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MACROPALEONTOLOGICAL INVESTIGATION OF THE UPPER ST. GEORGE GROUP, WEST ISTHMUS BAY TO EAST BAY SECTION, PORT AU PORT PENINSULA, WESTERN NEWFOUNDLAND

W.D. Boyce and I. Knight
Regional Geology Section

ABSTRACT

For the first time, trilobites and other macrofossils were recovered, systematically, from the Floian rocks of the St. George Group above the Boat Harbour Disconformity in the West Isthmus Bay section, Port au Port Peninsula. The section, already renowned for its part in understanding St. George Group sedimentology and micro-biostratigraphy, was logged, in detail, and in spite of many covered intervals has yielded several trilobite faunas that are consistent with other sections elsewhere in western Newfoundland. The faunas in the Boat Harbour and lower part of the Catoche formations (St. George Group) belong to the Strigigenalis brevicaudata, Strigigenalis caudata *and* Benthamaspis gibberula *zones. The* Strigigenalis brevicaudata *zone begins at the disconformity and continues to the FAD (First Appearance Datum) of* Strigigenalis caudata *Trilobite Zone, 5.5 m above the base of the Catoche Formation. The FAD of the* Benthamaspis gibberula *Zone occurs only a few metres below the middle dolomitized boundstone interval (Pine Tree dolomite) of the Catoche Formation. The Costa Bay Member of the Catoche Formation has so far not yielded any macro fossils. Logging of the Aguathuna Formation at the top of the West Isthmus Bay section indicates the presence of several rich fossiliferous limestone beds but has yet to be studied systematically. Abundant silicified opercula suggests the utility of the term* Ceratopea unguis *Zone for this part of the section.*

INTRODUCTION

The West Isthmus Bay section (Section 2 of Ji and Barnes, 1994a, pages 75-77) is located at the eastern end of the Port au Port Peninsula in western Newfoundland (Figures 1 and 3). It is a 563.50-m-thick[1] interval of cyclic carbonates (Ji and Barnes, 1994a) that begins in the uppermost strata of the latest Cambrian Berry Head Formation (Port au Port Group) and continues to the basal part of the Middle Ordovician (Whiterockian) Table Point Formation (Table Head Group). Two long-lived Tremadocian and Floian third-order megacycle sequences are recognized, separated by a significant disconformity termed the Boat Harbour Disconformity (*see* Figure 2; Knight and James, 1987; Knight *et al.*, 2007).

The St. George Group on the Port au Port Peninsula, is something of a macrofaunal enigma. Compared to their development elsewhere in western Newfoundland, both the Boat Harbour and Catoche formations are, atypically, sparsely fossiliferous. In type and reference sections at Boat Harbour, Port au Choix and Eddies Cove West, several trilobite zones are recognized (Boyce, 1989, 1997; Boyce and Stouge, 1997). In the West Isthmus Bay section, however, trilobites have proved to be difficult to find, even in the relatively fossiliferous Barbace Cove Member (Early Ordovician, Late Canadian) at the top of the Boat Harbour Formation. A small number of trilobite taxa were recovered from the overlying Catoche Formation (Whittington and Kindle, 1969; Boyce, 1989) where gastropods, brachiopods and cephalopods are the most common fossils. Correlations with trilobite zones locally and internationally have therefore been challenging and the present work is an attempt to address the poor macrofaunal coverage of this section and to integrate the trilobite faunas with conodont faunas defined from this section (Ji, 1989; Ji and Barnes, 1993, 1994a).

The section is celebrated as the focus of detailed conodont studies in the St. George Group (Ji, 1989; Ji and Barnes, 1993, 1994a, b; Zhang and Barnes, 2004a, b). The

[1] A more accurate thickness of about 490 m is likely based on this and previous studies by Knight *et al.* (2007, 2008).

Note: The appendix for this report is available only on the disc version and on the departmental website.

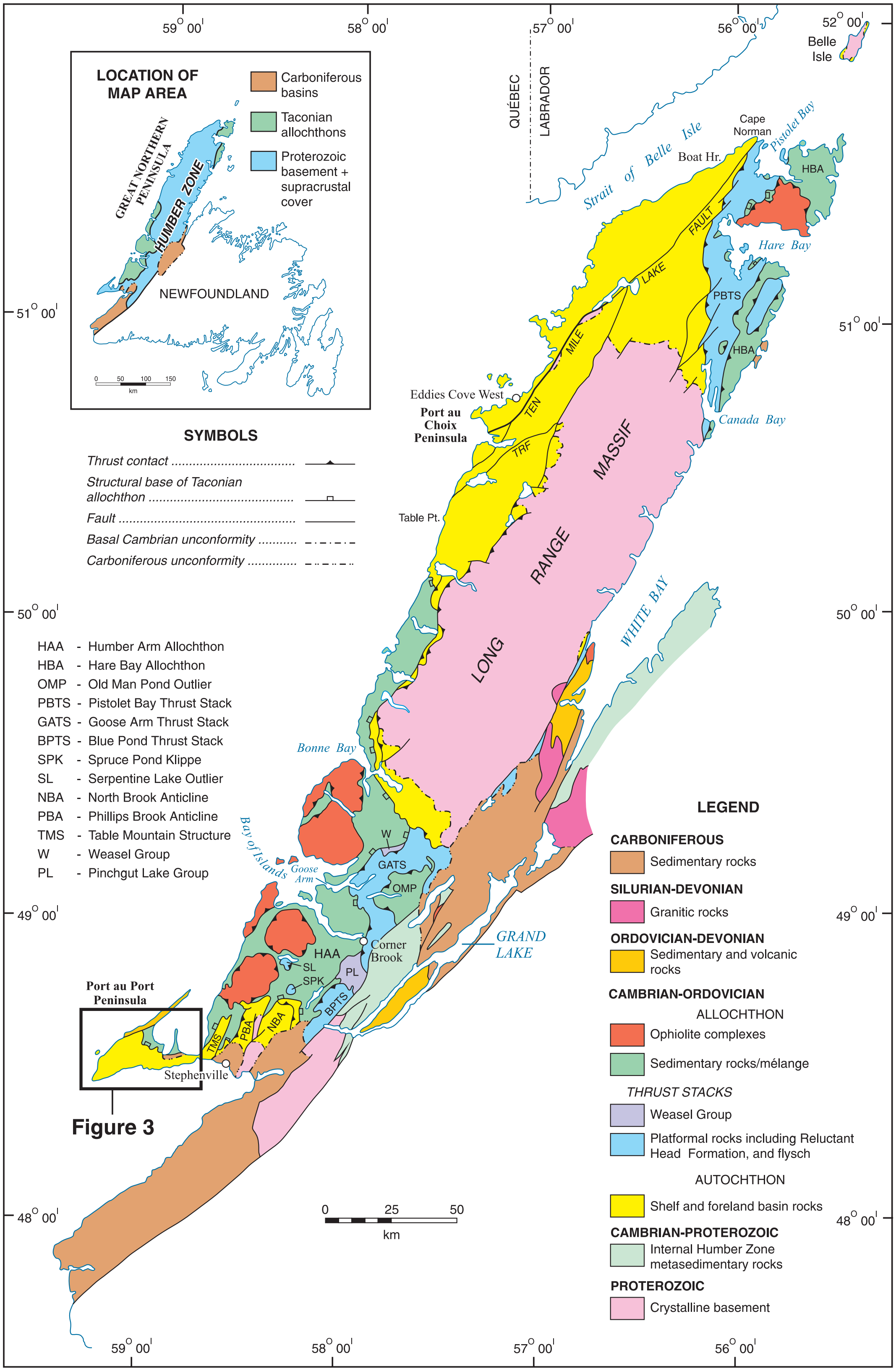

Figure 1. *Regional geological map of western Newfoundland showing major terranes, distribution of Lower Paleozoic shelf rocks and location of study area. TRF: Torrent River Fault.*

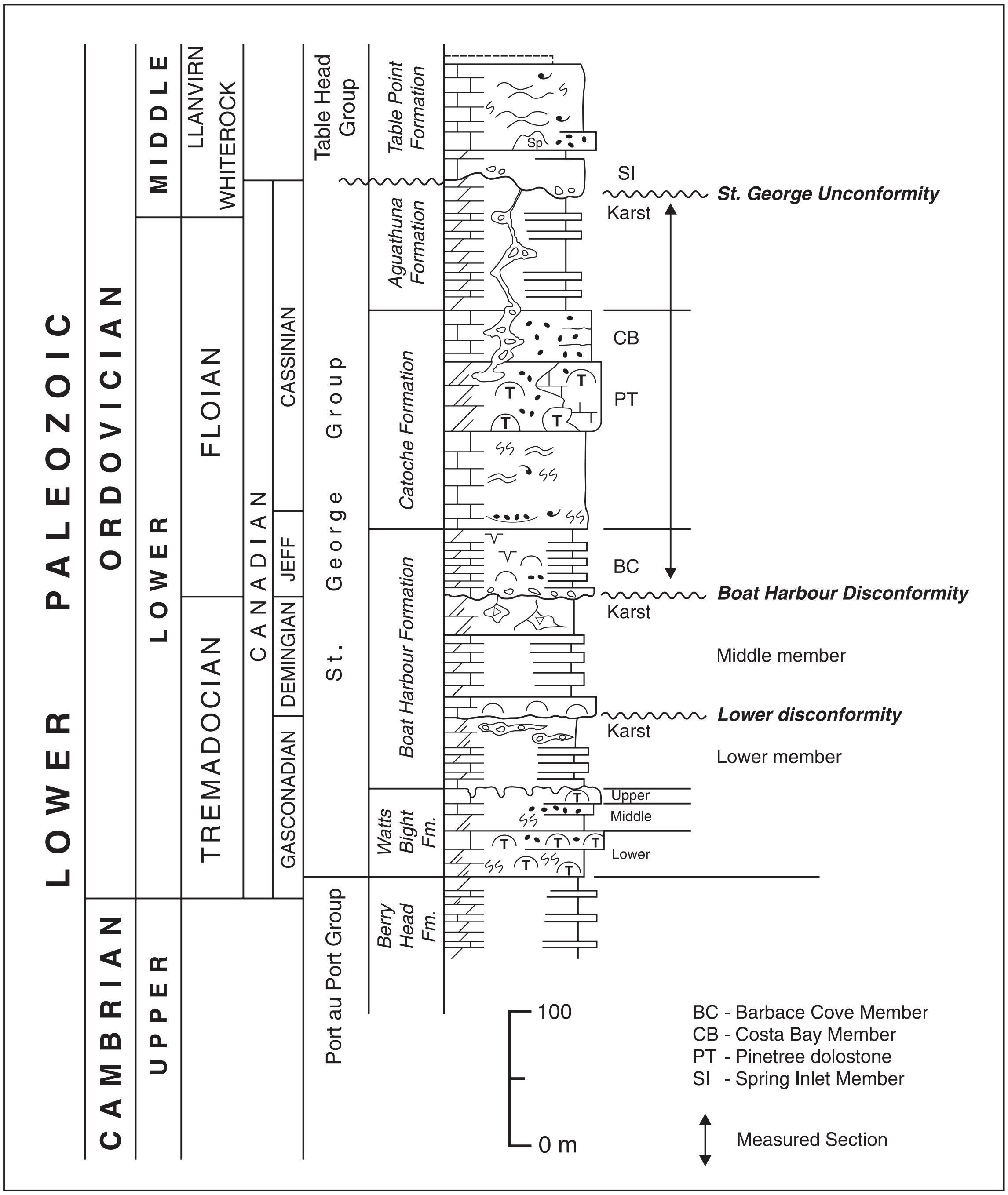

Figure 2. *Simplified lithostratigraphy of the St. George Group, Port au Port Peninsula.*

conodont sample localities of Ji and Barnes (1994a) are marked by blue paint. The numbers, which date from the mid to late 1980s are now variably degraded and a concerted effort was made to locate, photograph and record the UTM coordinates of the numbers as a prelude to searching for macrofossils. The section illustrated graphically in Figure 4 shows the stratigraphic location of the sample sites of Ji. Several sample number localities could not be found.

