INTRODUCTION

The Antigonish Basin is a Carboniferous structural basin in Antigonish County, northeastern mainland Nova Scotia (Fig. 1, p. 3; Fig. 2, p. 4). The portion of the Basin area included in this report (approximately 500 km^2) is on parts of National Topographic Survey (NTS) Map Sheets 11E/08, 11E/09, 11F/05 and 11F/12 and is bounded approximately by latitudes 45°26' to 45°45'N and longitudes 61°45' to 62°10'W (Fig. 2, p. 4; Nova Scotia Department of Mines and Energy Map 82-2, in pocket). The narrow extension of the Basin eastward from longitude 61°45'W to the Strait of Canso was not mapped.

The area is readily accessible by the Trans-Canada Highway 104 that extends from New Glasgow across the northern part of the area through the Town of Antigonish to Port Hawkesbury. The Canadian National Railway mainline from Stellarton to Port Hawkesbury closely parallels the Trans-Canada Highway 104. Route 7 through Sherbrooke along the Eastern Shore terminates at Antigonish. These major roads are connected with a good system of paved and unpaved roads which provide easy access to most of the map area.

The rocks described in this report occur principally in a lowland area which is characterized by gently rolling terrain with elevations rarely exceeding 100 m. This lowland area in northeastern mainland Nova Scotia forms part of the physiographic feature named the Antigonish-Guysborough Lowland. The Antigonish Highlands Massif forms the elevated western and northern borders of the map area (Fig. 2, p. 4). Elevations in the Highlands rise abruptly to 200 m and locally exceed 300 m. The southeastern border of the Basin, although included within the Antigonish-Guysborough Lowland, has distinctly greater relief with elevations of up to 170 m. The Antigonish Basin is traversed by several major river drainage systems that have their sources in the surrounding Highlands and have broad estuaries along St. Georges Bay. Within the Basin the rivers typically have low profiles and minimal bedrock exposure.

Agriculture, fishing and forestry are the principal industries in the area. The Town of Antigonish is the main service centre for Antigonish County and the surrounding area. At present, mining activity is limited

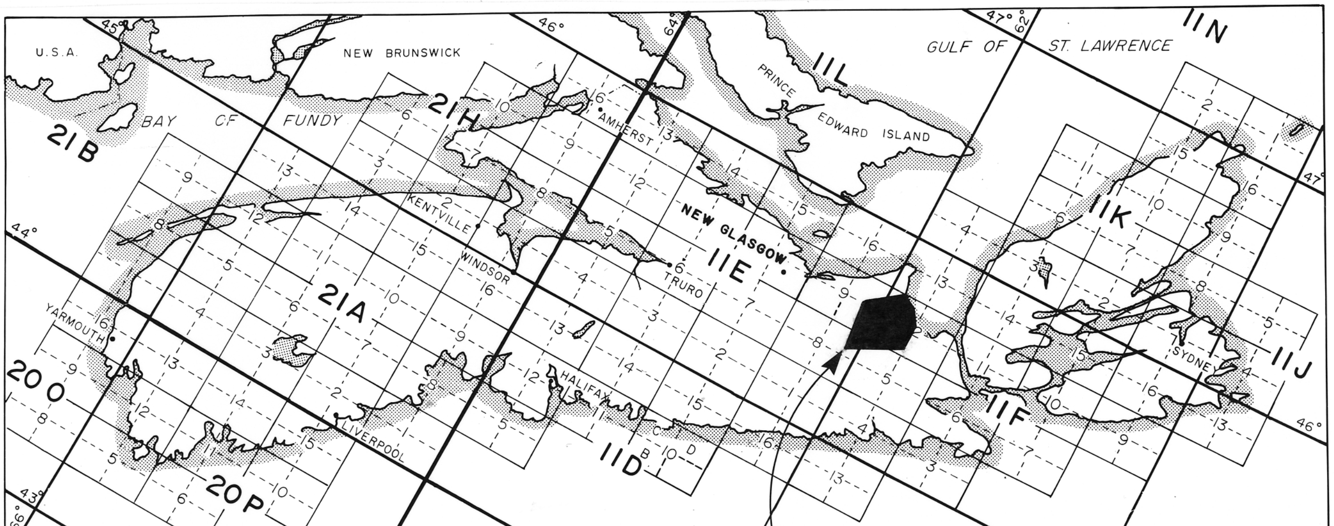


Figure 1. Antigonish Basin map area location on NTS reference map.

