GEOLOGY OF CAMBRO-ORDOVICIAN ROCKS IN PARTS OF THE CASTORS RIVER, ST. JOHN ISLAND AND PORT SAUNDERS MAP SHEETS

by

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INTRODUCTION

1:50,000 scale geologic mapping and detailed stratigraphic compilation of Cambro-Ordovician carbonate rock units within contiguous areas of the Castors River (12I/15), St. John Island (12I/14) and Port Saunders (12I/11) map sheets (Figures 1 and 2) began during the summer of 1982. This heavily wooded region includes substantial areas of forest cutovers, new forest growth and tuckamore spruce. Large open marshes occur on the New Ferolle and Castors Point Peninsulas and in areas east of Port au Choix. The terrain is generally of low elevation and rarely exceeds 75 m. Topographic features include broad ridges separated by forested or marshy, flat, narrow, fault- or bedding-controlled valleys. Narrow, steep-sided ridges occur near the St. John Highlands. In the north and centre of the area, the coast is rocky and irregular, consisting of small bays and promontories. Large east trending bays occur in the south of the area. Access to the map area is provided by the Viking Highway (Route 73) and several gravel and paved branch roads that link to Port au Choix, Bartlett's Harbour and Reef's Harbour. Outcrop is best located on the wooded and locally barren slopes of the ridges, as well as in the bottoms of sink holes that abound in many of the low-lying wooded and marshy valleys of the southern part of area. Drift cover is generally just a few metres thick. Only in the vicinity and east of Port Saunders do several metres of coarse glacial debris (and local sand dune deposits) fill major fault-controlled valleys.

GEOLOGIC SETTING

Most of the map area is underlain by generally gently dipping platformal carbonate rocks that range in age from Middle Cambrian to Middle Ordovician. In the southern half of the area, these rocks are transected by several northeast trending faults. To the north, some of the faults coalesce into the Ten Mile Lake fault. It separates Cambro-Ordovician carbonate rocks in the west from an uplifted eastern terrain of Lower Cambrian clastic and carbonate rocks sitting upon Precambrian basement. The uplifted terrain comprises the Highlands of St. John and Mount St. Margaret.

Stratigraphic subdivision in the area follows that previously used by Knight (1978, 1980).

STRATIGRAPHY

Unit 1

Precambrian basement rocks composed of pink and salmon-red granites form a narrow zone of outcrop at the foot of Mount St. Margaret and the Highlands of St. John. The granular, porphyritic to pegmatitic granites consist of quartz and K-feldspar with variably developed chlorite. The unit lies adjacent to the Ten Mile Lake Fault and is the southern extension of basement rocks previously thought to be confined to the Ten Mile Lake area (Williams, 1967, 1978).

Unit 2

Unit 2 (Labrador Group) is composed, in ascending order, of the Bradore, Forteau and Hawke Bay Formations.