This update is primarily concerned with the Floian strata above the Boat Harbour Disconformity, a sequence plagued by covered intervals and a local stratigraphic character (summarized in detail by Knight *et al.*, 2007) that is different from that encountered in the equivalent interval on the Great Northern Peninsula. The West Isthmus Bay succession consists of a lower interval of cyclic peritidal carbonates (Barbace Cove Member), a succession of bioturbat-

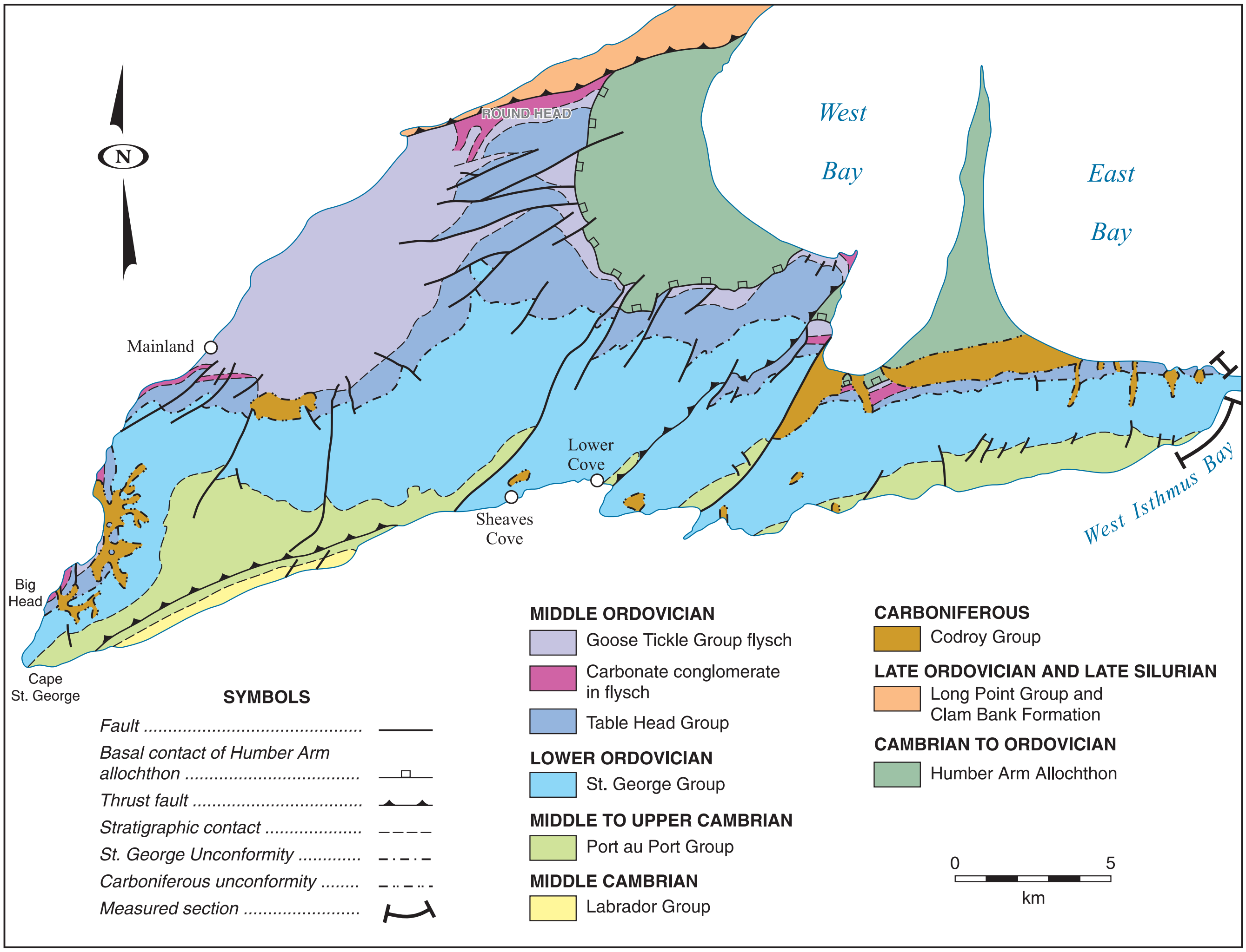

Figure 3. *Geological map of the Port au Port Peninsula showing the location of the West Isthmus Bay section (based on unpublished mapping of Knight, 1996).*

ed, grainy, microbial and lesser nodular carbonates of the lower Catoche Formation, overlain by an interval of largely, dolomitized and poorly fossiliferous thrombolitic boundstones (middle Catoche Formation, now, locally called the Pine Tree dolomite) and an upper interval of dominantly peloidal and fenestral grainstones, the Costa Bay Member, of the Catoche Formation. The Costa Bay sequence is followed, after a long covered interval, by the Aguathuna Formation, that is terminated at the erosionally karsted St. George Unconformity.

PREVIOUS BIOSTRATIGRAPHIC WORK

Most early and more recent macrofossil studies of the Ordovician limestones of the Port au Port Peninsula involved molluscs. Hyatt (1894) described several new cephalopod genera and species from the St. George Group. His material was later re-studied by Ulrich *et al.* (1942, 1944). A field reconnaissance study by Flower (1978) that listed various cephalopod and gastropod taxa was subsequently followed byYochelson (1992) and Rohr *et al.* (2000) who studied silicified gastropod material. General paleontological information is found in Schuchert and Dunbar (1934), Sullivan (1940), Johnson (1949), Riley (1962), Whittington and Kindle (1969) and Knight *et al.* (2008). The most recent detailed and useful paleontological studies are the conodont studies of Ji (1989) and Ji and Barnes, (1993, 1994a, b), which provided the basic data for the cluster analysis studies of Zhang and Barnes (2004a, b). The West Isthmus Bay section provided the most complete section studied, encompassing rocks from the uppermost Berry Head Formation (Port au Port Group) to the Aguathuna Formation.

LITHOSTRATIGRAPHY

The Floian autochthonous carbonates of southern Laurentia in western Newfoundland are preserved in a disconformity-bounded sequence, assembled in a Late Canadian (latest Jeffersonian)[2] to Whiterockian megacycle (Knight and James, 1987; Knight *et al.*, 2007). The base of the sequence is a sequence boundary recognized within the upper part of the Boat Harbour Formation as a single disconformity surface, in the north, and as an interval of repeated exposure and karsting at Isthmus Bay (Knight *et al.*, 2007, 2008). Above the sequence boundary, a thick Transgressive Systems Tract (TST) includes rocks of the Barbace Cove Member, Boat Harbour Formation and the lower part of the Catoche Formation. The latter also hides the Maximum Flooding Surface (MFS) and likely the early part of the Regressive Systems Tract (RST). The RST also includes rocks of the middle and upper Catoche Formation as well as the overlying Aguathuna Formation. The top of the Canadian (Ibexian) sequence finishes at the St. George Unconformity, a regional erosional and karsted surface that separates Sauk and Tippecanoe supersequences of Sloss (1963, 1988) in western Newfoundland.

The West Isthmus Bay section contains significant covered intervals that interrupt the lower limestone member, its best exposed part, and almost totally hide the middle part of the section (Pine Tree dolomite and Costa Bay Member) and the base of the Aguathuna Formation. This study is primarily focused on the TST and lower part of the RST hosted by rocks of the Barbace Cove Member and the lower limestone member of the Catoche Formation. The Barbace Cove Member at Isthmus Bay, although described in several earlier publications (Knight and James, 1987, 1988; Boyce, 1989; Knight *et al.*, 2007, 2008) is summarized here and includes some important new information and interpretations.

Boat Harbour Disconformity

The Boat Harbour Disconformity is a cryptic to readily recognized, regionally developed surface that was first noted at Boat Harbour on the Great Northern Peninsula (Knight, 1977; Boyce, 1978, 1989; Knight *et al.*, 2007, 2008) and which is highlighted here as the basal Sequence Boundary (SB) of the Late Canadian (Ibexian). In the West Isthmus Bay Section, the SB is placed at the top of an interval of metre-scale, shallowing-upward cycles at the top of the middle member of the Boat Harbour Formation; these are characterized by evidence of repeated penecontemporaneous karsting and are described and illustrated in Knight *et al.* (2007) and Knight *et al.* (2008, Plates 27 to 31). The disconformity roughly coincides with a -ve $\delta^{13}C$ maximum (Azmy and Lavoie, 2009) and separates older Middle Canadian (Demingian)[3] macro- and microfaunas from younger Late Canadian (latest Jeffersonian)[4] faunas stratigraphically above.

An irregular erosional surface at the top of dolomitized and fractured carbonates of the middle member of the Boat Harbour Formation overlain by a bed of poorly sorted dolomite- and quartz-pebble, dolomite-, and locally oolitic, matrix conglomerate was previously chosen as the disconformity (immediately above Z2-062; Knight and James, 1987, 1988; Knight *et al.*, 2007; Knight *et al.*, 2008, Plate 27). However, a narrow, compacted, dyke-like fissure, a few centimetres wide, filled by grainy dolostone that was discovered to cut the conglomerate (Knight *et al.*, 2008, Plate 27), has been traced upward through the overlying thin-bedded grainy and muddy limestones and dololaminite terminating at a higher surface of erosion. Limestone overlying this surface, contains gastropod cross-sections (*Lecanospira* or *Ophileta* sp. undet. and *Maclurites* or *Rhombella* sp. undet.; fossil locality 2009F002, just above Z2-063). A thin dololaminite capped by a conglomerate bed of chert and dolostone pebbles a few centimetres thick rests on this limestone and is succeeded by grainy and burrowed limestones that host abundant *Drepanoistodus concavus* (Branson and Mehl, 1933) and *Protopanderodus inconstans* (Branson and Mehl, 1933) (Z2-065). The *Acodus? primus* fauna appears immediately above this level within Z2-066. Also whereas *Macerodus dianae* Fåhraeus and Nowlan, 1978 terminates immediately below the previously selected disconformity in Z2-062, its long-ranging companion *Drepanoistodus nowlani* Ji and Barnes, 1994a continues above the surface to Z2-063. In addition, the Last Appearance Datum (LAD) of *Glyptoconus felicitii* Ji and Barnes, 1994a and renewed appearance of *Drepanoistodus concavus* (Branson and Mehl, 1933) occurs at Z2-064 (above the previously selected disconformity). It is sensible, therefore, at this locality not to choose a single surface as the 'disconformity' at the top of the middle member of the Boat Harbour Formation (as claimed by Knight *et al.*, 2007, 2008) but to recognize that the SB brackets a broad stratigraphic interval, 22 m thick, of several metre-scale parasequences (Z2-059 to Z2-064) that include evidence of karsted tops to parasequences and erosion and reworking of local carbonates into conglomerates. The top of this interval is placed at the thin conglomerate between Z2-064 and Z2-065 and would logically mark the disconformity if a single surface is delineated as the sequence boundary.

[2] Late Ibexian (latest Tulean) of northern Laurentia.

[3] Middle Ibexian (Stairsian) of northern Laurentia.

[4] Late Ibexian (latest Tulean) of northern Laurentia

Transgressive System Tract (TST)

The TST consists of peritidal rocks of the Boat Harbour Formation (Barbace Cove Member) and subtidal to peritidal limestones of the lower Catoche Formation.

Barbace Cove Member, Boat Harbour Formation

The Barbace Cove Member at Isthmus Bay (Figure 4a) is approximately 44 m thick (adjusted from 52 m given by Knight *et al.*, 2007, 2008) and consists of 20 shallowing-upward parasequences. The succession is divided into two parts separated by a cluster of shale beds located about 20 m below the top of the formation and appears to have interesting links to the evolving and proliferating post-SB faunas of the member (*see* Knight *et al.*, 2007, 2008).

Below the shale interval, each sequence sports a basal scour above which microbial mounds, both thrombolitic, *Renalcis*-rich and stromatolitic, are associated with plentiful grainstone and rudstone. The grainstone is oolitic, intraclastic, peloidal and skeletal grainstone, the latter rich in crinoid, brachiopod and mollusc debris. Oncolites are present in some beds. A bed of mounds and grainstone, deeply incised by depressions and pedestals of a coastal karst, occur locally in the lower part of the member. Burrowed, fossiliferous, dolomitic lime wackestone is weakly developed and laminated, dolomitic limestones and/or dololaminites, generally ranging from 10 to 60 cm thick, cap most parasequences.