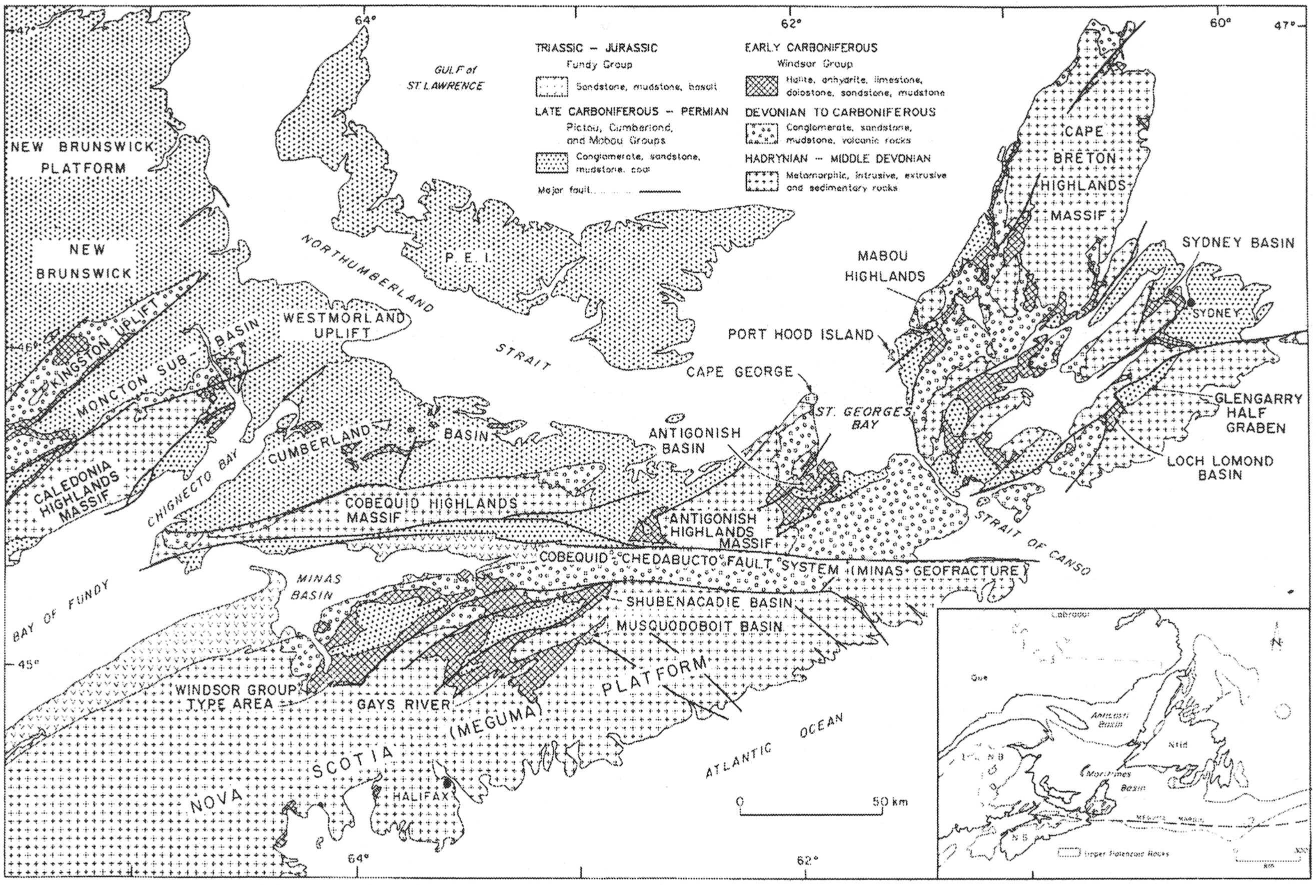
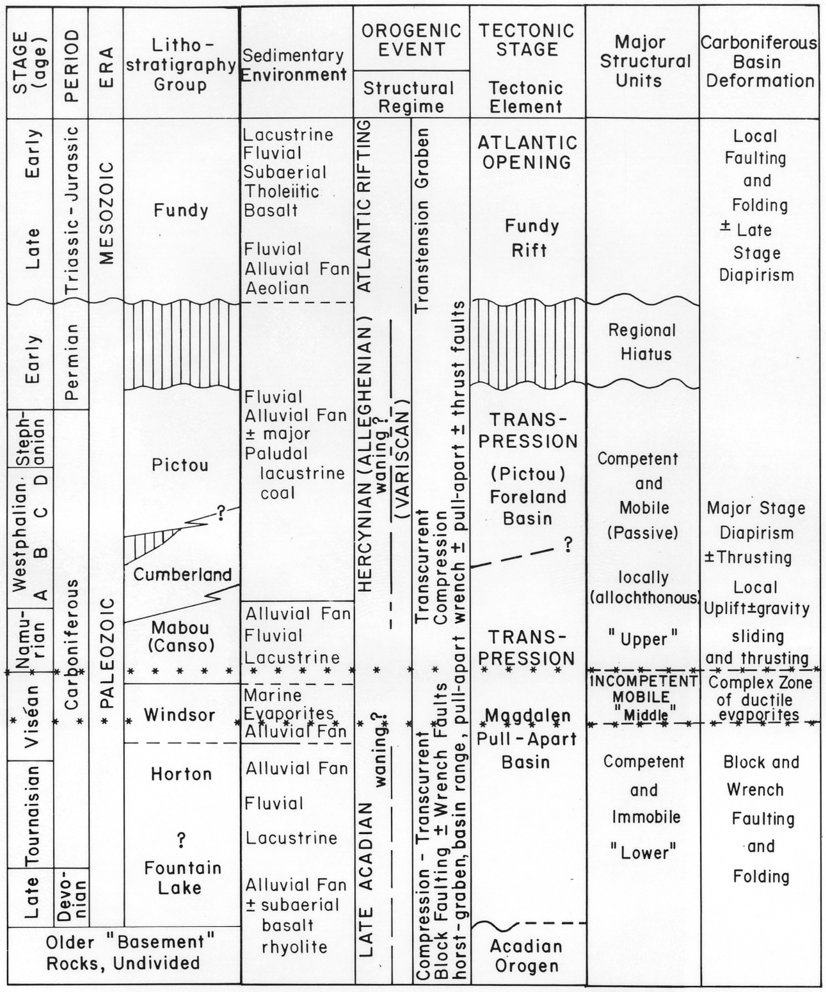