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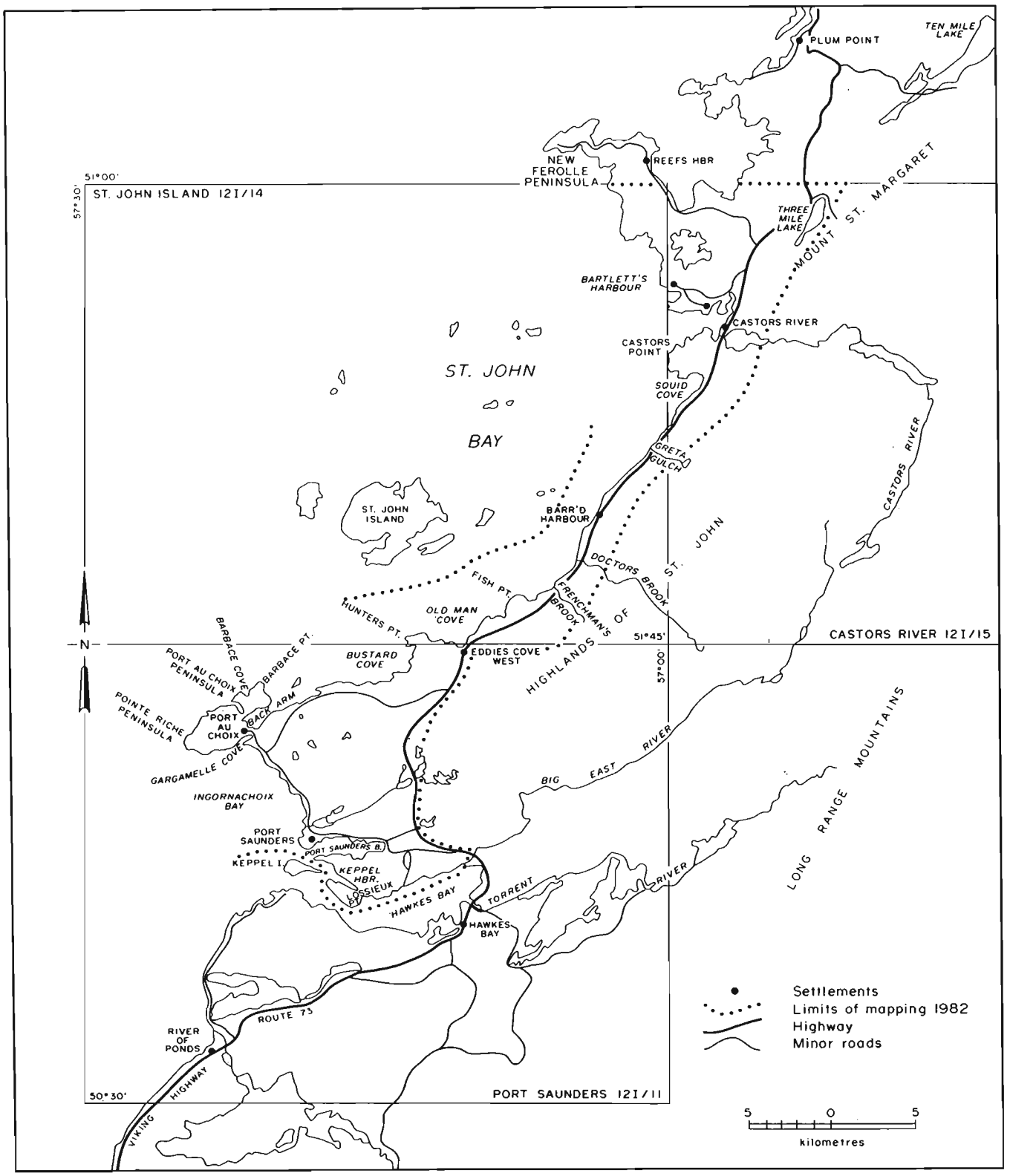

Figure 1: Geographic sketch map of parts of the Castors River, St. John Island and Port Saunders Map Areas.

