westphalian time period.

Nevertheless, Cumberland strata have only been identified in western Nova Scotia and possibly southeastern New Brunswick, where over 9,000 feet is represented in a continuous section along the eastern shore of Chignecto Bay. Elsewhere, however, Cumberland strata appear non-existent indicating localized accelerated subsidence north of the Cobequid Mountains that resulted in a period of non-deposition in the peripheral areas.

Pictou Group — The name Pictou Group (Bell, 1944) applies to a non-marine succession of alternating red and grey sandstone and siltstone, grey-green siltstone and coal lying stratigraphically above the Cumberland Group. As originally defined, the Pictou Group was considered the youngest Carboniferous time stratigraphic unit containing a characteristic Westphalian C and D flora. Subsequent work, however, (Barss and Hacquebard, 1967; Kelley, 1967) has shown the time limits of the Pictou Group to range from lowermost Westphalian C to lower Permian.

In New Brunswick the total Pictou succession can be subdivided into 3-1/2 megacycles, each several hundreds of feet thick. Each cyclic sequence comprises a lower grey conglomerate-sandstone facies sequence overlain by a finer grained red sandstone-siltstone facies sequence. Coal, in association with grey-green siltstone, is locally present at the transition interval from the grey to red facies sequences.

LOG AND DIRECTIONS

STOP 1 — Dorchester Cape, Windsor, Canso and Riversdale strata are exposed in the shore section of Dorchester Cape and Grande Anse. The succession lies on the northern flank of the Grande Anse Anticline and dips to the north-northeast at approximately 25°.

The base of the section is made up of orange-red siltstone of the Windsor group and includes an 18-inch bed of gypsum. Although subzone C limestone has not been identified, the sequence has previously been assigned on general stratigraphic principle to the top of subzone B (Gussow, 1953).