Figure 2. Regional location of the Antigonish Basin on a general geology map.

to large sand and gravel deposits and the quarrying of gypsum and limestone. Historically, attempts to exploit salt and copper deposits have had limited success.

Carboniferous rocks in Nova Scotia are a primary or exclusive source for a variety of economically important metallic and nonmetallic minerals including lead, zinc, gypsum, anhydrite, salt, limestone, dolomite, coal, barite and celestite. Production from Carboniferous rocks is, and has been, the dominant component of the mineral industry in Nova Scotia. The Carboniferous basins of Nova Scotia have had a long history of exploration for coal, petroleum, industrial and metallic minerals. The Antigonish Basin is one of several Carboniferous outcrop areas including the Shubenacadie Basin and Musquodoboit Basin (Giles and Boehner, 1979; 1982), Eureka area (Giles, 1982), Loch Lomond Basin (Boehner and Prime, 1985), Sydney Basin (Boehner and Giles, 1986) and Cumberland Basin (Ryan and Boehner, 1990; Ryan et al., 1990; Ryan et al., 1990a; 1990b) that have been investigated as part of a Carboniferous basins mapping program by the Nova Scotia Department of Mines and Energy (NSDME), now the Nova Scotia Department of Natural Resources (NSDNR), Mines and Energy Branches. A large volume of subsurface data, principally from diamond-drill holes by the mineral exploration industry has provided the basis for a greater understanding of the complex stratigraphy and structure prevalent in the basins. These mapping studies coincided with or followed a peak in mineral exploration and benefited from abundant, previously unavailable subsurface data.

The primary goals of the Antigonish Basin study are to describe the geology of the area using all available outcrop and critically important subsurface information (drilling and seismic data). Previous studies in the area were either detailed investigations in a portion of the Basin or were regional with no further subdivision of the major rock units (generally groups). Emphasis in this study is placed on determining the stratigraphy and structure of the Windsor Group with lesser emphasis on younger and older Carboniferous strata (Fig. 3, p. 5). Comparisons and correlations are made whenever possible with other Carboniferous outcrop areas. No attempt has been made to examine in detail the pre-Carboniferous rocks of the Antigonish Highlands or the pre-Windsor Group stratified sedimentary rocks beyond



adapted from Boehner et al. (1986)

Figure 3. Stratigraphic, tectonic, depositional and structural deformation summary, late Paleozoic-early Mesozoic, in Atlantic Canada.

the perimeter of the Antigonish Basin. The pre-Carboniferous rocks of the Antigonish Highlands are informally considered in this study as basement to the Antigonish Basin succession and their geology has been described by Benson (1974) and more recently by Murphy et al. (1991).

METHODS

Field mapping was accomplished during the summers of 1978 and 1979. Traverses were made of all streams, rivers and coastal sections as well as examinations of road cuts and previously reported outcrops. Field data were compiled on orthophoto maps at a scale of 1:10 000, for final publication at 1:50 000 (NSDME Map 82-2, in pocket; a simplified version is presented as Fig. 4, p. 6). All subsurface data from exploration drillholes were compiled and the drill core logged when possible. These data were used to supplement outcrop information in determining stratigraphy (Fig. 3, p. 5; Fig. 4, p. 6) and map unit boundary placement. In 1983 the Nova Scotia Department of Mines and Energy drilled GR83-1 near Glen Road for stratigraphic information (Boehner, 1984a). This drillhole has contributed significantly to the understanding of the Antigonish Thrust Fault.