The shale beds lie between Z2-074 and Z2-076 immediately above grain and microbial-rich limestone (Z2-070 to Z2-073) that coincide with a marked negative $\delta^{13}C$ spike (Azmy and Lavoie, 2009). Parasequences here are generally thin, rich in *Renalcis* including a newly discovered sponge–microbial mound and appear to lack intervening dololaminite. The shale-rich interval consists of two beds of shale and hackly fracturing silty mudstone that are associated with supratidal to high-intertidal laminites at the top of two parasequences. Mudcracks, flaser bedding and the lack of a fauna indicate that the siliciclastic rocks were deposited in a tidal-flat setting. They appear to mark a tipping point in the flooding of the Newfoundland platform when, following mobilization of fine-grained clastic sediments onto the Barbace Cove tidal flat by either non-marine processes or marine flooding of an inboard fine-grained siliciclastic source area, marine onlap expanded beyond the Isthmus Bay area and more outboard parts of the shelf across the rest of the western Newfoundland platform. This is supported by the change of character of the uppermost parasequences above this shale interval that compare to the cycles overlying the Boat Harbour Disconformity on the Great Northern Peninsula (GNP) and the uniform faunas of the upper part of the member throughout western Newfoundland (*see* Knight *et al.*, 2007, 2008). These uppermost parasequences consist of thick wackestone intercalated with grainstone–rudstone sheets and lenses capped by laminated, dolomitic limestone and/or dololaminite up to 2.2 m thick, rich in mudcracks, deeply penetrating, tapering, fissure cracks and fenestrae. Intraclastic, centimetre-size, discoidal pebbles of pink lime mudstone are found in the rudstones. Throughout western Newfoundland, the uppermost laminites are extremely well laminated, argillaceous dolomitic limestone-laminite markers.

Examination of the macro and microfaunas shows that there is a significant proliferation in both faunal diversity and number in this upper 20 m, above the coeval shale interval at Isthmus Bay, and in the Barbace Cove Member above the Boat Harbour Disconformity on the GNP.

Catoche Formation

The Catoche Formation along the shores of Isthmus Bay to the Isthmus itself consists of a lower limestone, a middle dolostone (after thrombolitic mounds) and the upper Costa Bay Member limestone (Knight *et al.*, 2007). Much of the middle and upper members are covered as is the upper contact with the Aguathuna Formation that must lie under the roadbed crossing the Isthmus. A detailed section through the lower limestone was measured (by Knight) and sampled for macrofauna (by Boyce) during the summer of 2009 and is described and illustrated here (Figure 4b). The limestone is approximately 69.5 m thick, and is succeeded by about 4.5 m of poorly exposed partly dolomitized limestone below the middle member of bituminous sucrosic dolostones. Several short, covered intervals affect the continuity of the limestone section. The Catoche Formation rests sharply and conformably upon the last, metre-thick limestone laminite at the top of the Barbace Cove Member (Z2-085). Ji and Barnes (1994a, page 76) designated Z2-081 as the base of the Catoche Formation. We place it 10 m higher, at Z2-085B, overlying a 2.15-m-thick mudcracked laminite of Z2-085.

The Catoche Formation at West Isthmus Bay is a succession dominated by stylobedded, burrowed, fossiliferous dolomitic lime wackestone, packstone and mudstone, intercalated with sheets and lenses of intraclastic-skeletal lime grainstone and intraformational rudstone. The lime mud-rich rocks consist of mud, peloids and skeletal grains, and, notably, mud-filled gastropods. Some beds are mud-dominated and include a few beds of stylonodular lime mudstone but mostly they are a mix of components. Burrows, which include *Planolites, Paleophycus, Thalassinoides* and *Chondrites*, are filled by mud or grainstone.

The grainstones contain lime-mudstone intraclasts. Macrofossils include ostracodes, trilobites, articulate bra-

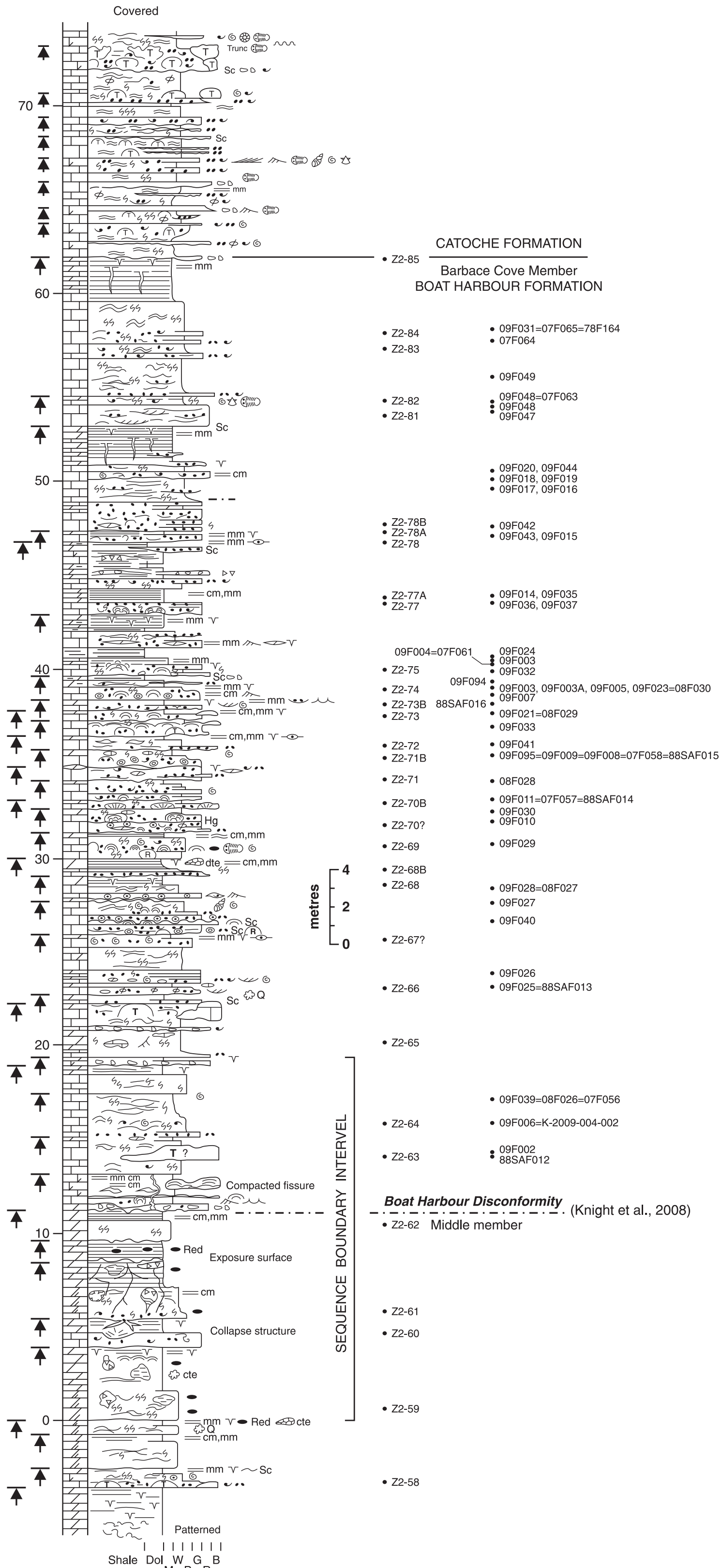

Figure 4. *Detailed stratigraphic logs of the upper Boat Harbour Formation (Barbace Cove Member) (Figure 4a) and lower Catoche Formation (4b), West Isthmus Bay section, Port au Port Peninsula, and Aguathuna Formation (4c) at East Bay, north of the isthmus. Figure 4a modified from Knight et al. (2008, page 125, Figure 4). All columns are to the same scale.*

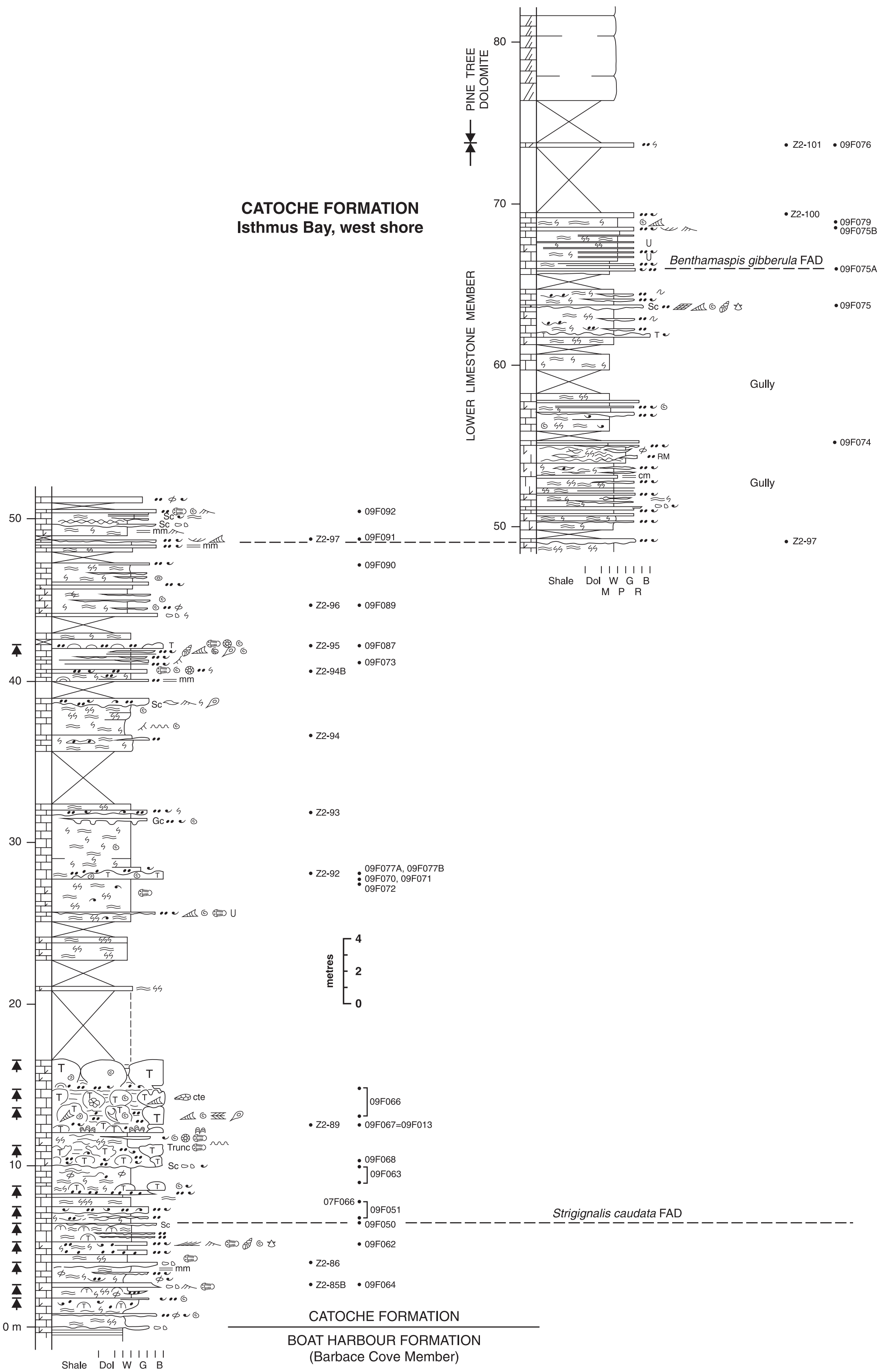

Figure 4b. (Caption on page 225).