The contact between the Windsor and Canso strata is transi-

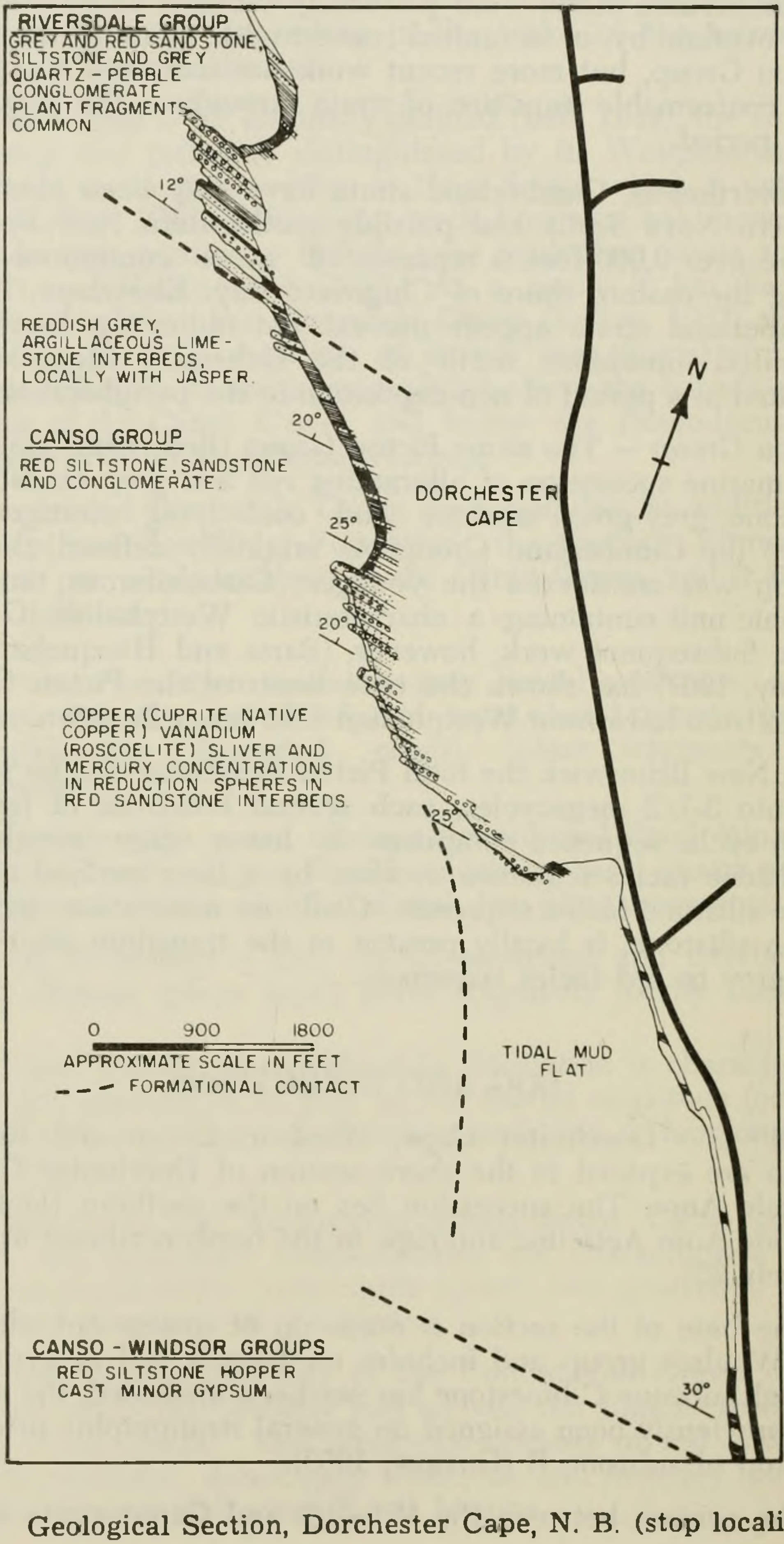

Fig. 2 Geological Section, Dorchester Cape, N. B. (stop locality 1)

tional and in the absence of Windsor limestone cannot be clearly defined. The lower part of the Canso Group comprises a coarsening upwards sequence and at Dorchester Cape is a cyclic succession of red conglomerate, sandstone and fine-grained red sandstone. The upper part of the Canso Group reverses to a fining upward sequence in which orange-red siltstone predominates. Several beds of nodular, and argillaceous greyish-red limestone with associated jasper occur near the top of the sequence. The Canso Group is interpreted to represent a salt flat-playa lake succession that includes a fan-toe wedge of an alluvial fan spreading from the north across the playa. Small concentrations of copper (malachite, cuprite, native copper), vanadium (roscoelite), silver and mercury (Sutherland, 1972), occur widespread with the conglomerate-sandstone sequence at Dorchester Cape. They form dark centres, up to 1/2 inch diameter in so-called "bull's eyes" or reduction spheres and appear particularly common in the cyclically recurring fine-grained sandstone interbeds.

Grey and red fluvial sandstone of the Riversdale group overlies strata of the Canso Group conformably. Although reversals to red siltstone are common, in particular near the base, the sequence exhibits an overall coarsening upwards tendency with frequent recurrences of extrabasinal quartz-pebble conglomerates, in particular at the base of the Boss Point Formation.

The characteristically mature composition and relatively high degree of roundness of the Boss Point conglomerates with respect to those of the Canso is interpreted to reflect a major change in the development of the basin. A transition from nearby to distal sources and concomitant widespread onlap of Pennsylvanian strata accompanied this change resulting in the gradual and complete transgression of all intrabasinal basement ridges in southern New Brunswick and western Nova Scotia such as the Cobequid and Caledonia Mountains, the Westmorland uplift and the Minto-Chipman basement ridge.

STOP 2 – Rock quarry, British Settlement. Vertical to steeply overturned Boss Point strata are exposed in the quarry. The sequence is characterized by medium-grained cross-bedded grey sandstone and minor dark siltstone. Large plant fragments are common. The succession is overlain by mottled grey and red quartzitic sandstone of the Cumberland group.

