CHAPTER 1. INTRODUCTION

INTRODUCTORY STATEMENT

This report is intended to direct attention to areas in Colchester and Halifax Counties where commercial grades of limestone and dolomite occur and to indicate briefly the potential that still exists for outlining additional economic deposits. Diamond drilling will be necessary in most locations for further investigation.

This coverage of Colchester and Halifax Counties involves both a surface examination of known and previously unknown limestone and dolomite occurrences and preliminary diamond drilling programs (Fig. 1-1). This work constitutes part of a full inventory of occurrences in areas underlain by limestones and dolomites throughout Nova Scotia.

The limestones described in this report follow the format proposed by Bell (1929). He introduced five main subzones, A, B, C, D and E, with A Subzone being the base of the Windsor Group of rocks and the E Subzone being the youngest limestone bed in the succession. Stacy (1953) later modified Bell's (1929) work and divided the subzones even further, i.e., A_1, A_2, B_1, B_2, B_3, etc. These were divided on the basis of fossil content or on some particular characteristic restricted to a specific limestone bed.

Some of these later divisions by Stacy (1953) cannot be considered strict time boundaries, but are probably due to a change in environmental conditions within an area. These divisions, however, are useful for describing different limestone beds in this report.

PURPOSE OF SURVEY

The primary purpose of this inventory of limestones and dolomites is to produce an assessment of Colchester and Halifax Counties comparable to those which have been completed for Cape Breton Island (Shea and Murray, 1969) and for Antigonish, Guysborough, Pictou and Cumberland Counties (Murray, 1975). Pertinent data covering location, extent, structure and characteristics are recorded herein. To these data have been added results of the analyses of all samples taken.

A preliminary drilling program to supplement the surface inventory was carried out in selected areas, guided primarily by economic considerations (Chapter 4 and Appendix 1).

SAMPLING PROCEDURE

Analyses of 122 surface samples (58 from Colchester County, 64 from Halifax County) taken from limestone and dolomite occurrences constitute part of this report and are included in the section dealing with individual outcrops and occurrences.

Samples which show an analysis for silica in excess of 20% are omitted from this report. Deletion of this will cause a break in the sampling sequence in some areas.

All samples collected and analyzed are coded, first by letter indicating the area from which the sample was taken, followed by two numbers. The first number denotes the outcrop, and the