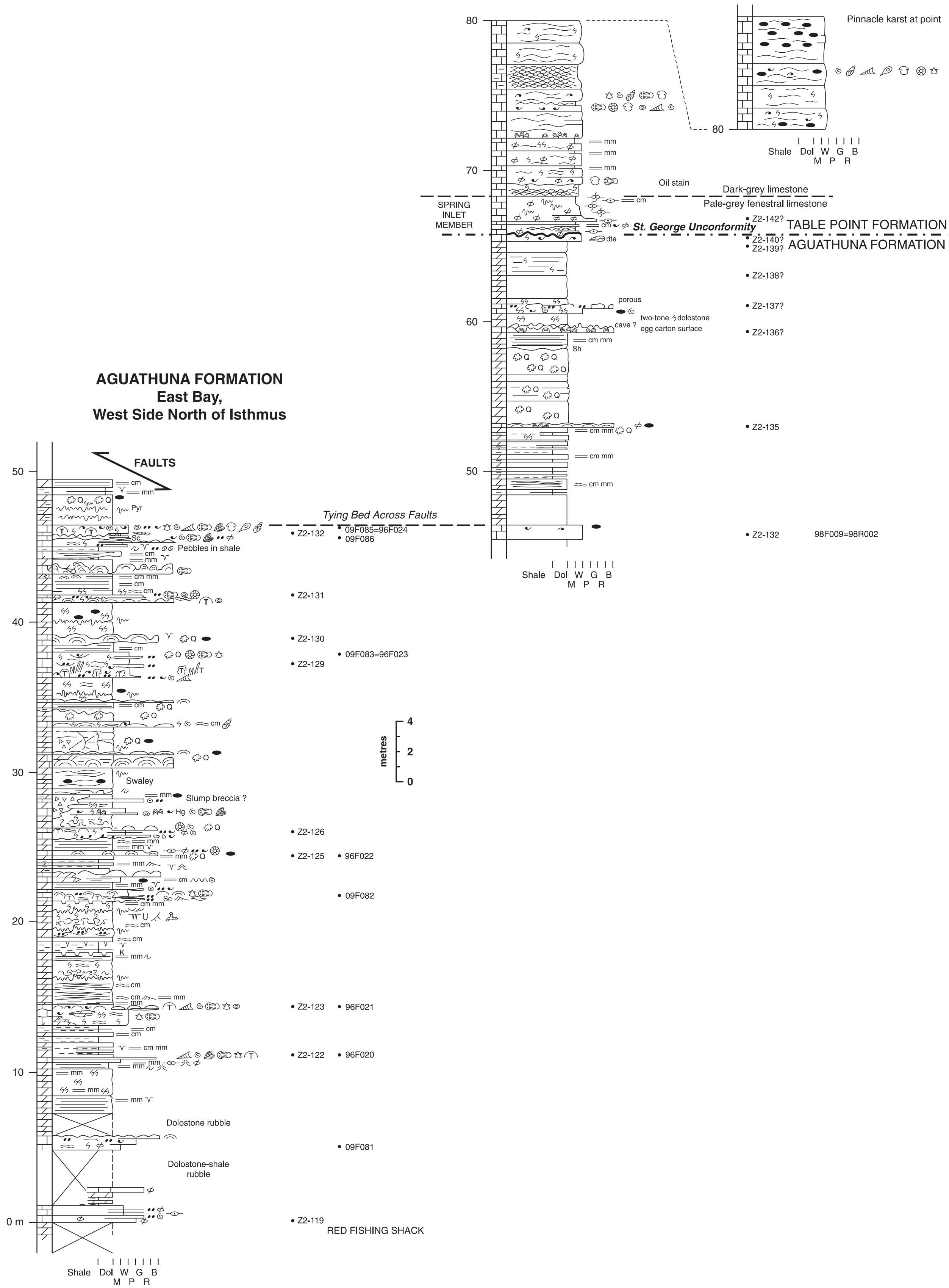

Figure 4c. (Caption on page 225).

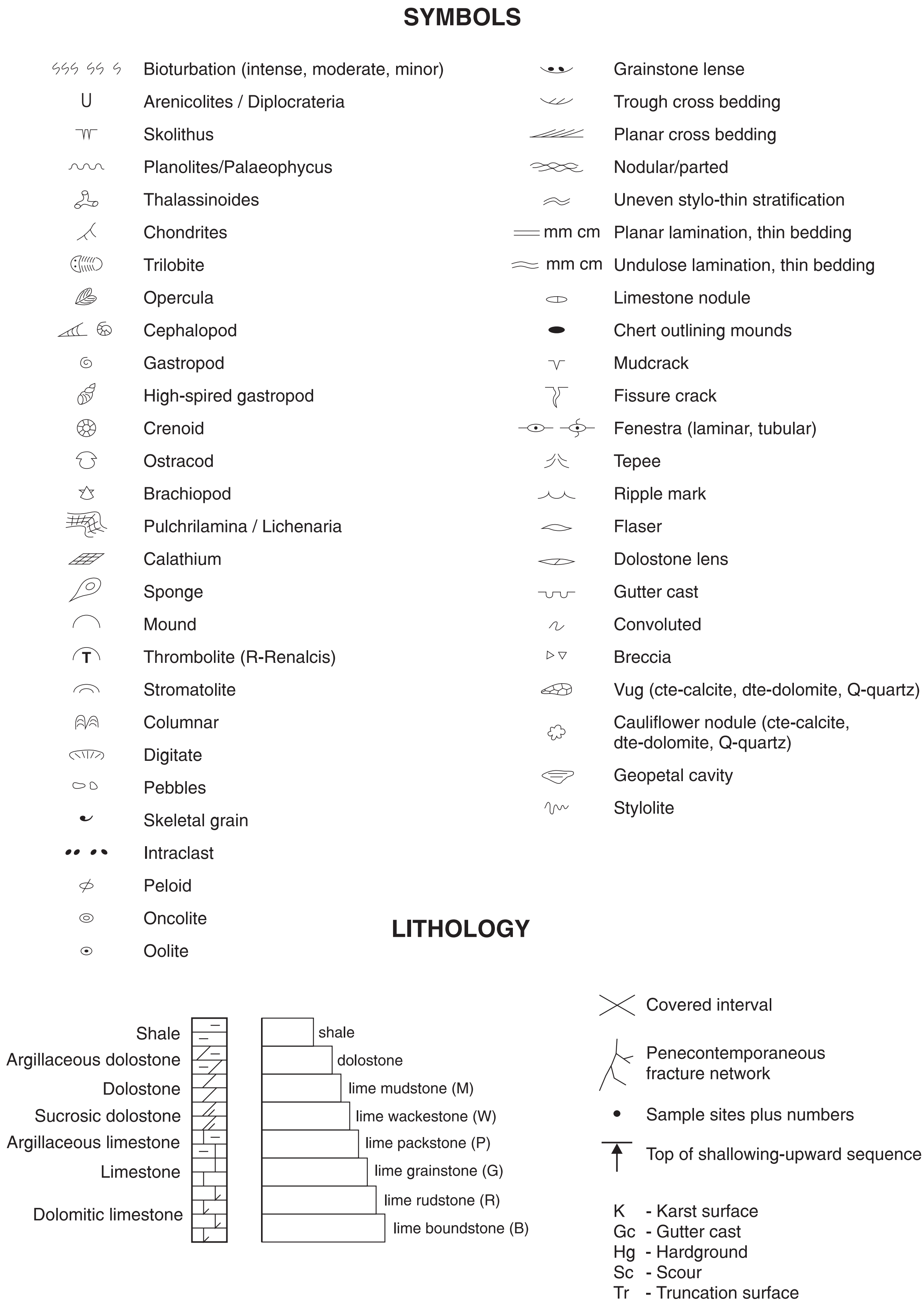

Figure 4. Legend.

chiopods, crinoids, straight and coiled cephalopods, high- and low-spired gastropods, and rarely *Calathium* and oncolites. *Arenicolites* and *Skolithos* were noted in some of the fine-grained grainstone sheets that generally also display low-angle lamination as well as crosslamination. Grainstone and rudstone, however, form beds up to 1.4 m thick and cap the mud-rich facies. The coarse-grained beds are generally scour-based, unevenly stratified but locally are crossbedded. Lime-mudstone pebbles form the rudstones; these are generally small, centimetre-sized discoid to irregular in shape, and some are pink.

Small, thrombolitic, boundstone mounds are scattered in the burrowed limestone for the lower 10 m and form a few isolated mound beds at 28, 42 and 63 m above the base. A cluster of thrombolite beds, 1.3 to 2.6 m thick, however, occurs between 10 to 17 m above the base of the unit. The thrombolite mounds are metre-scale in thickness, irregular in shape and rich in large cephalopods and gastropods, as well as sponges and trilobites. Fibrous calcite cement, likely of marine origin, locally lines vugs and shell cavities. Mixed, skeletal–intraclastic–peloidal grainstone and burrowed wackestone occur in intermound areas.

The succession consists predominantly of repetitive mud-rock to grainstone sequences, each about 1 to 1.5 m thick. This is typical of the lower 10 m below the mound interval and the upper part (38 to 69 m) of the lower limestone. The succession from 17 to 38 m, however, is essentially non-cyclic burrowed, stylobedded lime mudstone–wackestone, containing only rare beds of grainstone and thrombolite. Above 38 m, the succession returns to a mixed succession of burrowed mud rocks and grainstones with a rare thrombolite bed. Conodont faunas appear to be scarce in the mound interval (Z2-089 to Z2-090) but proliferate both numerically and in diversity from 29 to 36.5 m above the base (Z2-092 to Z2-094B) and again at 49.5 m (Z2-097 and Z2-098). This suggests that the sequence was deposited in a predominantly quiet subtidal yet periodically storm-influenced shelf setting on which thrombolite mounds formed massive buildups in the early phase of transgression. Maximum flooding probably occurred in the interval from 29 to 38 m above which, the return to a mix of facies like those below the mound interval suggests the shelf was beginning to shallow during the early phase of the RST.

Descriptions of the Pine Tree dolomite and the Costa Bay Member of the upper Catoche Formation are provided in Knight *et al.* (2007). These units are known to average 57 m and 28 m thick, respectively, in drill cores a few kilometres inland and west of the shoreline section (Knight, 1996). Both units have proven to be poor in both macro and micro fossils.

Aguathuna Formation

The section through the Aguathuna Formation on the western shore of East Port au Port Bay is the continuation of the West Isthmus Bay section. The basal contact of the formation with the Costa Bay Member, Catoche Formation is covered beneath the Route 460 road-bed crossing the Isthmus itself. In this same interval, there is also a significant but as yet uncertain thickness of finely crystalline dolostone at the base of the formation beneath the raised beach to the north of the Isthmus. The upper part of the formation is exposed in a section of low cliff and rocky foreshore that begins in a stuttering fashion just where the sweep of the Isthmus's straight pebble span curves to the north and merges with the cliff, which hosts the section measured and illustrated in Figure 4c. The section is 66.7 m thick from the Isthmus to the St. George Unconformity. This is 22 m less than an incomplete 88 m section encountered in a nearby drillhole to the west (Knight, 1996) suggesting that the base of the unit (between Z2-119 and Z2-120) was wrongly selected by Ji and Barnes (1994a). The St. George Unconformity in the West Isthmus Bay section is a paraconformable but strongly irregular surface with broad swells and depressions and relief of up to 20 cm. The section trends between 232° in the south to 262° in the north and dips at an average of 15° to the north. Nonetheless, the section is broken by several closely clustered high-angle faults midway through the section. A prominent limestone, host to Z2-132, is a useful marker 46 m above the base of the section to link across these faults.

The exposed section consists of intercalated dolostone and limestone with a few intervals of intercalated dolostone and green-grey shale. Dolostone dominates the upper 20 m of the formation below the St. George Unconformity. Chert nodules occur throughout. Some very irregular, erosional surfaces at 18.00, 23.50, 34.50, 39.50 and 60.03 m suggest that there may be minor karst disconformities throughout the section. A prominent breccia, 29 m above the base of the section, contains rubble in a shale matrix derived from a number of limestone and dolostone beds. It also displays evidence of local transport and penecontemporaneous deformation indicating that it might be related to tectonic instability during deposition of the Aguathuna Formation, although origin as a paleo-cave collapse breccia can not be ruled out.

The dominant dolostones are generally finely crystalline and occur in units up to 7 m thick. They range from those displaying lamination and thin stratification (dololaminites), to those with burrow-mottling to less common dolostone with a vague convoluted fabric interpreted here as patterned dolostone. The patterned dolostone however, is clearly mixed with burrowed fabrics suggesting it may be related to bioturbation of soft sediment. One bed of dolostone includes swaley stratification. Many dolostone beds are rich in white megaquartz and chalcedonic quartz nodules implying a likely evaporitic precursor. Shale that intercalates with dololaminite and marly dolostone is mostly found in the lower 30 m of the section where they range from 75 to 215 cm thick. Shale, also intercalated with dololaminite over 4.7 m, occurs 17 m below the St. George Unconformity. Each shale–dolostone association is rich in mudcracks, lamination and cross-lamination; each rests on a sharp and often irregular contact; and each forms the base of a metre-scale cycle. Some cycles consist of shale–dololaminite overlain by dololaminite and in turn burrow dolostone whilst others include shale–dololaminite capped by stromatolitic and/or fossiliferous limestone.