STOP 3 – Pecks Point, Cape Maringouin. The cliffed shore from Pecks Cove to Ward Point displays a continuous and conformable sequence of Canso-Riversdale strata and exemplifies the facies transition from a shallow marine salt flat-playa environment to a

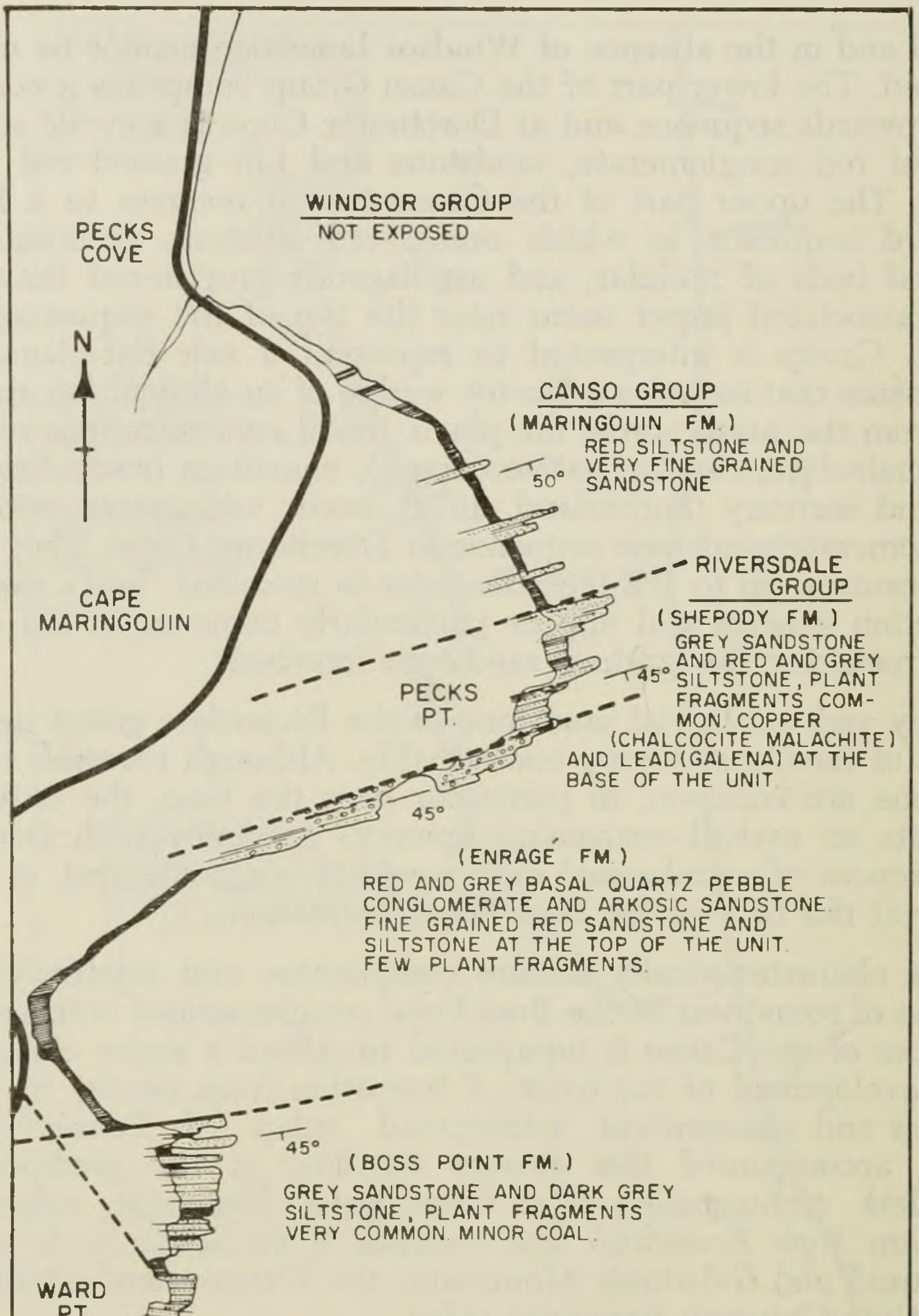

Fig. 3 Geological section, Pecks Cove to Ward Point, Cape Maringouin, N. B. (stop locality 3)

continental flood plain environment of deposition. The succession lies on the southern flank of the Maringouin (piercement) anticline and dips to the south-southeast at an average of 40°.