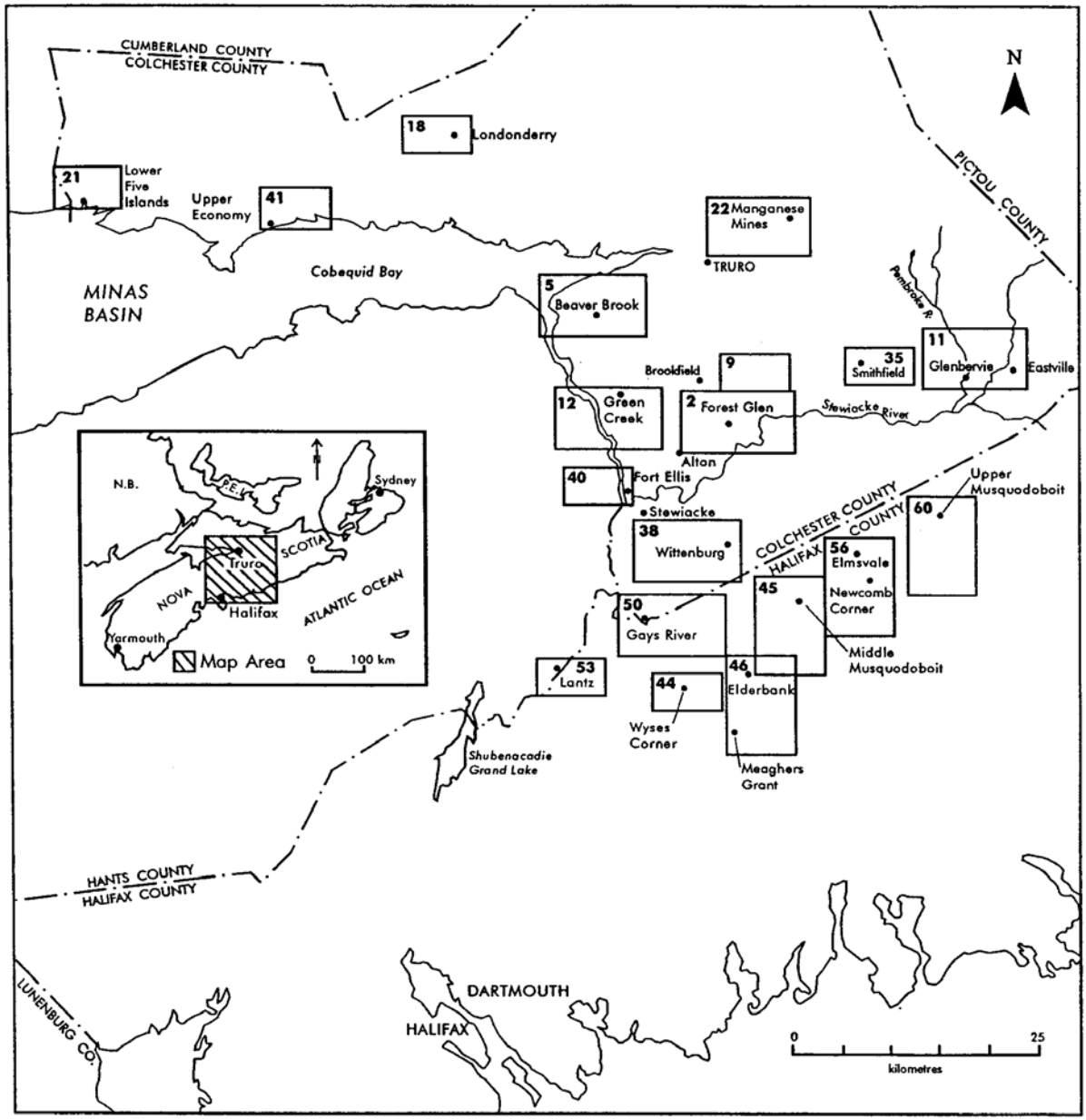

Figure 1-1. Locations and numbers of figures for limestone and dolomite occurrences in Colchester and Halifax Counties.

second number denotes the sample. As an example, consider sample MM-1-1. The code indicates that this sample was taken in the Manganese Mines area of Colchester County, on the first outcrop examined and sampled. All locations of samples taken are recorded by longitude and latitude in Appendix 2 with reference to the National Topographic System for Nova Scotia, scale 1:50 000.

The distances and thicknesses given in the descriptions have been converted from British units to metric units.

SCOPE OF INVESTIGATION

The investigation of limestone and dolomite occurrences in Colchester and Halifax Counties began during the latter part of 1967 and continued through 1968. Field work was directed primarily towards surface inventory of known and previously unknown occurrences. Samples taken from these occurrences and outcrops were analyzed, each showing described and the geology studied. Where good quality stone was found with tonnages of possible significance, a preliminary drilling program consisting of two or more holes was undertaken. All limestone and dolomite cores from the drilling were analyzed.

Preliminary data and regional geological references were obtained from the old and new series geological maps and reports published by the Geological Survey of Canada.

GENERAL GEOLOGY

(*R. C. Boehner*)

The Colchester and Halifax Counties area, described in this report, is located in the eastern and northern part of the Minas Sub-basin of Bell (1958) which includes the area underlain by Carboniferous age rocks in Hants, Halifax and Colchester Counties. The area is included on parts of the following National Topographic System (NTS) maps sheets: 11D/14, 11E/02, 11E/03, 11E/05, 11E/06, 11E/07 and 21H/08. The area is accessible from the Trans-Canada Highway 104 connecting Truro and Amherst, and the Trans-Canada Highway 102 connecting Halifax and Truro. There is a good system of paved and unpaved roads which provides easy access to most of the area.

The majority of the limestone and dolomite occurrences and deposits in Colchester and Halifax Counties occur in the Windsor Group making it the most important Carboniferous age rock unit for limestone and dolomite resources in the region. The location maps and descriptions of these localities are very useful in relocating the stratigraphically important carbonate outcrops. More recently, the stratigraphy and general geology of the major carbonate buildups in the area were described by Boehner (1988) and Boehner *et al.* (1987). The larger A Subzone carbonate buildups and small B Subzone carbonate buildups, as well as other limestone members in the Colchester and Halifax Counties area, were used locally as a source of limestone for agricultural needs.