The numerous limestones beds in the dominantly dolostone section are generally clean, fine-grained stromatolitic boundstones, 20 to 75 cm thick, but also include oolitic, oncolitic, intraclastic and peloidal grainstone. Spaced through the lower 45 m of the section, however, are several thicker limestone beds (70 to 175 cm) consisting of bioturbated, fossiliferous and peloidal wackestone–packstone with thin fossiliferous and intraclastic grainstone lenses and sheets and thrombolitic boundstone mounds. These limestones host a surprising variety of shelly fossils including ostracodes, trilobites, articulate brachiopods, crinoids, cephalopods, gastropods (shells and opercula), rostroconchs, sponges and possibly bryozoa. The articulate brachiopods and gastropod opercula commonly are silicified. These fossiliferous limestones also yield a more open-marine conodont fauna that together with the macrofauna imply that several normal marine-flooding events briefly drowned the restricted and shallow peritidal shelf of the Aguathuna platform.

BIOSTRATIGRAPHY

Boat Harbour Formation (Barbace Cove Member)

The Barbace Cove Member at Isthmus Bay collectively yielded the following:

Arthropoda–Ostracoda
- ?*Isochilina* sp. undet.

Arthropoda–Trilobita
- *Bathyurellus abruptus* Billings, 1865 (Plate 2E, F)
- *Benthamaspis*? sp. undet.
- *Bolbocephalus convexus* (Billings, 1865)
- Gen. et spp. undet. – cross-sections
- *Isoteloides peri* Fortey, 1979 (Plate 2B)
- *Isoteloides peri* Fortey, 1979? – large, flat cross-section
- *Jeffersonia angustimarginata* Boyce, 1989
- *Jeffersonia angustimarginata* Boyce, 1989? – pygidium (-)
- *Peltabellia crassimarginata* (Cullison, 1944) (Plate 2D)
- *Peltabellia crassimarginata* (Cullison, 1944)? – librigena (+), pygidial axis, smooth convex fragments
- ?*Peltabellia* sp. undet. – possible pygidium (+)
- *Petigurus nero* (Billings, 1865)

Brachiopoda–Articulata
- *Tritoechia* sp. undet.
- ?*Tritoechia* sp. undet.

Brachiopoda–Inarticulata
- Gen. et sp. undet.
- *Lingulella* sp. undet.
- ?*Schizambon* sp. undet.

Echinodermata–Crinoidea
- Gen. et spp. undet. – fragmentary debris, stem (Plate 2A)

Mollusca–Cephalopoda
- *Cassinoceras wortheni* (Billings, 1865)
- endoceroid gen. et sp. undet. – small, straight form
- Gen. et spp. undet. – straight and curved forms
- *Protocycloceras lamarcki* (Billings, 1859)? – siphuncle
- *Pycnoceras apertum* Hyatt, 1894 – coiled form (Plate 1F)
- *Tarphyceras prematurum* Hyatt, 1894 – coiled form (Plate 1A)

Mollusca–Gastropoda
- *Ceratopea* sp. cf. *C. capuliformis* Oder, 1932 (Plate 1C)
- *Hormotoma* or *Murchisonia* sp. undet.
- *Lecanospira* or *Ophileta* sp. undet. – cross-sections
- *Lytospira* sp. undet. (Plate 1D)
- *Maclurites* sp. undet.
- ?*Maclurites* sp. undet. – tiny shell
- *Maclurites* or *Rhombella* sp.undet. – cross-sections
- macluritid gen. et spp. undet.
- *Malayaspira affinis* (Billings, 1865)
- *Ophileta* sp. undet.
- ?*Ophileta* sp. undet.
- *Pleurotomaria normani* Billings, 1865 (Plate 1B)
- ?*Subulites* sp. undet. (Plate 1E)

Trace Fossils
- Gen. et spp. undet.
- Horizontal branching burrow

Rohr *et al.* (2000, page 246) report *Ceratopea* sp. cf. *C. capuliformis* Oder, 1932 from the Barbace Cove Member at Hunters Point near Eddies Cove West, where it occurs in bioturbated packstone and wackestone below mudcracked and laminated, lime mudstone within the *Strigigenalis brevicaudata* Zone.

The lowest trilobite horizon is 2009F033, which contains *Peltabellia crassimarginata* (Cullison, 1944), ? *Jeffersonia angustimarginata* Boyce,1989? and ?*Peltabellia* sp.

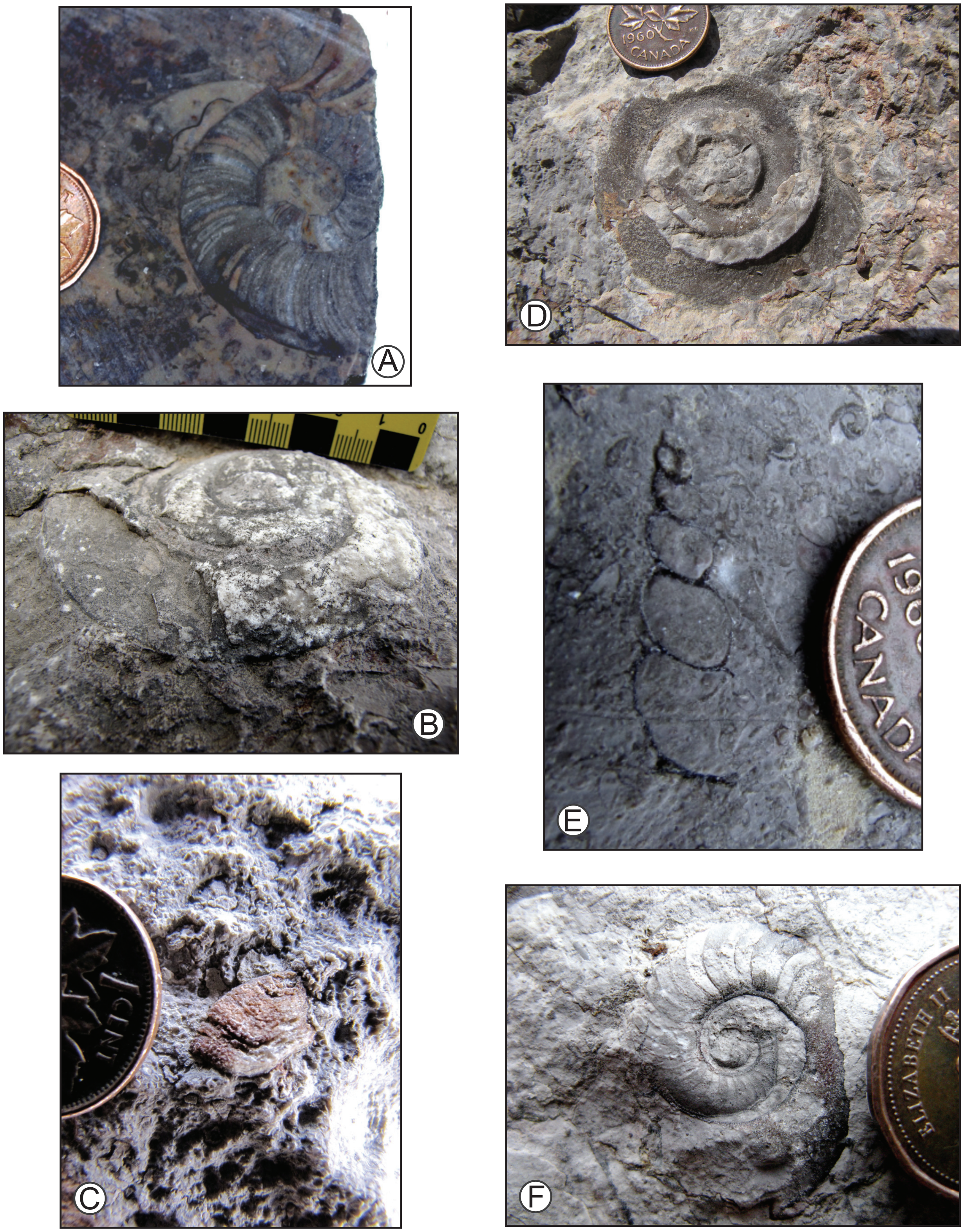

Plate 1. *Fossils from the Boat Harbour Formation (Barbace Cove Member). A) Coiled nautiloid* Tarphyceras prematurum *Hyatt, 1894 from 1988SAF014 = Z2-070B (NFM F-773). One-cent coin (18 mm in diameter) for scale. B) Gastropod* Pleurotomaria normani *Billings, 1865 from 2009F009. Scale in cm. C) Gastropod operculum* Ceratopea *sp. cf.* C. capuliformis *Oder, 1932 from 2009F003 (NFM F-774). One-cent coin (18 mm in diameter) for scale. D) Loosely coiled planispiral gastropod shell* Lytospira *sp.undet. from 2009F003 (mold in outcrop of NFM F-775). One-cent coin (18 mm in diameter) for scale. E) High spired gastropod shell* Subulites *from 2009F003A. One-cent coin (18 mm in diameter) for scale. F) Coiled nautiloid* Pycnoceras apertum *Hyatt, 1894 from 2009F032 = Z2-075 (NFM F-776). One-cent coin (18 mm in diameter) for scale.*

Plate 2. *Fossils from the Boat Harbour Formation (Barbace Cove Member) and the Catoche Formation. A) Crinoid stem in loose block from 2009F037 (Z2-077). Scale in cm. B) Trilobite* Isoteloides peri *Fortey, 1979 from 2009F9037 (Z2-077). Dorsal view of hypostome (NFM F-777). One-cent coin (18 mm in diameter) for scale. C) Trilobite* Petigurus nero *(Billings, 1865) from 2009F072. Dorsal view of cranidium (NFM F-778). One-cent coin (18 mm in diameter) for scale. D) Trilobite* Peltabellia crassimarginata *(Cullison, 1944) from 2009F031. Dorsal view of pygidium (NFM F-779). One-cent coin (18 mm in diameter) for scale. E) Trilobite* Bathyurellus abruptus *Billings, 1865 from 2009F031. Dorsal view of incomplete cranidium (NFM F-780). One-cent coin (18 mm in diameter) for scale. F) Trilobite* Bathyurellus abruptus *Billings, 1865 from 2009F031. Ventral view of pygidium (NFM F-781). One-cent coin (18 mm in diameter) for scale.*

undet. occur in 2009F032 = Z2-075. Between Z2-075 and Z2-084 of Ji and Barnes (1994a) (*i.e.*, above the shale interval), the Barbace Cove Member yielded *Bathyurellus abruptus* Billings, 1865 (Plate 2E, F), *Bolbocephalus convexus* (Billings, 1865), *Isoteloides peri* Fortey, 1979 (Plate 2B), *Jeffersonia angustimarginata* Boyce,1989, *Peltabellia crassimarginata* (Cullison, 1944) (Plate 2D) and *Petigurus nero* (Billings, 1865), collectively indicative of a Late Canadian (latest Jeffersonian) *Strigigenalis brevicaudata* Trilobite Zone age. Except for *Peltabellia crassimarginata* (Cullison, 1944), these species range into the overlying basal Catoche Formation. *Acodus delicatus* Branson and Mehl, 1933 is replaced by *Acodus comptus* (Branson and Mehl, 1933) at this interval, where it is also joined by *Glyptoconus multiplicatus* Ji and Barnes, 1994a.

Bathyurellus abruptus Billings, 1865 (Plate 2E, F), *Benthamaspis*? sp. undet., *Bolbocephalus convexus* (Billings, 1865) and *Jeffersonia angustimarginata* Boyce, 1989 were recovered from lime mudstone–wackestone near the top of the *Strigigenalis brevicaudata* Trilobite Zone in the Barbace Cove Member. These species are absent from the associated interbedded lime packstone–grainstone, suggesting biofacies control.

Correlation of the Barbace Cove Member

Peltabellia crassimarginata (Cullison, 1944) also occurs in northeast Greenland (W.D. Boyce, unpublished data, 2009) in the lower part of the Cape Weber Formation as defined by Cowie and Adams (1957), in the Cotter Formation (Blackjack Knob Member) of Missouri (Cullison, 1944; Boyce, 1989), and in the *Bolbocephalus stitti* and basal *Strigigenalis caudata* zones of the middle Kindblade Formation of Oklahoma, where it is accompanied by *Isoteloides peri* Fortey, 1979 (Loch, 2007).

Catoche Formation

The Catoche Formation at Isthmus Bay collectively yielded the following:

Arthropoda–Ostracoda
- Gen. et sp. undet.
- *Isochilina* sp. undet.