GEOLOGICAL INVESTIGATIONS

The earliest geological investigations of the area occurred during the mid to late 1800s and were reconnaissance or exploratory in nature. The most significant of those who reported their observations were Dawson, Gesner, Honeyman, Jackson and Alger (see Sage, 1954; Bell, 1926; 1927; 1929; 1958; Benson, 1974). The first systematic mapping and detailed descriptions were included in the reports and maps by Fletcher (1887; 1892) from surveys completed during the later part of the 1800s (Fig. 5, p. 7). These maps at a scale of one inch equals one mile are of particular value in attempting to relocate stratigraphically useful outcrops because strict attention was made in locating indications and outcrops of coal, gypsum and limestone.

The next major investigation of the area was carried out by Pohl *in* Hayes (1931) as part of a regional potash and salt study. The investigation involved limited reconnaissance mapping and salt spring sampling and analysis. During the 1940s and 1950s the petroleum exploration potential was described by Whitehead (1944), MacNeil (1946; 1947; 1948; 1952; 1959) and Bell (1958). In this same period the Atlantic Centre for Geological Sciences was in operation at Crystal Cliffs under the auspices of the Massachusetts Institute of Technology. Many graduate and undergraduate theses dealing with the geology of the area were completed. The most pertinent to this study was the work of Sage (1954). Sage (1954) studied the Windsor Group stratigraphy and paleontology in the Antigonish Quadrangle (11F/12). A stratigraphic section was worked out from broken and structurally complex sections. Goodman (1952) described the geology of the gypsum deposits in the area as part of a Province-wide study. The stratigraphy of the Horton Group in the area was described by Murray (1960) as part of a broad correlation study that included Cape Breton Island and the Horton Group type area. Schiller (1961) mapped