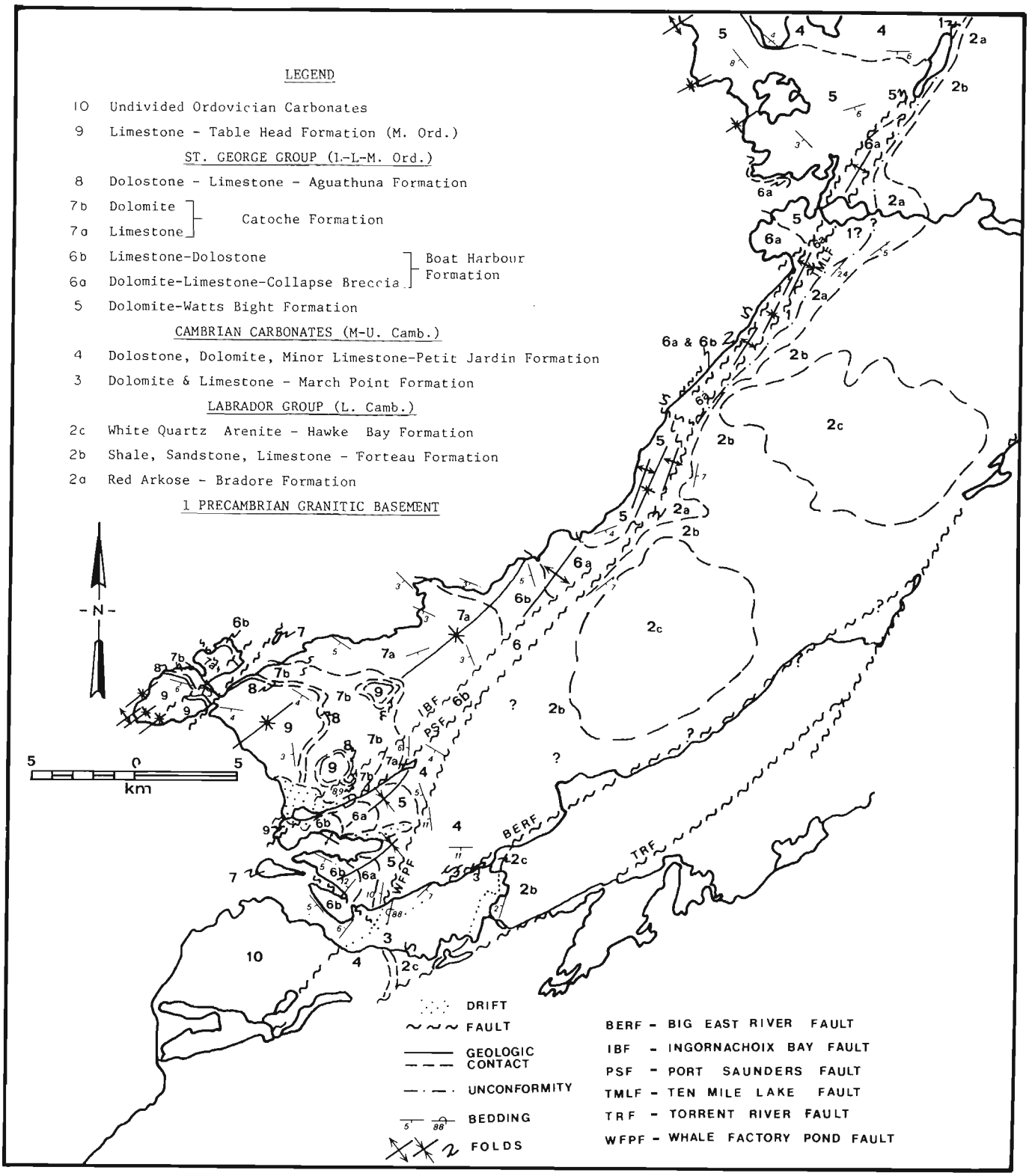

Figure 2: Geologic sketch map of parts of the Castors River, St. John Island and Port Saunders Map Areas. Geology of the Highlands of St. John partly taken from Bostock *et al.*, 1976.

The Bradore Formation (2a) unconformably overlies Unit 1 at the foot of Mount St. Margaret and at the northern end of the Highlands of St. John; the unconformity is truncated by the Ten Mile Lake Fault. The formation consists of red to brown arkosic grits and sandstones, which exhibit planar bedding and crossbedding. Lenses of quartz-pebble conglomerate also occur. A sequence of planar-bedded gray sandstones intruded by a 60 cm thick, green-gray diabase sill outcrops on Doctors Brook.

Rocks of the overlying Forteau Formation (2b) consist of gray and black shales and calcareous mudstones, interbedded with ripple bedded, bioclastic black limestones and thin, rusty weathering gray sandstones. Massive archaeocyathid-bearing limestones occur in outcrops 5 km southwest of Doctors Brook.