Arthropoda–Trilobita
- *Bathyurellus abruptus* Billings, 1865
- *Bathyurellus* sp. undet.
- *bathyurid* gen. et sp. undet.
- *Benthamaspis conica* Fortey, 1979
- *Benthamaspis gibberula* (Billings, 1865) (Plate 4A)
- *Benthamaspis* sp. undet.
- *Bolbocephalus convexus* (Billings, 1865)
- *Catochia* or *Jeffersonia* sp. undet.
- *Catochia ornata* Fortey, 1979
- *Illaenus* sp. nov. – pygidium
- *Ischyrotoma anataphra* Fortey, 1979 (Plate 4A)
- *Ischyrotoma* sp. undet.
- *Isoteloides peri* Fortey, 1979
- *Isoteloides* sp. undet.
- *Jeffersonia angustimarginata* Boyce, 1989
- *Jeffersonia* sp. undet.
- *Petigurus nero* (Billings, 1865) (Plate 2C)
- *Punka flabelliformis* Fortey, 1979
- *Punka* sp. nov. (Plate 3A, B)
- ?*Punka* sp. undet.
- *Strigigenalis caudata* (Billings, 1865) (Plate 3C)
- *Uromystrum affine* (Poulsen, 1937) (Plate 3D)
- *Uromystrum marginiatus* (Billings, 1865) (Plate 3E, F)

Brachiopoda–Articulata
- orthid gen. et spp. undet.
- ?*Tritoechia* sp. undet.

Brachiopoda–Inarticulata
- Gen. et sp. undet.

Echinodermata–Crinoidea
- Gen. et sp(p). undet.

Mollusca–Cephalopoda
- Gen. et spp. undet. – coiled and straight forms
- *Protocycloceras lamarcki* (Billings, 1859)

Mollusca–Gastropoda
- Gen. et spp. undet. – high spired & planispiral forms
- *Hormotoma* or *Murchisonia* sp. undet.
- *Maclurites* sp. undet.
- macluritid gen. et spp. undet.
- *Malayaspira affinis* (Billings, 1865)

Porifera
- *Calathium anstedi* Billings, 1865?
- Gen. et sp. undet.

Trace Fossils
- *Arenicolites*
- *Chondrites*
- *Paleophycus*
- *Planolites*
- *Skolithos*
- *Thalassinoides*

A distinctive new species of Punka (Plate 3A, B), accompanied by *Ischyrotoma* sp., *Isoteloides peri* Fortey, 1979 and *Petigurus nero* (Billings, 1865) was found 4.84–5.17 m above the base of the Catoche Formation (0.84–1.17 m above Z2-086; sample 09F11). The bases of the *Strigigenalis caudata* and *Benthamaspis gibberula* trilobite zones are documented for the first time in the section. The FAD (First Appearance Datum) of the *Strigigenalis caudata* Trilobite Zone is 5.5 m above the base of the formation (1.5 m above Z2-086; in 2009F050/2009F050Float). Above this level, *Bathyurellus abruptus* Billings, 1865, *Benthamaspis conica* Fortey, 1979, *Bolbocephalus convexus*

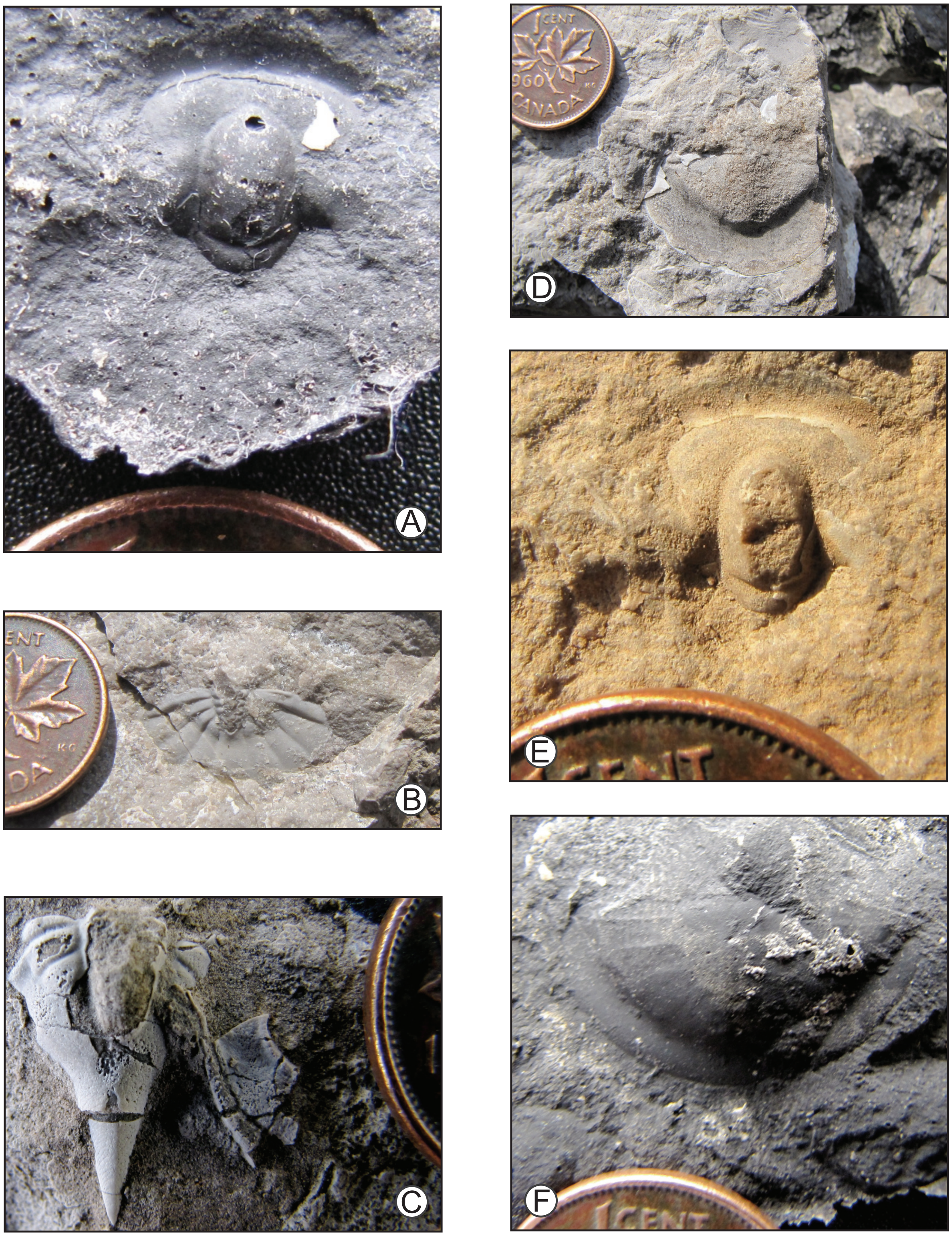

Plate 3. *Fossils from the Catoche Formation. A) Trilobite* Punka *sp.nov from 2009F061. Dorsal view of cranidium (NFM F-782). One-cent coin (18 mm in diameter) for scale. B) Trilobite* Punka *sp.nov from 2009F061. Dorsal view of pygidium (NFM F-783). One-cent coin (18 mm in diameter) for scale. C) Trilobite* Strigigenalis caudata *(Billings, 1865) from 2009F051. Dorsal view of broken pygidium (NFM F-771) and librigena (NFM F-772). One-cent coin (18 mm in diameter) for scale. D) Trilobite* Uromystrum affine *(Poulsen, 1937) from 2009F067 (Z2-089). Dorsal view of pygidium (NFM F-784). One-cent coin (18 mm in diameter) for scale. E) Trilobite* Uromystrum marginiatus *(Billings, 1865) from 2009F066. Dorsal view of cranidium (NFM F-785). One-cent coin (18 mm in diameter) for scale. F) Trilobite* Uromystrum marginiatus *(Billings, 1865) from 2009F066. Dorsal view of pygidium (NFM F-786). One-cent coin (18 mm in diameter) for scale.*

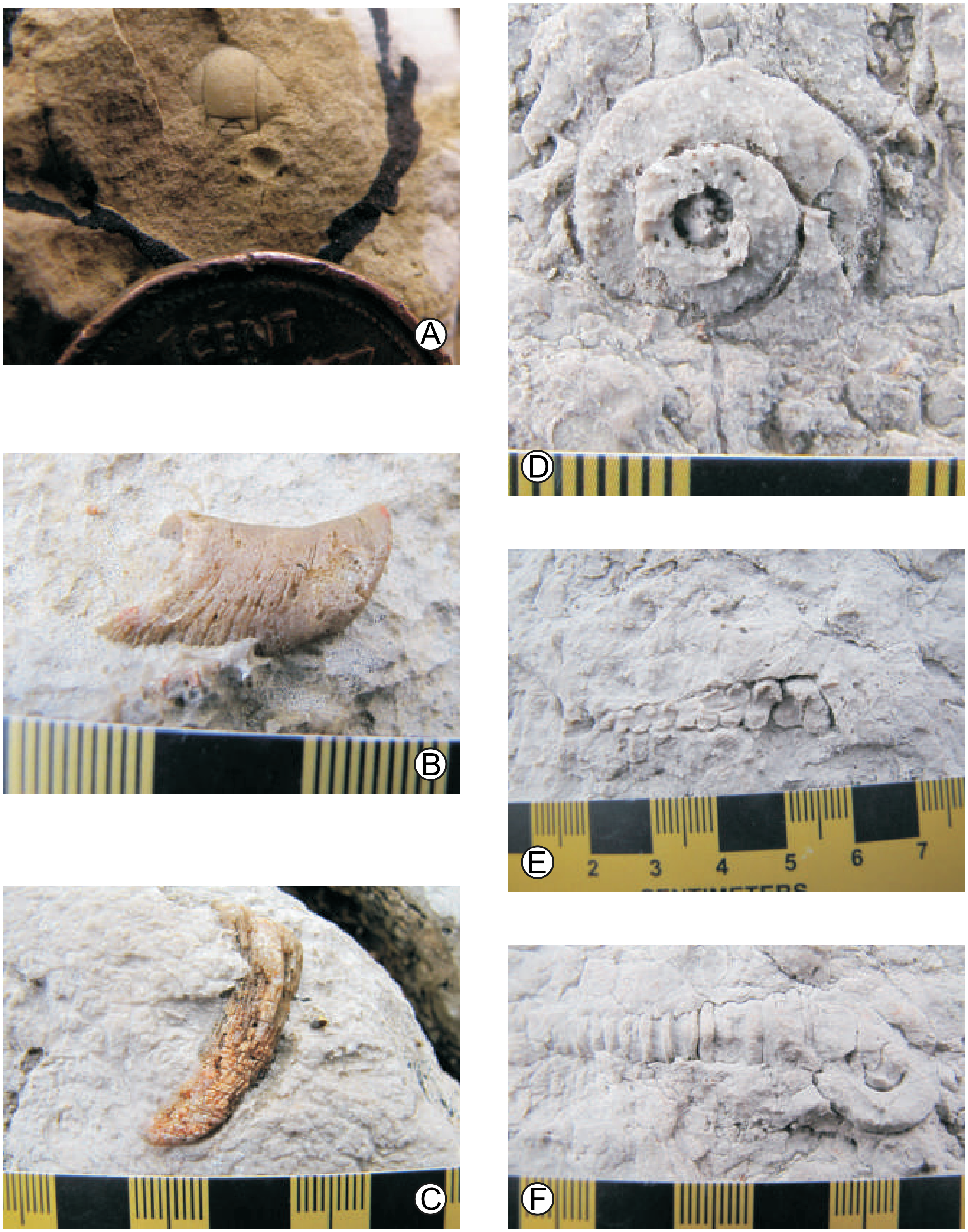

Plate 4. *Fossils from the Catoche and Aquathuna formations. A) Trilobites from 2009F075A. Dorsal view of "large"* Benthamaspis gibberula *(Billings, 1865) cranidium (NFM F-787) and tiny mold of* Ischyrotoma anataphra *Fortey, 1979 cranidium (NFM F-788). One-cent coin (18 mm in diameter) for scale. B) Gastropod operculum* Ceratopea unguis *Yochelson and Bridge, 1957 from 2009F084A (loose block). Scale in cm. C) Gastropod operculum* Teiichispira odenvillensis *(Butts,1926) from 2009F085. Scale in cm. D) Badly weathered gastropod shell* Ceratopea unguis *Yochelson and Bridge, 1957 from 2009F085. Scale in cm. E) High spired gastropod shell from 2009F085. Scale in cm. F) Straight nautiloid ?*Protocycloceras *sp. undet. from 2009F085. Scale in cm.*

(Billings, 1865), *Catochia ornata* Fortey, 1979, *Ischyrotoma anataphra* Fortey, 1979, *Isoteloides peri* Fortey, 1979, *Jeffersonia angustimarginata* Boyce, 1989, *Petigurus nero* (Billings, 1865) (Plate 2C), *Punka flabelliformis* Fortey, 1979, *Strigigenalis caudata* (Billings, 1865) (Plate 3C), *Uromystrum affine* (Poulsen, 1937) (Plate 3D) and *Uromystrum marginiatus* (Billings, 1865) (Plate 3E, F) occur in a variety of associations.