Most of the carbonate rocks of the central Nova Scotia region occur within parts of two Carboniferous structural basins referred to as the Musquodoboit Basin and the Shubenacadie Basin (Figs. 1-2, 1-3). The Musquodoboit and Shubenacadie Basins are northeasterly elongated synclinal structural basins in central mainland Nova Scotia (Giles and Boehner, 1982a) and contain up to 1500 m (stratigraphic thickness) of upper Paleozoic continental and marine sedimentary rocks. The strata range in age from Late Devonian-Early Carboniferous (Tournaisian) to Late Carboniferous (Westphalian B-C). They overly, with angular unconformity, Cambrian to Ordovician age meta-sedimentary rocks of the Meguma Group that were intruded by Late Devonian age peraluminous granitoid rocks. Contacts with the bounding basement blocks are complicated by syn- and post-Carboniferous fault movements. The earliest basin fill (up to 500 m) is dominated by coarse- to fine-grained alluvial, fluvial and lacustrine strata of Late Devonian-Tournaisian to early Viséan age comprising the Coldstream, Horton Bluff and Cheverie Formations of the Horton Group. The Horton Group onlaps the basement along parts of the southern and western borders with the Meguma Group metasedimentary rocks and Musquodoboit Batholith granitoid rocks. The Windsor Group (Viséan)