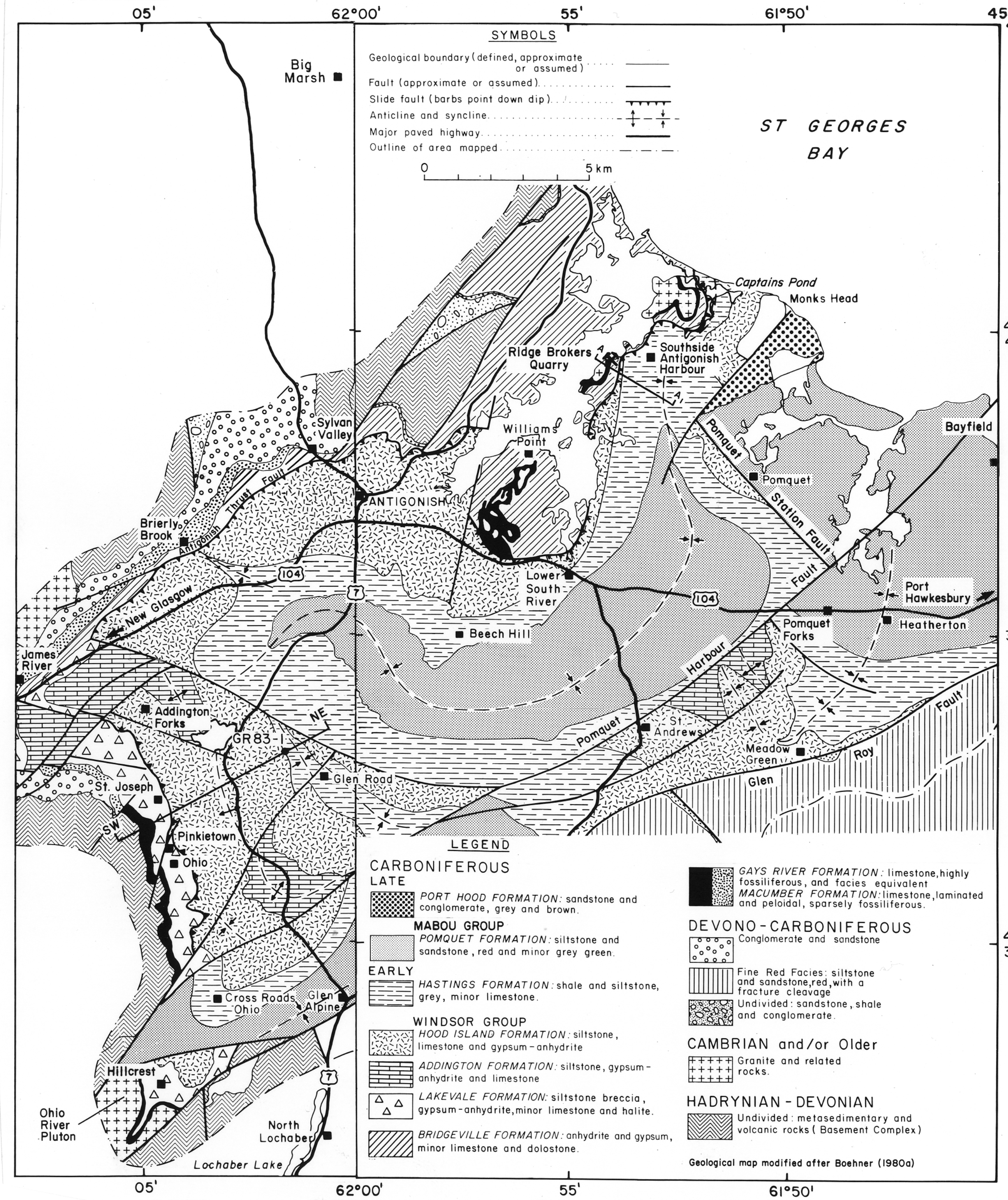


Figure 4. Simplified geological map of the Antigonish Basin.

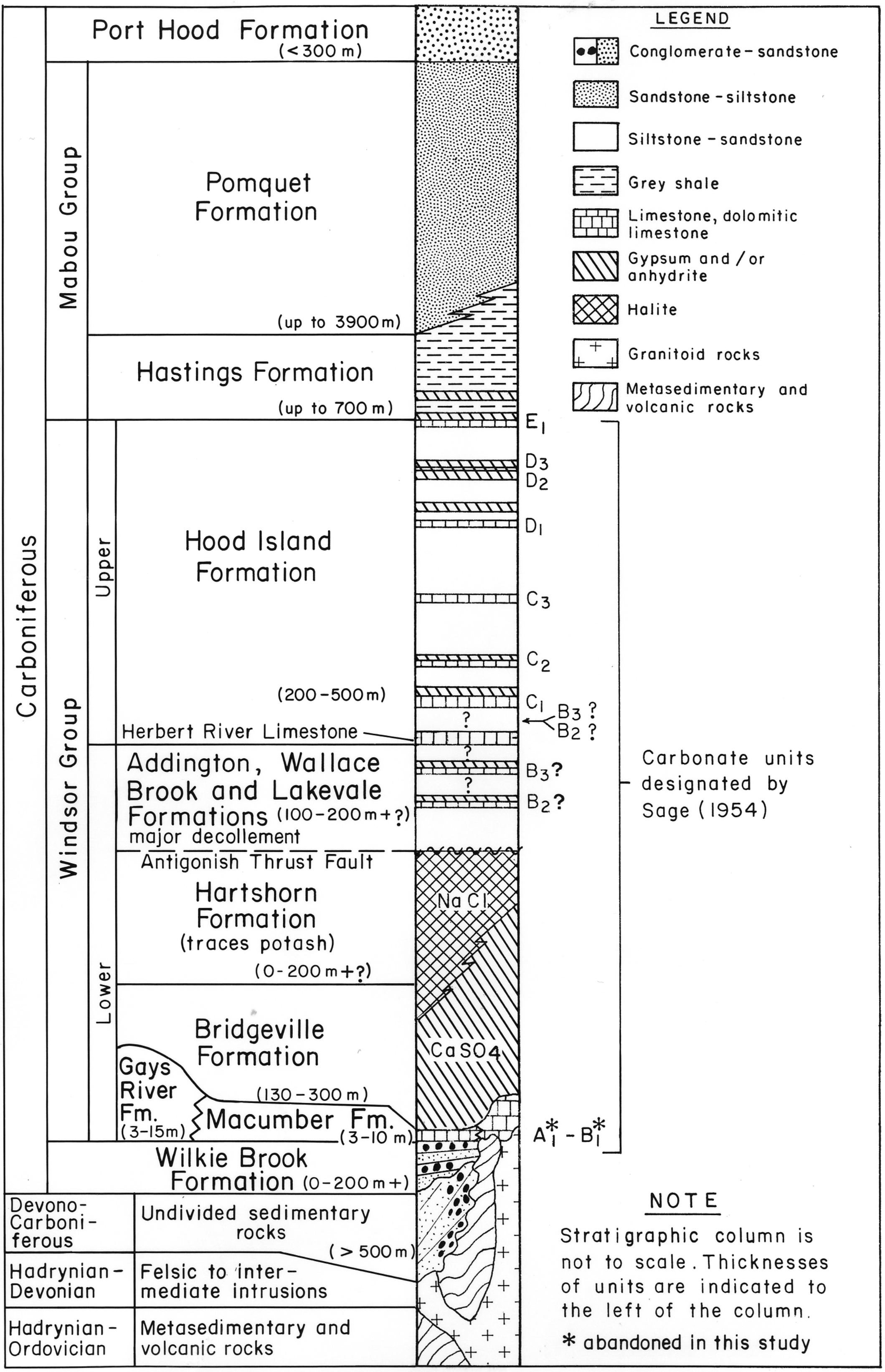


Figure 5. Stratigraphic column in the Antigonish Basin.

the Guysborough Map Sheet (11F/05) including a small part of the Antigonish Basin covered in this report.