White, red and gray quartz arenites form the Hawke Bay Formation (2c). The formation caps the Highlands of St. John and was mapped elsewhere in the map area only as faulted and folded strata on the northeast shore of Hawkes Bay. The quartz arenites are dominantly crossbedded but also exhibit ripple marks and trace fossils.

CAMBRIAN CARBONATE ROCKS

Unit 3

This unit, referred to elsewhere as the Micrite formation (Knight, 1978) and later as the March Point Formation (Knight, 1980), is of late Middle Cambrian age. It occurs only as folded and faulted strata on the northeast shore of Hawkes Bay. The unit, which is at least 35 m thick sits conformably upon unit 2c. It consists of a basal unit of black shales overlain by rusty weathering, well bedded, dark gray to black dolomitic limestones which exhibit flaser and lenticular bedding, bioturbation, scour-based intraformational breccias and some ripple marks. Minor beds of oolitic grainstone also occur. Inarticulate brachiopods have been recovered from both the shales and limestones.

The formation was probably deposited in intertidal to subtidal environments.

Unit 4

Unit 4 (Dolomite formation, Knight, 1978; Petit Jardin Formation, Knight, 1980) consists of apparently unfossiliferous, yellow weathering, pale gray dolostones, green, red and rarely black dolomitic shales and minor blue-gray limestones, of presumed Late Cambrian age. It is exposed in the southeast portion of the map area along and inland from the north shore of Hawkes Bay and on the northern edge of the Castors River map sheet from South Cove to the north end of Three Mile Pond. Elements of four members defined elsewhere on the Northern Peninsula (Knight, 1980) occur in the map area but are not differentiated on the map. The lower contact of the unit is faulted out and continuity of section is disrupted by faults so that thickness cannot be determined.

The dolomites vary from light gray, thin-bedded dolostones to thick-bedded (>50 cm), fine to medium crystalline, pale gray epigenetic dolomites. Original sedimentary structures preserved in the thin-bedded dolostones include planar bedding, ripple marks, planar lamination, ripple cross-lamination, mudcracks, tepee structures and minor bioturbation. Intraformational breccias are also common. Green and red dolomitic shales and shaly dolostones exhibiting mudcracks form 1-2 m units in the lower half of the formation. In the middle of the formation, large, domal stromatolites are associated with crossbedded, intraclastic oolitic lime grainstones and bedded dolostones. The stromatolites, which are composed of both limestone and dolostone exhibit columnar and laminar internal structures. West of Whale Factory Pond on the north shore of Hawkes Bay the upper half of the formation is dominated by massive and

thick-bedded, crystalline dolomites locally exhibiting bioturbation, chert and collapse breccias. Blue chalcedonic, quartz-filled vugs occur locally in some beds towards the top of the formation near Three Mile Pond.

The sedimentological characteristics of the formation suggest that it was deposited in shallow peritidal conditions.

ORDOVICIAN CARBONATE ROCKS

Unit 5

Unit 5 (Watts Bight Formation, Knight, 1978) consists of an estimated 90-100 m of massive, thick-bedded, black to dark gray, epigenetic, frequently cherty dolomites. The formation is best exposed on the New Ferolle and Castors Point Peninsulas in the north of the area. It also outcrops on the north shore and inland of Hawkes Bay and in the vicinity of Barr'd Harbour. At South Cove it overlies unit 4 conformably, but at Hawkes Bay the base of the formation is faulted.

The dark-colored dolomites are generally thick-bedded, massive and bituminous and characterized by a light gray to white mottling. Original structures include large stromatolite mounds, intense bioturbation and poorly preserved gastropods and straight cephalopods. Intercrystal and cavity porosity (Choquette and Pray, 1970) is well developed and locally filled by buff-colored geopetal dolomitic mudstone.

Unit 6

Unit 6 (Unnamed Unit, Knight, 1978; Boat Harbour Formation, Knight, 1980) consists of two lithological sequences. The lower sequence (6a) consists of approximately 32-50 m of dark to light gray epigenetic dolomites, rare beds of blue-gray and white limestones and extensively developed collapse breccias. The upper sequence (6b) contains 105 m of cyclically developed gray limestone and buff weathering, light gray dolostone or dolomitic limestone.