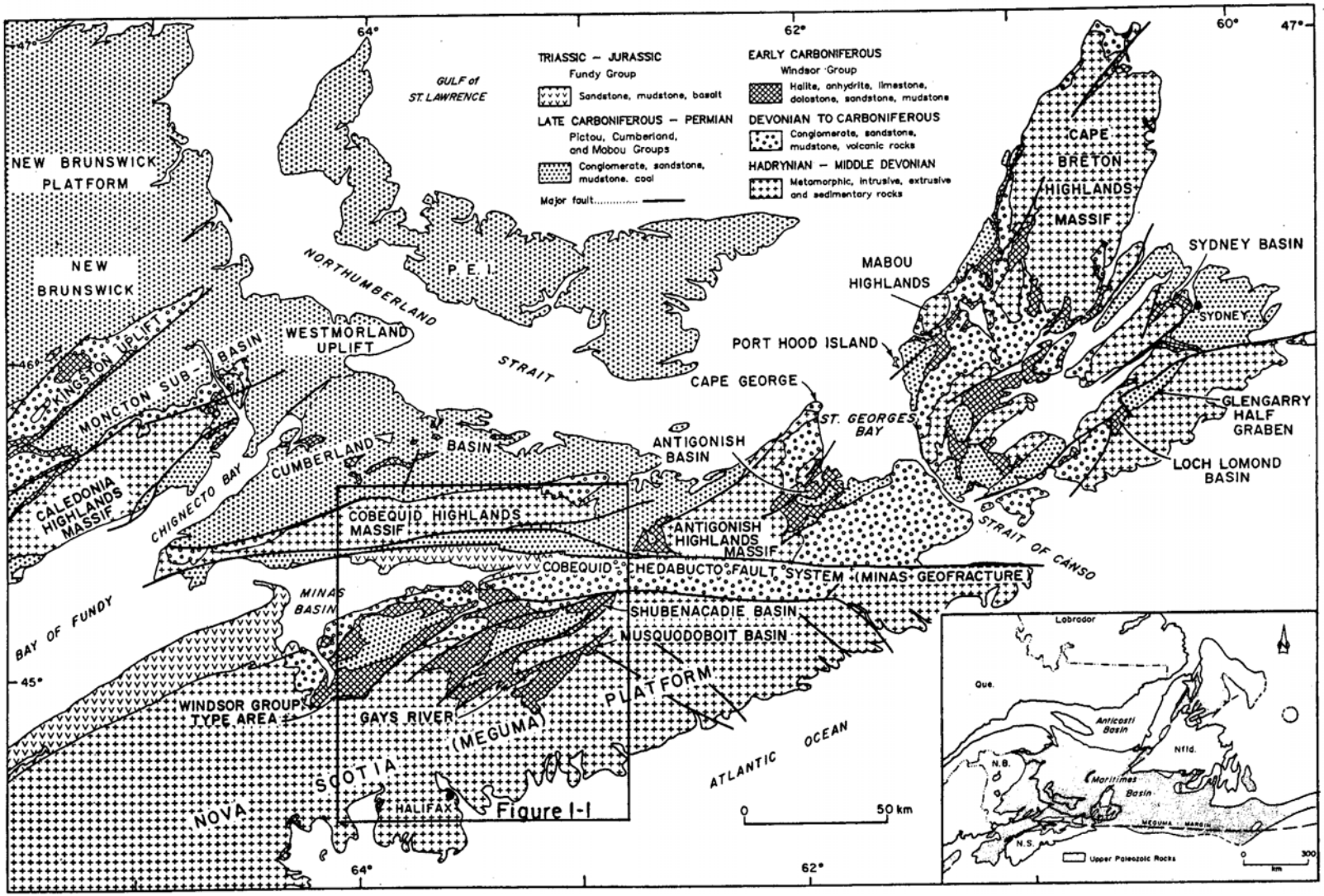

Figure 1-2. Regional location of the study area on a general geology map.

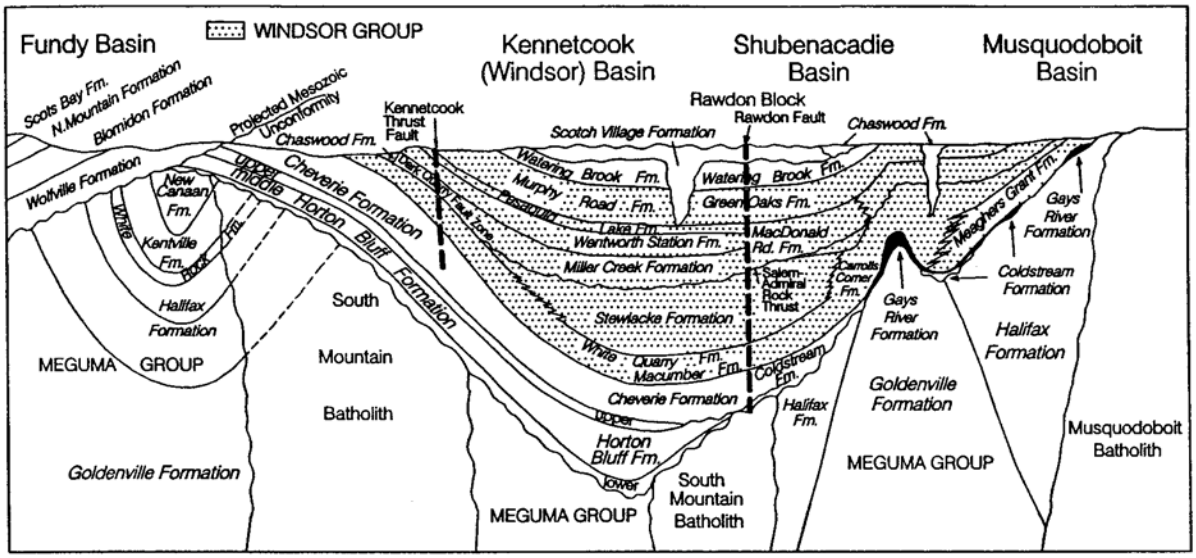

Figure 1-3. Highly simplified diagrammatic representation of the geological map units of the Fundy, Kennetcook, Shubenacadie and Musquodoboit Basins.

disconformably overlies the Horton Group and comprises an interstratified sequence (up to 800 m) of marine evaporite, carbonate and continental redbeds. The Windsor Group contains numerous industrial mineral occurrences including: barite, gypsum, anhydrite, salt, dolomite and limestone as well as occurrences and deposits of base metals including Pb, Zn and Cu.

The Windsor Group is overlain by a locally variable succession of younger Carboniferous age sandstone and mudrock strata including the Mabou (Canso), Cumberland and Pictou Groups (Viséan, Namurian and Westphalian). These represent the return to continental lacustrine and fluvial deposition with the retreat of the Windsor seas. The variably deformed Carboniferous basin fill near the Cobequid-Chedabucto Fault System is unconformably overlain by the southern outcrop margins of the Mesozoic rift basin fill of the Fundy Basin. These Late Triassic age strata comprise medium grained redbed siliciclastics of the Fundy Group (Wolfville Formation). The Carboniferous basin fill is locally overlain by remnants of Early Cretaceous age silica sand and clay correlative with the Chaswood Formation in the Shubenacadie and Musquodoboit Basins.