In the early 1950s a study to determine the feasibility of establishing a soda ash industry was initiated in the Southside Antigonish Harbour area by the Province of Nova Scotia. The project involved geological and geophysical surveys by the Nova Scotia Department of Mines and the Nova Scotia Research Foundation. Although significant limestone and salt deposits were discovered at Southside Antigonish Harbour, the project never proceeded beyond the survey level. The high calcium limestone deposit is currently mined by Ridge Brokers Ltd. (Fig. 4, p. 6). Traces of natural gas in one of the salt holes, however, influenced subsequent petroleum exploration in the area (McMahon et al., 1986). Petroleum exploration drilling was first carried out by Lura Corporation in the early 1950s. Three wildcat drillholes were put down, but all were dry and abandoned (McMahon et al., 1986). In 1976, deeper petroleum exploration drilling was completed in the Southside Antigonish Harbour area by Brador Oil Company Limited (McMahon et al., 1986). This hole was also dry and abandoned.

The stratigraphy of the Carboniferous section above the Windsor Group was studied and described by Belt (1964; 1965). Belt (1964) proposed a revised stratigraphic nomenclature that involved dropping the names Canso and Riversdale groups and elevated the Mabou Formation (Norman, 1935) to group status. Mudrock-dominated strata formerly assigned to the Canso and Riversdale groups were included in the Mabou Group which comprises variably subdivided locally named formations. Two of these units (Pomquet and Hastings formations) have type or reference sections in the Antigonish Basin. Although the revised Mabou Group proposed by Belt (1964; 1965) has not gained wide usage it has been adopted by Ryan et al. (1991) in a recent revision of Upper Carboniferous stratigraphy in the Cumberland Basin.

Schenk (1967a; 1967b; 1969) made a detailed study of Windsor Group lithofacies in the area. Particular emphasis was placed upon the Macumber Formation and the cyclic carbonate-sulphate-redbed rocks. Murray (1975) described the limestone and dolomite deposits in the area, providing location maps and descriptions of the deposits which are very useful in relocating the stratigraphically important carbonate outcrops. More recently the geology of the carbonate buildups in the area was included in Boehner et al. (1988) and Boehner (1987). Previous to NSDME Map 82-2, the most recent systematic mapping in the area was completed by Benson (1970; 1974). No attempt was made by the Benson (1970; 1974) survey to map subdivisions within the Windsor Group. A preliminary report on the results of this study has been published by Boehner (1980a; 1980b).

Since the mid 1960s and especially between 1973 and 1980, there has been active exploration for base metals, salt, potash and petroleum deposits associated with the Windsor Group throughout Nova Scotia. In the Antigonish Basin, exploration companies involved in those surveys include Kenneco Exploration (Canada) Ltd. (Grace, 1966), Amax Exploration Limited (1975), Noranda Exploration, Pacific Coast Mines (Burton, 1977), Imperial Oil Ltd. (Burton, 1974; Johnston, 1972; Ward, 1974; 1975a; 1975b; McLeod, 1980), Millmor-Rogers Syndicate et al. (1974), Lura Corporation, Maritime Exploration, Cuvier Mines (Black, 1979; 1981), Brador Oil Limited (Farries Engineering Limited, 1976) and Malagash Salt Company.

GENERAL GEOLOGICAL SETTING

The Antigonish Basin is a small element (erosional remnant) of the larger group of structural basins in Atlantic Canada containing Carboniferous rocks (Fig. 2, p. 4). The collection of basins has been variously called the Fundy Epieugeosyncline (Kelley, 1967), Fundy Basin (Bell, 1958; Belt, 1968) and Fundy Aulacogen (Keppie, 1977). The name Maritimes Basin after Roliff (1962) and Boehner et al. (1988) is used here as a nongenetic, general term referring to collective areas in Atlantic Canada underlain by late Paleozoic strata. The Carboniferous succession (Fig. 3, p. 5) of the Maritimes Basin was deposited in a complex series of fault blocks and downwarped intermontane troughs developed on the folded Acadian Orogen (Belt, 1968). A great thickness of predominantly molassic sedimentary deposits accumulated in the deeper central mobile area beneath the Gulf of St. Lawrence (Boehner et al., 1986) where thicknesses up to 10 000 m are indicated by Howie and Barss (1975). Although the sedimentary rocks are predominantly Carboniferous, the succession includes strata as old as Middle-Late Devonian which locally contain interstratified volcanic rocks and, in the central area, strata as young as Early Permian (Howie and Barss, 1975; Howie, 1988).