Sullivan (1940, page 24), (*see* also Johnson 1949, page 30; Riley, 1962, page 65 and Corkin, 1965, page 51) collected several molluscs from a bed of very thin-bedded, shaly medium-grey limestone, designated Bed 36, which was reported to occur at the west end of the southernmost bar of The Gravels. This bed that likely occurs in the *Strigigenalis caudata* zone was reported to contain the cephalopod *Protocycloceras lamarcki* (Billings, 1859) and the gastropods *Maclurites oceanus* (Billings, 1865) and *Pleurotomaria normani* Billings, 1865. Most likely, this is equivalent to Boyce locality 2009F066. Rubble from mound-capping and mound-flanking beds yielded:

Arthropoda–Ostracoda
- *Isochilina* sp. undet.

Arthropoda–Trilobita
- *Benthamaspis conica* Fortey, 1979
- *Bolbocephalus convexus* (Billings, 1865)
- *Illaenus* sp. nov. – pygidium
- *Ischyrotoma anataphra* Fortey, 1979
- *Isoteloides peri* Fortey, 1979
- *Jeffersonia angustimarginata* Boyce, 1989
- *Petigurus nero* (Billings, 1865)
- *Uromystrum affine* (Poulsen, 1937) – at the bottom of interval only (Plate 3D)
- *Uromystrum marginiatus* (Billings, 1865) – at the top of interval only (Plate 3E, F)

Brachiopoda–Articulata
- ?*Tritoechia* sp. undet.

Mollusca–Cephalopoda
- Gen. et spp. undet. – coiled and straight forms

Mollusca–Gastropoda
- *Malayaspira affinis* (Billings, 1865)

Another fossil collection from fossiliferous grey limestone reported by Sullivan (1940, page 23; *see* also Johnson, 1949, pages 9-10, Riley, 1962, page 65 and Corkin, 1965, page 51) from scattered outcrops of alternating hackly weathering buff dolomite and massive grey limestone, within a reportedly 205.4-m-thick covered interval between the north and south bars of The Gravels, included the following taxa:

Brachiopoda–Articulata
- *Billingsella* sp.

Mollusca–Cephalopoda
- *Orthoceras explorator* (Billings, 1865)

Mollusca–Gastropoda
- *Euconia etna* (Billings, 1865)
- *Maclurites rotundatus* (Billings, 1865)
- *Straparollina pelagica* Billings, 1865
- *Turritoma acrea* (Billings, 1865)

Mollusca–Rostroconcha
- *Euchasma blumenbachi* (Billings, 1859)

The FAD of the *Benthamaspis gibberula* Trilobite Zone occurs 66 m above the base of the formation and approximately 3.5 m below the top of Z2-100 (fossil collection 2009F075A). *Benthamaspis gibberula* (Billings, 1865) and *Ischyrotoma anataphra* Fortey, 1979 occur together (Plate 4A, B) in the extensively bioturbated lime mudstone–wackestone; no trilobites were found above Z2-101 in beds of the middle boundstone dolostone, an interval essentially also devoid of conodonts (Ji and Barnes, 1994a).

Biostratigraphic problems exist within this portion of the West Isthmus Bay section. This is largely because of the undocumented or understated covered intervals (*see* Plate 5) in the 200-m-thick interval from Z2-090 to Z-119 omitted by Ji and Barnes (1994a) and Zhang and Barnes (2004b) and because of the dolomitization of the middle boundstone interval. Furthermore, between Z2-110 to Z2-116, Ji and Barnes (1994a, page 76) report a “middle fenestral limestone rich in trilobites, brachiopods and gastropods” , clearly limestones of the Costa Bay Member. However, these horizons that occur in a poorly exposed roadside ditch section, show no trace of any macrofossils.

Graptolites indicated in the West Isthmus Bay section by Zhang and Barnes (2004b, page 850, Figure 4) are projected there from studies of sections elsewhere (Williams *et al.*, 1987, 2000). In the Eddies Cove West–Port au Choix area, *Tetragraptus approximatus* Zone and *Tetragraptus akzarensis* Zone graptolite faunas are present. The former occurs in the lower part of the formation within the *Strigigenalis caudata* Zone; the latter occurs higher, in the *Benthamaspis gibberula* Zone, and ranges into the Laignet Point member (Williams *et al.*, 1987). On the western side of the Port au Port Peninsula, *Didymograptellus bifidus* Zone graptolites are present near the top of the Costa Bay Member associated with trilobites of Ross-Hintze Zone J (Boyce *et al.*, 2000; Williams *et al.*, 2000). In the Table Point Ecological Reserve, *Pendeograptus fruticosus* Zone graptolites occur at the base of the Aguathuna Formation (Williams *et al.*, 1987, 2000). Graptolites have not been found in the West Isthmus Bay section, and we consider these projections to be questionable and to have distorted the understanding of the biostratigraphy of the Floian upper St. George Group.

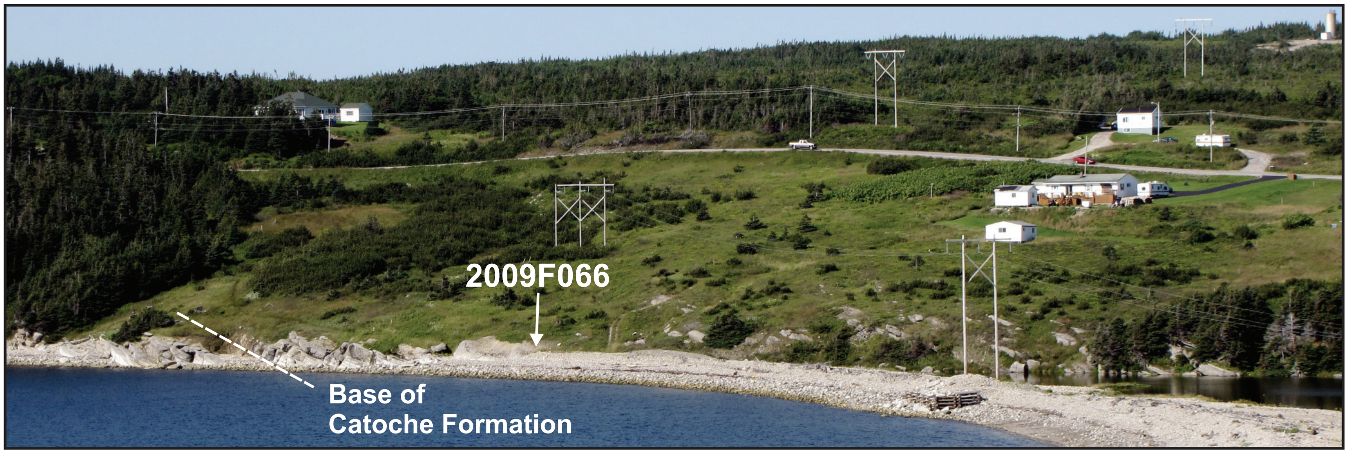

Plate 5. *Poorly exposed limestone strata of the lower Catoche Formation, showing fossil locality 2009F066.*

Correlation of the Catoche Formation

The diverse macrofauna of the Catoche Formation allows other sequences of the Appalachian–Caledonian margin of Laurentia to be correlated with it. In northwest Scotland for example, *Jeffersonia angustimarginata* Boyce, 1989[5] and *Petigurus nero* (Billings, 1865) are known from the Croisaphuill Formation, Durness Group (Boyce, 1989; Fortey, 1992). Farther afield in northern Spitsbergen, *Bathyurellus abruptus* Billings, 1865, *Petigurus nero* (Billings, 1865) and *Punka flabelliformis* Fortey, 1979 are present in the Nordporten Member of the Kirtonryggen Formation (Fortey and Bruton, 1973; Boyce, 1989). In Greenland, *Bathyurellus abruptus* Billings, 1865, *Benthamaspis conica* Fortey, 1979, *Bolbocephalus convexus* (Billings, 1865), *Ischyrotoma anataphra* Fortey, 1979, *Petigurus nero* (Billings, 1865) and *Punka flabelliformis* Fortey, 1979 occur in the Wandel Valley Formation of eastern North Greenland (Fortey (1986) and *Bolbocephalus convexus* (Billings, 1865), *Jeffersonia angustimarginata* Boyce, 1989 and *Uromystrum affine* (Poulsen, 1937) are known from the Cape Weber Formation of northeast Greenland (Poulsen, 1937; Boyce, 1989). The molluscs *Protocycloceras lamarcki* (Billings, 1859) and *Euchasma blumenbachi* (Billings, 1859), widespread in the Catoche Formation, are both found in the Cape Weber Formation of northeast Greenland (W.D. Boyce, unpublished data, 2009). *Jeffersonia angustimarginata* Boyce, 1989 and *Benthamaspis gibberula* Billings, 1865) also occur in the Canyon Elv Formation of Ellesmere Island (Poulsen, 1946; Boyce, 1989).

Closer to Newfoundland, in Québec and the US Appalachians, coeval rocks of the Romaine Formation of the Mingan Islands, Québec contain *Bolbocephalus convexus* (Billings, 1865) and *Strigigenalis caudata* (Billings, 1865) (GSC localities 95953 and 96722 respectively; Desbiens *et al.*, 1996). The molluscs *Protocycloceras lamarcki* (Billings, 1859) and *Euchasma blumenbachi* (Billings, 1859) were originally described from the Romaine Formation (Billings, 1859, 1865; Twenhofel, 1938). In western Newfoundland, *Euchasma blumenbachi* (Billings, 1859) ranges from the *Strigigenalis brevicaudata* to the *Benthamaspis gibberula* zones. It also occurs in Early Ordovician rocks in Virginia, as well as central and western Texas (Rohr *et al.*, 2008, page 82). A limited macrofauna from the lower beds of the Ogdensburg Member (Beauharnois Formation) of Grande-Île, St Lawrence Lowlands, Québec is similar to that in the Catoche Formation (Desbiens *et al.,* 1996). It includes the trilobites *Bolbocephalus convexus* (Billings, 1865), *Isoteloides peri* Fortey, 1979 and *Strigigenalis caudata* (Billings, 1865) and the gastropod *Malayaspira affinis* (Billings, 1865)

In the US Appalachians, *Isoteloides peri* Fortey, 1979 and *Protocycloceras lamarcki* (Billings, 1859) are known from the Fort Cassin Formation of the Champlain Valley (Brett and Westrop, 1996; Kröger and Landing, 2009). *Isoteloides peri* Fortey, 1979, *Jeffersonia angustimarginata* Boyce, 1989 and *Strigigenalis caudata* (Billings, 1865) plus the gastropod *Malayaspira affinis* (Billings, 1865) are also identified in the Axeman Formation of central Pennsylvania (Lees, 1967; Boyce, 1989). Farther south in Oklahoma and Missouri–northern Arkansas, *Strigigenalis caudata* (Billings, 1865) of the *Strigigenalis caudata* Zone occurs in the Kindblade Formation (Loch, 2007) and the Cotter Formation (Boyce, 1989), respectively.

[5] *Jeffersonia timon* (Billings, 1865) of Fortey (1992, pages 116-118; Figure 1d).

It is noteworthy that none of the above macrotaxa, with the possible exception of *Benthamaspis gibberula* (Billings, 1865) – *see* Fortey (1979) and Boyce (1989) – occur in the Ibexian type area of Ibex, Utah; the only successful correlations of Appalachian–Caledonian Floian carbonates with this area are based on conodonts.

Aguathuna Formation

Peritidal limestones of the Aguathuna Formation in the East Bay section, north of the isthmus, are abundant and unexpectedly have proved to be richly and diversely fossiliferous yielding trilobites, brachiopods, high- and low-spired gastropods, ostracodes, cephalopods, crinoids, sponges and possible bryozoa. Yochelson (1992) and Rohr *et al.* (2000) previously documented *Ceratopea unguis* Yochelson and Bridge, 1957 and *Teiichispira odenvillensis* (Butts, 1926).