The Windsor Group rocks of the Musquodoboit and Shubenacadie Basins are bounded to the south and west by metasedimentary rocks of the Meguma Group and plutonic rocks of the Musquodoboit Batholith. The central part of the Colchester County area is a complex of variably folded and faulted Horton Group rocks extending into the St. Marys Basin at the boundary between the Meguma Zone and Avalon Zone, including the Cobequid-Chedabucto Fault System. Small fault blocks or outliers of Windsor Group rocks, including carbonates, are scattered within the predominantly Triassic and Upper Carboniferous rocks in the structurally complicated Cobequid-Chedabucto Fault System south of the Cobequid Highlands (e.g. Upper Economy, Glenholme, East Mountain). The Cobequid Highlands is an uplifted block of the Avalon Terrane and comprises a complex of pre-Carboniferous age (Hadrynian, Neoproterozoic to Devonian) metasedimentary and igneous basement rocks. Carbonate rocks are very rare in the Cobequid Highlands, however metamorphic marble occurrences are described in the western part of Colchester County.

The carbonate rocks described in this report occur primarily in the Hants-Colchester Lowlands in central Nova Scotia. This is an area characterized by gently rolling terrain where elevations rarely exceed 100 m. This Lowland area is bordered to the south and west by the Atlantic (Southern) Uplands and by the Cobequid Highlands in the north. Elevations in the Uplands rise gently to locally abruptly to over 200 m and may exceed 300 m in the Cobequid Highlands. The Lowland area is traversed by numerous low gradient drainage systems characterized by small streams and scattered lakes and still waters. The area is substantially influenced by the Bay of Fundy-Minas Basin tidal system, especially in the Salmon River and Shubenacadie River and their tributaries which have tidal influence extending over 30 km from the Minas Basin. Although the streams and rivers typically have low profiles, there is modest bedrock exposure in the river beds. Tributary streams with steeper profiles on highlands basement rocks of the Meguma Group and Cobequid Highlands, also have moderate outcrop.

Mining activity in the Colchester and Halifax Counties area has concentrated on the economically significant industrial mineral resources including large and small aggregate operations, gypsum, barite, silica sand and clay over the past 100 years. More limited mining of gold occurred in the early 1900s and again in the 1980s as well as base metal production at Gays River in the 1980s. Mineral exploration has historically focussed on base metals and barite in the basal Windsor Group as well as sulphur, salt, potash and gypsum in the Windsor Group.

Gypsum mining has been active in the Shubenacadie Basin for over 40 years with major production at East Milford, Halifax County by National Gypsum. Lafarge Canada Inc. has been producing cement products from their operation near Brookfield for nearly 40 years. The Avon Limestone Member of the Upper Windsor is quarried adjacent to the plant as the primary source of limestone. Cretaceous and Quaternary sediments are primary sources of sand and clay material for Shaw Resources that produces silica sand products at Shubenacadie and Shaw Brick that produces structural clay products at Lantz. Mosher Limestone Company Limited has operated quarries and a dolomitic limestone processing facility at Upper Musquodoboit that has supplied aglime products to the Maritime region for more than 50 years. Carbonate buildups of the Gays River Formation Lower Windsor Group (A Subzone) have been the primary source of dolomitic limestone. Nystone-Division of E-Z-EM Canada Inc. has been producing barite at Upper Brookfield and medical barite products at Debert since the 1980s.

As a result of the discovery and development of the Gays River Pb-Zn deposit in the 1970s and 1980s, the Musquodoboit and Shubenacadie Basins, as well as most other Carboniferous basins in the Province, were extensively explored for base metal and barite deposits associated with the basal carbonates of the Windsor Group. This exploration activity included extensive diamond drilling and resulted in the documentation of limestone and dolomite occurrences and deposits investigated as part of this report in the late 1960s. Exploration for various mineral resources including barite, gypsum, limestone, celestite, sulphur, salt, potash, titanium and petroleum has occurred in several less intensive phases and continues to contribute valuable information on limestone and dolomite resources.

The type area for the Windsor and Horton Groups, which are regionally significant geological units in Atlantic Canada, is located in the adjacent Hants County. A detailed understanding of these rocks was not achieved until Bell (1929) described their litho- and biostratigraphic subdivision. The detailed stratigraphy of the Windsor and Horton Groups in the

Shubenacadie and Musquodoboit Basins (as well as regionally) has been subsequently investigated and described by Moore (1967), Giles and Boehner (1979), Giles *et al.* (1979) and Boehner (1984). The adjacent Shubenacadie Basin in the eastern part of Hants County was the first Carboniferous outcrop area investigated by Giles and Boehner (1979, 1982a) as part of a Carboniferous basin mapping program by the Nova Scotia Department of Mines (now Natural Resources).