The lower sequence sits conformably upon unit 5, the contact placed either at the base of a series of dolomite and chert breccias or at a bed of finely laminated, mudcracked, buff-gray dolomite observed near Bartlett's Harbour and at Castors Point. Above the base, the sequence consists of thick- and thin-bedded, white to brown weathering, light to dark gray, very fine to medium crystalline dolomites. White and pink sparry dolomite is common and outlines various secondary diagenetic, solution and structural textures. Locally, limestone beds are preserved and include bioturbated fossiliferous wackestones and packstones, stromatolitic limestones, intraformational breccias, rare thin oolitic grainstones and mudcracked, laminated and flaser-bedded lime mudstones and/or dolostones. Some beds are exceptionally rich in the gastropod *Lecanospira*. Other fossils include inarticulate and orthid brachiopods, silicified straight cephalopods and trilobites. Beds of laminated and structureless, pebbly and sandy dolostones, in a 2.37 m thick interval, occur on the south shore of Squid Cove. The pebbles and sand consist of gray chert, white quartz and dolomite.

Highly variable bedding attitudes and coarse breccias laterally replacing bedded lithologies suggest that widespread solution collapse affected the lower sequence of unit 6. These features are best exposed in the coastal sections north of Fish Point, on the Castors Point peninsula and near Lossieux Point, Hawkes Bay.

The upper limestone-dominated sequence lies apparently conformably upon the lower; undulose bedding at the base of the sequence may reflect molding of basal limestones over the irregularities of the top of the lower sequence. The upper sequence commences with 3 m of thin-bedded limestones with shale drapes. These limestones exhibit numerous structures including wrinkle marks, rill marks, ripple marks, small boundstone mounds and mudcracks. Overlying

this unit, the succession consists of cyclic shoaling-upward sequences 1 to 5 m thick of bioturbated wackestones and packstones and flaser-bedded and/or laminated dolomitic lime mudstones or dolostones and thick sequences of bioturbated wackestones with packstone lenses. Intraformational conglomerates may occur locally at the base of some cycles; other cycles contain boundstone mounds including stromatolites and thrombolites; mudcracks are common at the top of several cycles.

Twenty-four to thirty metres from the top of the formation, the succession is extensively dolomitized for some 10 to 20 m. Two sequences within this interval contain numerous quartz-lined spherical vugs and a solution surface occurs near the top of the second sequence. This stratigraphic interval is best exposed at Barbace Point and is only partially exposed at Old Man Cove. It is probably equivalent to the stratigraphic interval that contains the "pebble bed" and disconformity in the type section of the formation near Boat Harbour (see Knight, 1978).

Above the dolomitized interval, the upper 10 - 11 m returns to limestone. Here, crossbedded and ripple marked, skeletal-intraclastic grainstone beds up to 28 cm thick are common within cyclic sequences of bioturbated, flaser-bedded and laminated limestones and dolomitic limestones. The top of the formation is placed at the top of the last mudcracked, laminated limestone exposed in all sections of the formation.

Fossils recovered from the formation include trilobites, brachiopods, straight cephalopods, eocrinoid debris, ostracods and gastropods. Trilobite faunas collected from the formation this summer establish that a faunal break coincides with the dolomitized interval 24 to 30 m from the top of the formation. This supports the regional extension of the disconformity at this stratigraphic level already established farther north at Boat Harbour (Knight, 1978; Boyce, 1979). Limestones in the lower sequence at Fish Point and in the upper sequence below the dolomitized interval at Old Man Cove have yielded trilobites suggestive of the Early Ordovician Ross-Hintze Zones E and F in Utah and Nevada (see Boyce, this volume). Above the dolomitized interval at Old Man Cove, limestones of the upper 11 to 12 m of unit 6 contains trilobite species that belong to Ross-Hintze Zone G_2 of the Early Ordovician. Zone G_1 is, therefore, apparently absent as has been documented in the same stratigraphic interval at the type section of the formation near Boat Harbour (Knight, 1978, Boyce, 1979).