The Antigonish Basin is a present day structural basin (Fig. 4, p. 6) defined by northeasterly trending faults. The northwestern border is a faulted contact or an unconformity with basement rocks of the Antigonish Highlands. The western border is an unconformity with the Antigonish Highlands. The southern border is a fault which truncates the Basin and juxtaposes the deformed, highly indurated rocks of the Guysborough block. The original (pre-erosion and predeformation) limits of the Basin are not known. The basinfill up to the base of the Windsor Group apparently onlaps the Antigonish Highlands basement on the western border and at the eastern part of the northwestern border. The succession of Carboniferous rocks ranges in age from Early Tournaisian to Early Westphalian (Fig. 3, p. 5; Fig. 5, p. 7; Fig. 6, p. 9; Fig. 7, p. 10; NSDME Map 82-2, in pocket). Late Devonian rocks may be important constituents near the base of the succession in the subsurface. The Carboniferous basinfill is dominated by stratified, continental siliciclastics ranging from coarse boulder-pebble conglomerate, sandstone and minor siltstone, near the bottom, to finer grained facies including siltstone and sandstone near the top (Fig. 6, p. 9). The only major marine deposition in the Carboniferous is recorded by interstratified marine carbonates and evaporites of the Windsor Group. The Basin has a prominent northeast-southwest structural trend defined by a series of major faults including the Glenroy, Lanark and Morrison faults. To the northeast the Basin is submerged beneath the waters of St. Georges Bay, but probably extends as a continuous structural feature into the Mabou area of southwestern Cape Breton Island. These two Carboniferous outcrop areas together with their extensions beneath St. Georges Bay may be considered parts of a larger structural basin (Antigonish-Mabou Sub-basin, Wade et al., 1977). Little is known regarding the stratigraphy and structure of the portion submerged beneath St. Georges Bay although some reflection seismic data are available.

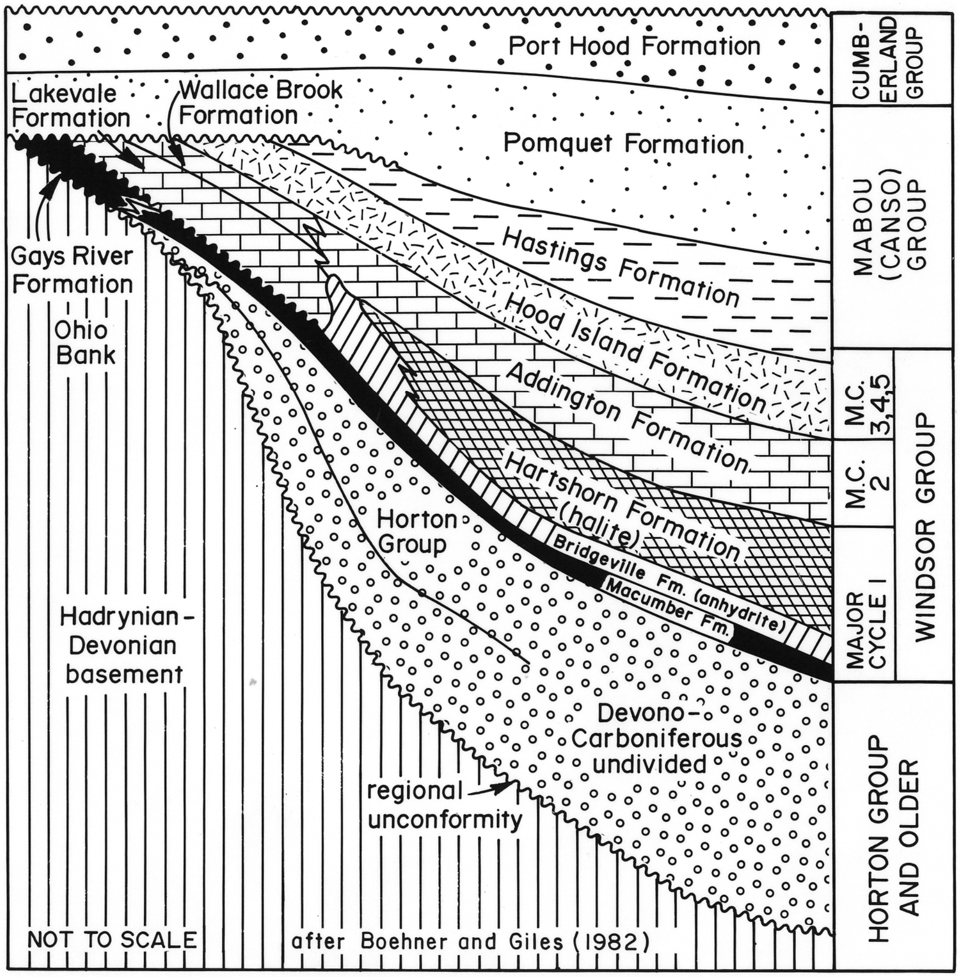


Figure 6. Diagrammatic representation of major stratigraphic relationships in the Antigonish Basin.