The improved understanding of the detailed litho- and biostratigraphy, as well as the structural geology of the Windsor Group, would not have been possible without access to the quarries and the large volume of subsurface data, principally from the hundreds of diamond-drill holes by the gypsum mining and mineral exploration industry. This information has been essential in providing the basis for a greater understanding of the geology and mineral resource potential of the Windsor Basin (and others). The basins contain major salt, gypsum, anhydrite, limestone, dolomite, barite, silica sand, clay resources and other industrial mineral potential and have significant base metals, silver and gold. The carbonate rocks of the Windsor Group are the key units used for lithostratigraphic subdivision and local and regional correlation. These carbonates are very significant as sources of limestone and dolomite mineral resources.

GENERAL WINDSOR GROUP STRATIGRAPHY

The Windsor Group is one of the most important stratigraphic and economic units in the late Paleozoic basins of Atlantic Canada. It comprises a complex succession of interstratified evaporites including gypsum, anhydrite, salt and potash, fine- and coarse-grained redbeds, and fossiliferous marine carbonates, all of which constitute mineral commodities of economic interest. The thickness ranges from a few metres up to more than 1500 m with 750-1000 m typical. It is widely distributed throughout Atlantic Canada.

The Windsor Group extends throughout much of mainland Nova Scotia, and is also represented in southern New Brunswick and southwestern Newfoundland. It extends throughout the Gulf of St. Lawrence, and appears in surface exposure on the Magdalen Islands of Quebec. The Windsor Group was originally defined by Bell (1929, 1958) for a sequence of interstratified red-maroon siltstones, marine carbonates (limestone to dolostone), gypsum, salt and anhydrite. Bell (1929) estimated a minimum total thickness of 472 m in the structurally complicated type area at Windsor, however it is now known to be substantially thicker. Regionally, Windsor Group strata conformably or disconformably overly the continental siliciclastics of the Horton Group, and locally rest with angular unconformity upon older basin fill (Late Devonian-Early Carboniferous). In some areas it onlaps directly onto basement with angular unconformity or nonconformity (e.g. Shubenacadie Basin and Loch Lomond Basin). The Windsor Group is generally overlain conformably by mudrocks and evaporites of the basal Mabou Group. In some areas it is unconformably overlain by younger Late Carboniferous age units.

The Windsor Group in the area was biostratigraphically subdivided by Bell (1929) into two major faunal zones and five subzones based mainly upon their contained Brachiopoda, Cephalopoda and Cnidaria. The Lower Windsor zone of *Composita dawsoni* was subdivided into the A Subzone, the basal limestone (characterized by a paucity of megafauna), and the B Subzone, characterized by *Diodoceras avonensis*. Bell (1929) subdivided the Upper Windsor zone of *Martinia galataea* into C Subzone, characterized by *Dibunophyllum lambii* and *Nodosinella (Paleocrisidia) priscilla*; D Subzone, characterized by *Productus (Ovatia) semicubiculus*; and E Subzone, characterized by

Caninia dawsoni and *Chonetes politus (Tournquistia polita)*. The names and ranges of these forms and others have been modified by Moore and Ryan (1976).

The base of the Windsor Group in Hants County is marked by a thin laminated basal limestone known as the Macumber Formation. Bell (1929) also included an underlying calcareous, grey quartzite and limestone conglomerate unit (Pembroke breccia of Lavoie *et al.*, 1995) as part of the Windsor Group. In the type area, the basal limestone is approximately 4 m thick. The underlying quartzite unit, locally bearing *Schizodus cheverensis* on its upper surface, is 6.7 m thick and conformably overlies the Cheverie Formation of the Horton Group. Near the type area, the basal limestone was subsequently named the Macumber Formation (Weeks, 1948), but in other areas it has been referred to as A_1 limestone. It is usually overlain by a thick section of gypsum and anhydrite, sometimes informally referred to as the basal anhydrite (in Hants County this section is named the Carrolls Corner or White Quarry Formation). The name Pembroke Formation introduced by Weeks (1948) is abandoned and the informal term Pembroke breccia is now used to refer to the variety of limestone breccia and conglomerate associated with the near surface exposures of the Macumber Formation. (Note: The term Pembroke Formation is used in the occurrence descriptions in this report reflecting terminology at the time of the study). The Macumber Formation and related Pembroke breccia occur in outcrop primarily along the northwestern part of the Windsor Basin.