The sedimentological characteristics of the formation suggests that it was deposited under peritidal conditions that produced repeated shallowing-upward sequences typical of shoreline deposition (James, 1979).

Unit 7

Unit 7 (the Catoche Formation, Knight, 1978) consists of gray limestones (7a) that are replaced towards the top of the formation by epigenetic dolomites (7b), previously mapped as "Diagenetic Carbonates" (see Knight, 1977, 1978). The formation as a whole is calculated to be approximately 105 to 165 m thick, with 32-40+ m of epigenetic dolomite at the top of the formation.

The formation conformably overlies unit 6. It consists dominantly of rubbly weathering, gray, extensively bioturbated, well bedded wackestones containing discrete beds and lenses of packstone, grainstone and intraformational conglomerates. Dolomitic mottling, stylolites and laminated drapes are characteristic of the limestones. Coarser grained beds may exhibit scoured bases, large ripple marks, steived ripple marks and may consist of large crossbeds. The limestones are generally fossiliferous, containing trilobites, orthid and inarticulate brachiopods, high- and low-spired and

planispiral gastropods, cephalopods, sponges, eocrinoids, ostracods and receptaculitids. Mounds composed of cryptalgal structures (Pratt and James, 1982) but also hosting sponges and many other metazoan fossils occur as irregular to linear structures at several levels in the formation. The limestones accumulated mostly in an open, subtidal shelf environment.

Epigenetic dolomites (7b) at the top of the formation consist of 1 - 2 m beds of porous to nonporous, dark to light gray, fine to medium crystalline bituminous dolomites. Sparry dolomite is extensively developed, especially in the porous centres of beds, giving 'pseudobreccia' textures (Cumming, 1968). Burrow mottling in the porous dolomites and some thin bedding in the nonporous dolomites are locally noted. No basal contact with the underlying limestones is seen and the upper contact is also hard to define because of poor exposure. At Back Arm, however, the dolomites appear to underlie beds of unit 8 conformably.

An abundant trilobite fauna documented from two sections of the formation indicates it contains species common to the Early Ordovician Ross-Hintze Zones G_2, H and possibly I (Boyce, 1979, this volume; Fortey, 1979).

Unit 8

Unit 8, referred to as the Siliceous Dolomite formation (Knight, 1977) and more recently the Aguathuna Formation (Pratt and James, 1982) apparently conformably overlies unit 7b. In Back Arm, it is 17 m thick compared to 70 to 90 m at Table Point (Levesque, 1977; Knight, 1978). The unit is poorly exposed elsewhere in the map area.

At Back Arm, the unit, which was deposited mainly in an intertidal environment, consists of two parts. The lower 4 m consists of 20 to 50 cm beds of yellow weathering, massive to laminated dolostone with several distinct solution surfaces marking bedding planes; some ripple marks and mudcrack polygons were also observed.

Above the dolostones, the succession is completed by several cycles of mottled, argillaceous, dolomitic lime mudstones and wackestones capped by calcareous dolostones or dolomitic lime mudstones. The mottled wackestones contain ostracods, brachiopods and the trilobite *Bathyurus perplexus* Billings, which indicates the unit is of probable early Middle Ordovician age (Boyce, this volume). The calcic dolostones or lime mudstones may be laminated and some beds contain laminoid fenestral fabrics (Logan, 1974; Grover and Read, 1978).

The unit is extensively replaced by epigenetic dolomites in an irregular fashion on the Point Riche Peninsula and east of Ingornachoix Bay and Port au Choix.