The Windsor Group, although not exposed in the section, is known from exposures on strike on the western shore of Cape Maringouin to include limestone, red siltstone and gypsum. The limestone is assigned to subzone C (Bell, 1944), and overlies the red siltstone-evaporite succession of subzone B.

Canso strata in the section are characterized by orange-red siltstone with fine-grained red sandstone interbeds. The succession becomes more sandy towards its upper contact, and the predominance of ripple drift gradually gives way to small-scale crossbedding and parting lineations.

The succession is interpreted to reflect the introduction of a large sediment supply in a low energy environment of deposition and is attributed to playa-coastal mudflat sedimentation.

The base of the Riversdale sequence is set at the lower contact of massive grey channel sandstone unit with a channel-lag mud-pellet conglomerate at the base. Plant fragments with concentrations of copper (chalcocite, malachite) and lead (galena) are common near the base of this unit. Regional stratigraphic work has shown that copper (chalcocite, malachite), silver and to a minor extent galena are widely concentrated at or near the base of the Riversdale.

STOP 4 – Gravel quarry, College Bridge. The quarry strata are made up of horizontal, poorly consolidated, thick bedded basal conglomerates of the Boss Point Formation. The characteristically mature composition (quartz, quartzite, jasper, chert, rhyolite and relatively high degree of roundness (Rho factors up to 70%)) of the clasts are well displayed and attest to the distal, extrabasinal fluvial origin of these strata.

STOP 5 – Joggins (stop co-leader: Dr. L. Ferguson). The Joggins shore section lies on the southern limb of the Maringouin Anticline (Minudie Anticline in Nova Scotia) and offers a unique view of vertical facies variations in the lower Pennsylvanian coal measures Cumberland Group. The Cumberland Group conformably overlies grey sandstone of the Boss Point Formation, and grade upwards into strata of the Pictou Group. The sequence is of non-marine origin and, as originally mapped by Logan (1845), Dawson (1878) and modified by Shaw (1951), contained five principal coarse and fine interfingering clastic units. From an