Investigations in the southeastern extremity of the Shubenacadie Basin and Musquodoboit Basin by Giles and Boehner (1979) indicated that the basal A Subzone limestone equivalent was deposited upon pre-Carboniferous basement rocks (overstepping the Horton Group pinchout), and locally developed a varied flora and fauna. In these carbonate banks it reaches thicknesses of over 45 m and was named the Gays River Formation by Giles *et al.* (1979). These buildups are known to be present along the western border of the Shubenacadie Basin near Nine Mile River in eastern Hants County and are especially well developed near Gays River and around the borders of the Musquodoboit Basin in Halifax County (Giles *et al.*, 1979; Boehner *et al.*, 1989a).

The thick overlying anhydrite was named the Carrolls Corner Formation and it is overlain in the deeper parts of the basins by the Stewiacke Formation (Giles and Boehner, 1979). This is a thick (up to 300 m) salt unit that is well documented in the Shubenacadie Basin. It overlies and, in part, may be a lateral equivalent of the Carrolls Corner Formation (Boehner, 1984). These two units have a combined minimum thickness of approximately 400 m. The salt occupies a similar position in the Windsor area (Moore and Ryan, 1976) and is the most important salt unit in central Nova Scotia.

In most cases, the thick A Subzone sulphate-halite units are overlain by the B Subzone cyclic sequence consisting of interstratified fossiliferous marine carbonates, siltstones and evaporites including thin halite beds. In the Shubenacadie Basin area, this section comprises the Macdonald Road Formation (Giles and Boehner, 1979), which includes a series of thin siliciclastic rich carbonate members (typically <3 m thick) as subdivisions. Thick, high purity biohermal facies (up to 15 m thick) of one or more of these carbonate members are of particular interest as potential limestone resources (e.g. Miller or Maxner limestones of Bell, 1929). Correlative bioherms are known to occur with the Mosher Road, Cloverdale and Ryan Brook members in the Shubenacadie Basin. The MacDonald Road Formation has a total thickness of approximately 170 m. The MacDonald Road Formation was subdivided into six carbonate units defined as members (Giles and Boehner, 1979) which are typically of significant thickness, and which are lithologically distinct. Associated rock

types, although not formally named, are often useful to corroborate the identification of specific members. The distinctive carbonate members recognized in the MacDonald Road Formation include in ascending order: the Mosher Road, Cloverdale, Ryan Brook, Hardwoodlands, North Salem and McPhee Corner members. The carbonate members of the MacDonald Road Formation are laterally extensive and may be correlated throughout the Shubenacadie Basin and into the adjacent type area of the Windsor Group near Windsor.

The MacDonald Road Formation is overlain with possible slight disconformity by a sequence of alternating fossiliferous marine carbonates, red siltstone and locally gypsum and anhydrite (in a saline facies) called the Green Oaks Formation (Giles and Boehner, 1979; Boehner, 1984). The lithostratigraphy of the Upper Windsor Zone carbonate units was described by Moore (1967) and can be readily correlated throughout the Minas Sub-basin area as laterally extensive transgressive-regressive marine carbonate sheets. The thickness of this interval ranges from 137 m in the Shubenacadie Basin to over 730 m in the incomplete composite section of the Green Creek area (Moore, 1967).

Individual carbonate members were named by Bell (1929) who used the terms Avon and Kennetcook for two Upper Windsor carbonate units, which were also used by Moore (1967), who described the lithostratigraphy of the Upper Windsor carbonate members in the Minas Sub-basin. In addition, Giles and Boehner (1979) introduced the Green Creek and Kent Road members to complete the subdivision of the Upper Windsor. The carbonate members of the Green Oaks Formation are in ascending order: Herbert River (C Subzone), correlative Musquodoboit Limestone in the Musquodoboit Basin, (C Subzone), Kent Road (C Subzone), Shubenacadie (C Subzone), Green Creek (C Subzone), Avon (D Subzone), Meander River (D Subzone), Wallace Point (D Subzone) and Kennetcook (E Subzone) limestone members.

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