The Aguathuna Formation north of the isthmus collectively yielded:

Arthropoda–Ostracoda
- Gen. et sp. undet.

Arthropoda–Trilobita
- ?*Bathyurus* sp. undet. (Plate 6B)
- Gen. et sp(p). undet.

Brachiopoda–Articulata
- Gen. et sp(p). undet. (Plate 6C-F)

Echinodermata–Crinoidea
- Gen. et sp. undet.

Mollusca–Cephalopoda
- Gen. et sp. undet. – coiled form (Plate 6A)
- ?*Protocycloceras* sp. undet. – straight form (Plate 4F)

Mollusca–Gastropoda
- Billings' second operculum – *see* Billings (1865, page 243; Figure 229)
- *Ceratopea unguis* Yochelson and Bridge, 1957 – opercula and shells (Plate 4B, D)
- Gen. et sp. undet. – high spired form (Plate 4E)
- macluritid gen. et sp(p). undet.
- *Teiichispira odenvillensis* (Butts, 1926) – fibrous opercula (Plate 4C)

Particularly common throughout the formation are silicified *Ceratopea unguis* Yochelson and Bridge, 1957, which is known to be common in many coeval sequences of Greenland and the Appalachians of the US (*see* below). This widespread geographical distribution suggests it has stratigraphic utility and that the term *Ceratopea unguis* Zone can be utilized.

Correlation of the Aguathuna Formation

Using *Ceratopea unguis* Yochelson and Bridge, 1957, the Aguathuna Formation can be correlated widely along the paleo-southern margin of Laurentia since its opercula is restricted to the latest Early Ordovician. It is known from the following areas (Rohr *et al.*, 2004, page 218):

1. North Greenland – Wandel Valley and Nunatami formations (Peel and Yochelson, 1979).
2. New York – Providence Island Dolomite, *Didymograptus protobifidus* Zone (Yochelson and Barnett, 1972).
3. Maryland – Rockdale Run Formation (Sando,1957).
4. Virginia – Rockdale Run Formation (Butts, 1940, 1941).
5. Missouri – Smithville Formation (Rohr *et al.*, 2004).
6. Arkansas – Smithville Formation (Yochelson and Wise, 1972); and
7. Oklahoma – West Spring Creek Formation (Yochelson, 1973).

In southern Laurentia, *Teiichispira odenvillensis* (Butts, 1926) also occurs in the Odenville Member of the Newala Formation of Alabama (Butts, 1926).

Along the paleo-northern margin of Laurentia, *Ceratopea unguis* Yochelson and Bridge, 1957 and *Teiichispira* aff. *T. odenvillensis* (Butts, 1926) are recorded from the Whiterockian Skoki Formation of British Columbia (Rohr *et al.*, 1995, 2004).

CONCLUSIONS

1. The Boat Harbour Disconformity that marks the base of the Barbace Cove Member and forms the basal sequence boundary to a Late Canadian (Ibexian) 3rd order megacycle in the upper St. George Group is re-evaluted and placed higher in the Boat Harbour Formation at Isthmus Bay. The sequence boundary in this section is interpreted to be a broad interval of karst-topped parasequences rather than a single surface as it is on the Great Northern Peninsula.
2. Newly documented trilobite faunas above the Boat Harbour Disconformity in the Barbace Cove Member, Boat Harbour Formation and the lower Catoche Formation belong to the *Strigigenalis brevicaudata*, *Strigigenalis caudata* and *Benthamaspis gibberula* zones. The *Strigigenalis brevicaudata*

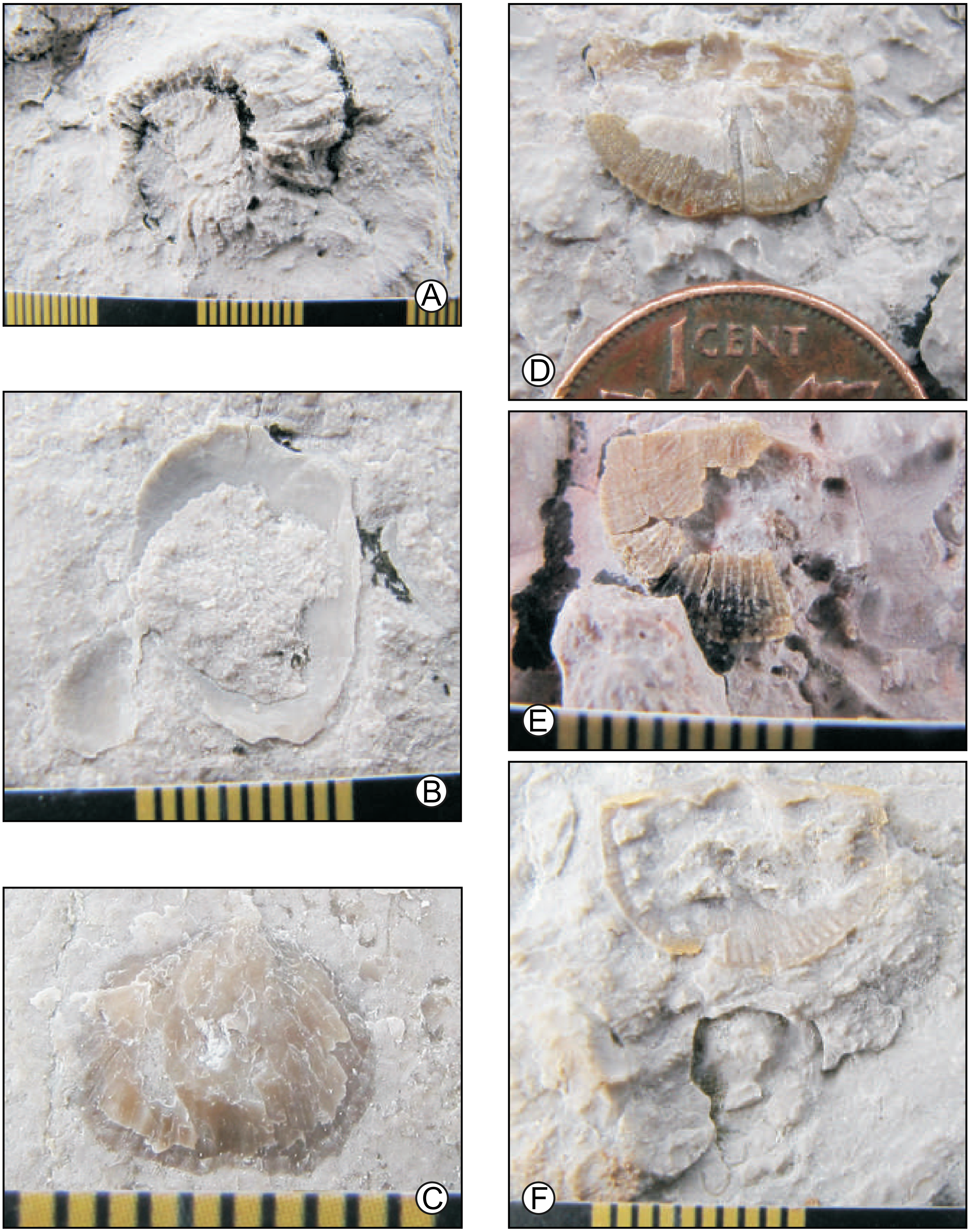

Plate 6. *Fossils from the Aguathuna Formation, all from 2009F085. A) Coiled nautiloid. Scale in cm. B) Trilobite ?*Bathyurus *sp. undet. Dorsal view of cranidium mold. Scale in cm. C) Articulate brachiopod. Scale in cm. D) Articulate brachiopod. One-cent coin (18 mm in diameter) for scale. E) Articulate brachiopod. Scale in cm. F) Articulate brachiopod. Scale in cm.*

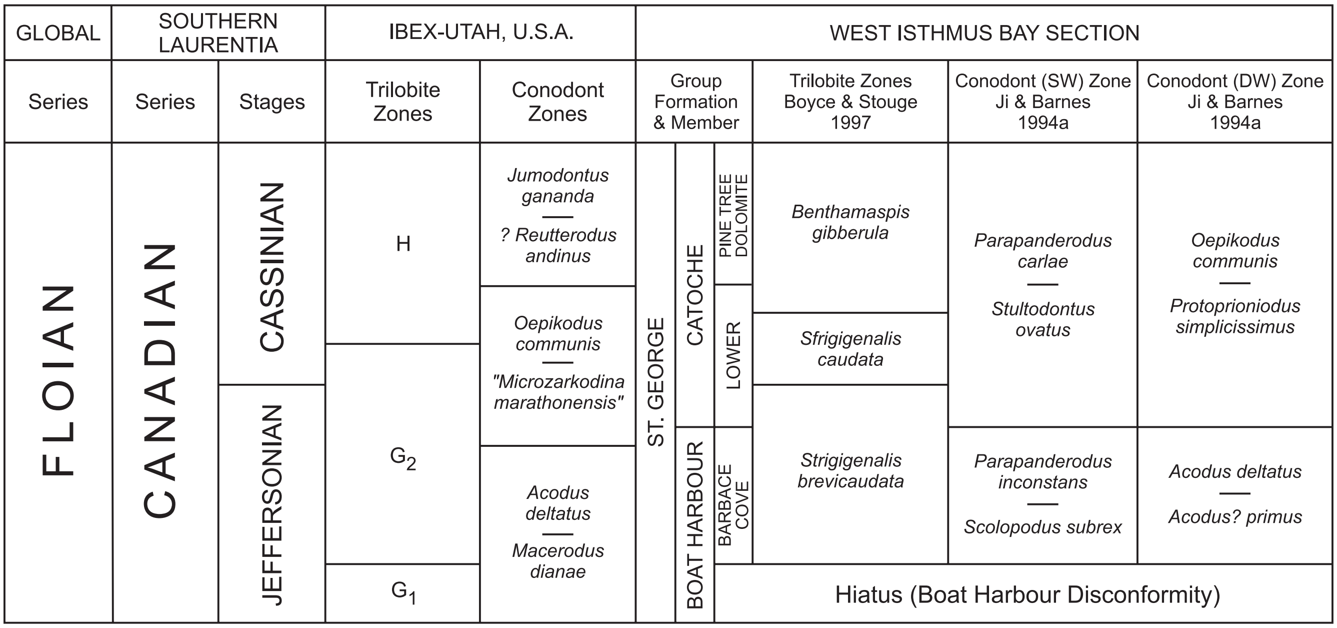

Figure 5. *Biostratigraphy of the St. George Group on the Port au Port Peninsula.*

zone spans from the disconformity to 5.12 m above the base of the Catoche Formation. The overlying *Strigigenalis caudata* zone continues to the base of the *Benthamaspis gibberula* Zone, which occurs 68 m above the base of the formation and only a few metres below the middle dolomitized boundstone interval of the Catoche Formation.

3. Both the middle dolomitized boundstone unit and the overlying Costa Bay Member are apparently unfossiliferous. This, plus numerous covered intervals in the upper part of the formation, cause significant biostratigraphic and regional correlation problems within the Catoche Formation in western Newfoundland.
4. The Aguathuna Formation has several, normal marine, fossil-rich limestones intercalated in the predominantly environmentally restricted peritidal dolostone succession.
5. New faunas are now being evaluated from the Aguathuna Formation.
6. The base of the Catoche Formation is placed at Z2-085B rather than Z2-081.
7. Z2-119 is part of the Aguathuna Formation, not the Catoche Formation.
8. The abundance and widespread distribution of *Ceratopea unguis* Yochelson and Bridge, 1957 suggest that a *Ceratopea unguis* Zone can be utilized for the latest Canadian (Ibexian) carbonates throughout southern Laurentia.

ACKNOWLEDGMENTS

Devon Seymour and Brian Sutton provided affable and competent field assistance. Devon Seymour discovered the first specimens of *Strigigenalis caudata* (Billings, 1865) in the West Isthmus Bay section. The specimens illustrated in this report are housed in the Natural History Annex of The Rooms Provincial Museum (NFM), St. John's; Mr. Randy Batten (Natural History Collections Manager) provided specimen numbers. Tony Paltanavage drafted the figures. Dr. W. Lawson Dickson critically reviewed the first draft of the manuscript.

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