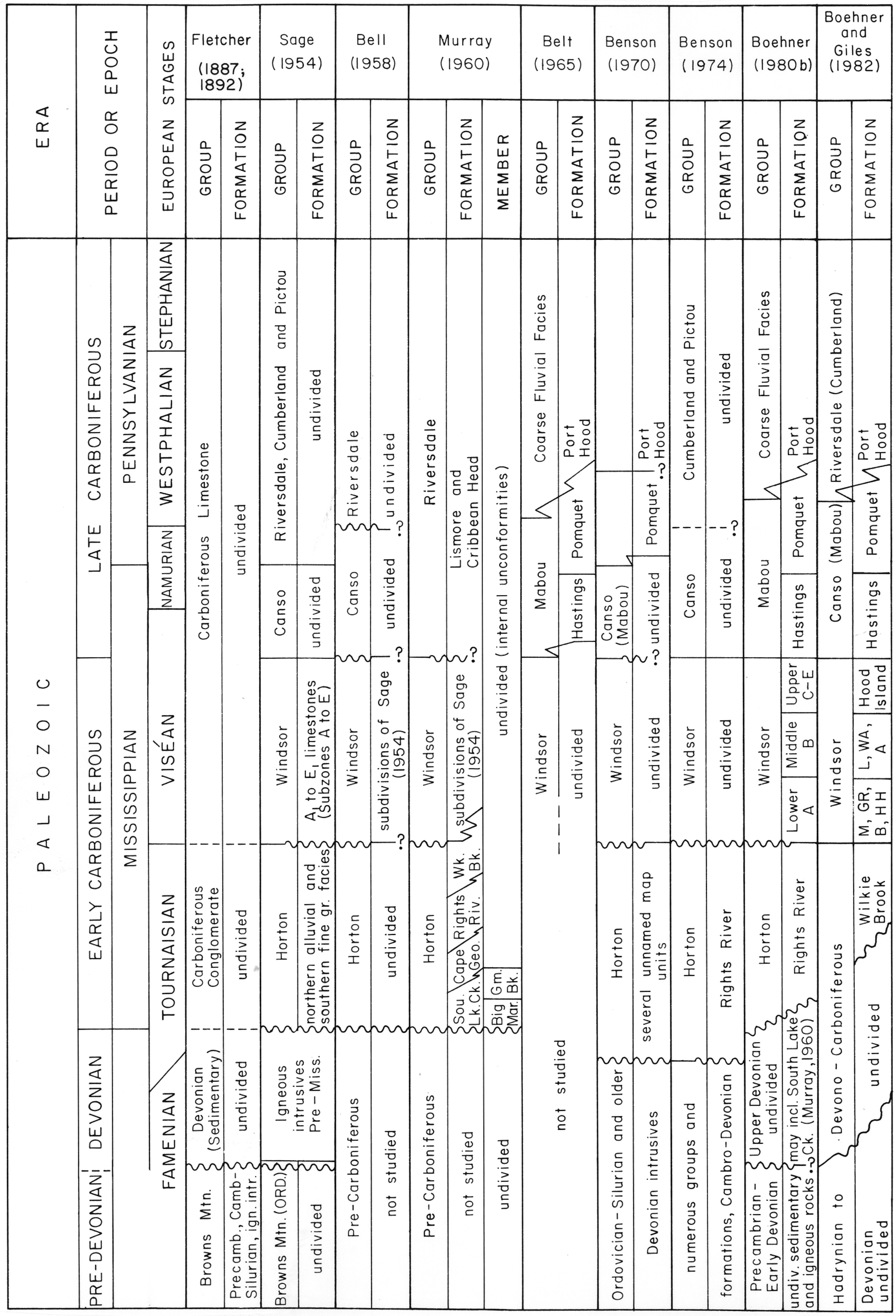


Figure 7. Summary of Antigonish Basin stratigraphic nomenclature with approximate age correlation. Conformable section (stated, inferred) —— – – ; Unconformity 〰〰 ; Facies boundary ⁄〰⁄ ; Contact relations unspecified and uncertain –?–; Formations of Boehner and Giles (1982), M = Macumber, GR = Gays River, B = Bridgeville, HH = Hartshorn, L = Lakevale, WA = Wallace Brook, A = Addington.