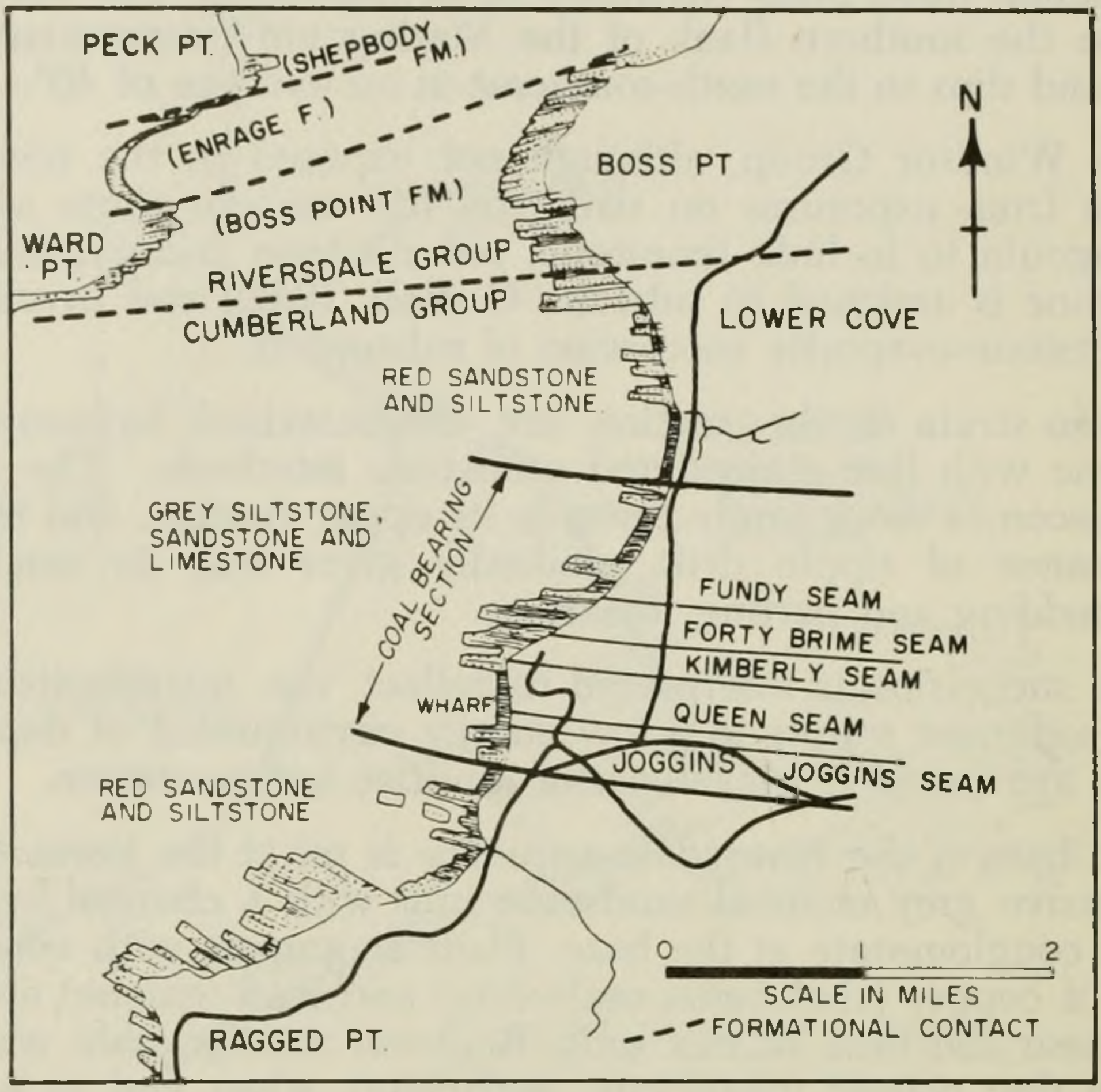

Fig. 4 Geological section of Joggins from Boss Point to Ragged Point, N. S. (stop locality 5). (Geology modified after Shaw, 1951)

economic point of view the most significant unit is the middle, fine-grained, coal bearing facies which is exposed in the Joggins area see "Coal Bearing Section" Fig. 4). This unit is characterized by cyclic recurrences of beds exhibiting the following sequence of deposition:

7) interbedded grey sandstone and shale,

6) grey shale, locally with plant remains,

5) black carbonaceous shale containing ostracods and pelecypods,

4) grey to black highly calcareous shale containing ostracods and pelecypods,

3) coal,

2) underclay with *stigmariae*,

1) grey sandstone containing comminuted plant remains.

Incomplete cycles are common, and the stratigraphic interval that each cycle occupies may range from a few inches to several tens of feet (Copeland, 1957). Most spectacular were the fossilized trees standing upright in the massive sandstone. However, rapid erosion of the coast has removed the best exposures although a few tree trunks are usually still visible.