Unit 9

Unit 9, the Table Head Formation of Middle Ordovician age, consists of well bedded, blue-black and rubbly weathering, bioturbated, gray limestones that were deposited in a subtidal, open shelf environment. They are part of an incomplete section approximately 50 m thick and are characteristically thickly bedded, massive and abundantly fossiliferous. Bedding at several levels has been affected by postdepositional mass movement that in some instances has produced extensively brecciated limestones. Crossbedding was noted a few metres above the base of the formation at Gargamelle Cove.

The base of the formation is placed at the base of the first bed of continuous, thick, rubbly-weathering limestone, as earlier proposed by Knight (1977, p. 25). It is exposed at Back Arm and Gargamelle Cove where the base of the formation is conformable. Elsewhere, however, as at Black Point and inland on the Pointe Riche Peninsula and east of Port au Choix, the base of the formation

has been dolomitized for many metres up into the unit. The epigenetic dolomites have sharp, irregular to linear contacts with adjacent limestones. Some dolomites are clearly related to nearby faults as for example at Gargamelle Cove where the dolomites form a narrow linear outcrop. The dolomites are pale yellow weathering, light gray to yellowish gray in color and show lighter colored mottling. Porosity is often abundant in the dolomites.

STRUCTURE

In general, the map area is underlain by gently dipping strata that young from north to south. However, the strata are gently warped about northeast trending fold axes, and some tight upright folds have been mapped locally between closely spaced faults. A northeast trending, steeply dipping fracture cleavage is locally developed in the limestones of the area.

Long, northeast trending, straight to gently curved faults which splay and interconnect with each other (Fig. 2) dominate the map area. The Ten Mile Lake Fault is the major structure in the north. There it juxtaposes southwestward-dipping and folded Lower Ordovician strata in the west and southeastward-dipping Lower Cambrian rocks and Precambrian basement in the east, a vertical displacement of at least 1 km. To the south the fault splays to form the Port Saunders, Ingornachoix Bay and Whale Factory Pond Faults. The Port Saunders Fault is apparently the main dislocation, juxtaposing dolomitized rocks of unit 6 in the south and limestones and dolomites of the Table Head Formation (unit 9), a vertical throw to the northwest of approximately 350 to 500 m. Other faults in the south include the Back Arm Fault near Port au Choix and the Big East River Fault which cuts the northeast shore of Hawke Bay. The Big East River Fault is an important splay of a fault that separates the Highlands of St. John terrain from Precambrian basement rocks that form the backbone of the Great Northern Peninsula. In the map area, it downthrows Upper Cambrian dolostone (unit 4) against the Hawke Bay and Forteau Formations (units 2b and c), a vertical throw to the northwest of 50 to 100 m.

The fault zones are exposed at Port Saunders, in a quarry near Greta Gulch and on the north shore of Hawkes Bay. They vary from intensely shattered and locally brecciated zones several metres wide to sharp, planar surfaces. Dolomite commonly replaces limestones adjacent to the faults. Vertical, oblique and horizontal slickensides have been noted along the faults, and gentle to tight drag folds with locally inverted bedding may be developed close to the faults.

Northwest trending faults of lesser importance also occur in the area at Barbace Cove and just north of Barr'd Harbour. A northwest trending fault is also inferred to strike along Keppel Harbour. Minor northwest trending folds are associated with the faults, and horizontal as well as vertical slickensides have been noted. These faults commonly offset minor northeast trending faults.

The main northeast trending faults are all downthrown to the northwest, suggesting that they are normal faults. Vertical slickensides and local drag folds support this sense of movement. However, where major faults such as the Port Saunders, Ten Mile Lake and Big East River Faults are crossed, the distribution of rock units indicates that stratigraphic rock boundaries northwest of the faults are displaced tens of kilometres to the northeast. This suggests that right-lateral strike-slip movements have also affected the succession, as indicated locally by slickensiding.

ECONOMIC GEOLOGY

The area contains no known economic mineral deposits. Massive to disseminated pyrite was noted in limestones,

dolomites and collapse breccias in unit 6. Fluorite occurs in vugs in the dolostones and limestones of unit 6 and also as disseminations in the limestones.

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