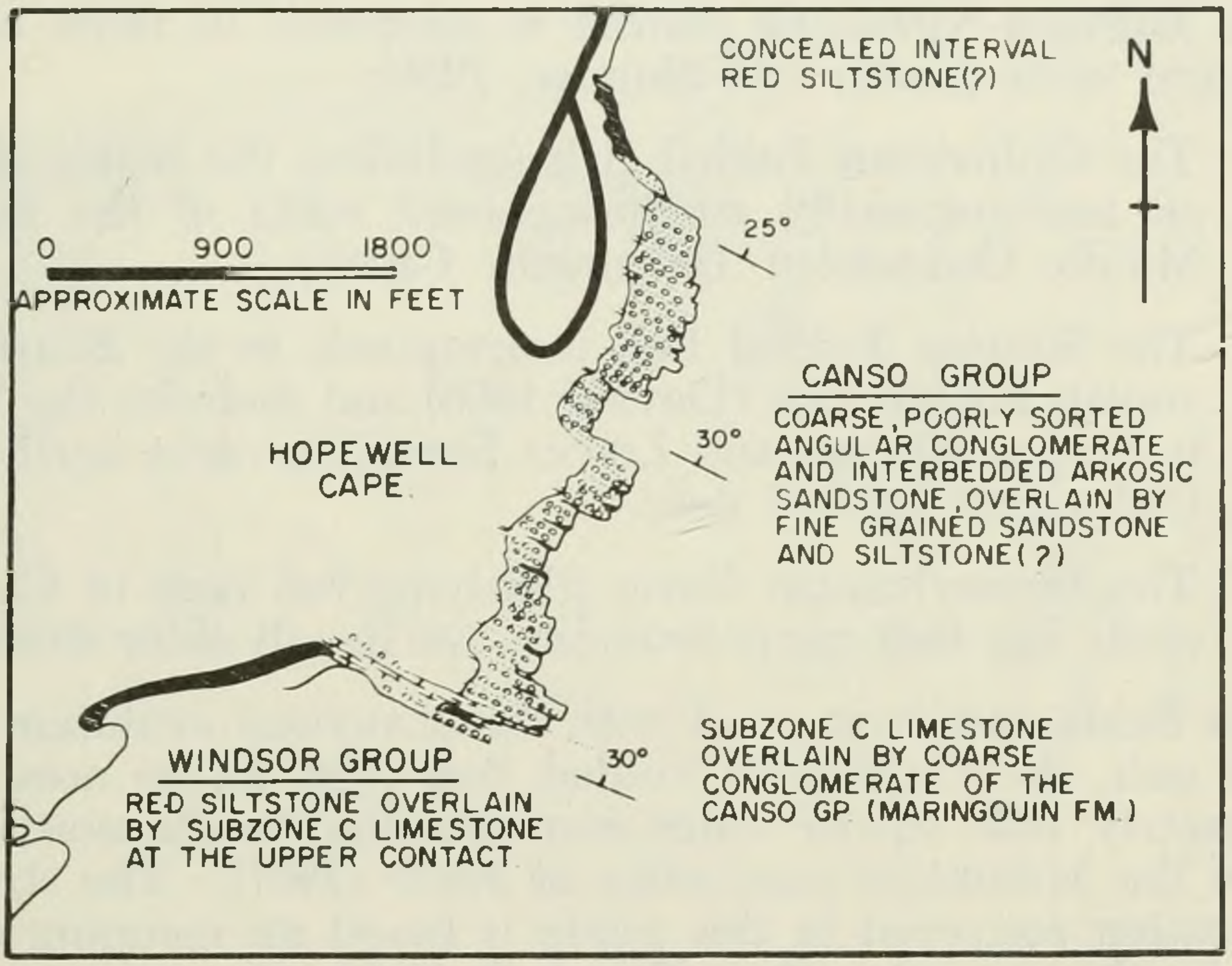

Fig. 5 Geological section of Hopewell Cape, N. B. (stop locality 6)

STOP 6 – Hopewell Cape. Dark grey fossiliferous limestone of subzone C lies at the base of the section at Hopewell Cape where it underlies and is intercalated with coarse conglomerate of the Canso Group.

The succession lies on the northern flank of the Grande Anse Anticline and dips to the north-northwest at approximately 25°. In contrast to playa type silt and fine-grained sandstone, which characterized the Canso Group elsewhere in the Shepody Bay region (e. g. at Pecks Cove, Stop Locality 2), the Hopewell Cape sequence is mainly coarse, poorly sorted conglomerates and arkosic sandstone in which sub-angular clasts of granite, gneiss, and volcanic rocks predominate. The succession is interpreted to represent a high-energy fan-head or mid-fan deposit of an alluvial-fan spreading easterly from a nearby source area in the Caledonia Mountains in the wake of the retreating Windsor sea.