Current Research (1997) Newfoundland Department of Mines and Energy, Geological Survey, Report 97-1, pages 183-200

TRILOBITE AND CONODONT BIOSTRATIGRAPHY OF THE ST. GEORGE GROUP, EDDIES COVE WEST AREA, WESTERN NEWFOUNDLAND

W.D. Boyce and S. Stouge[1]
Newfoundland Mapping Section

ABSTRACT

An emended and expanded trilobite zonation and a new conodont zonation are proposed for the Early Ordovician St. George Group in the Eddies Cove West area. These zonations are based on two sections through the uppermost Watts Bight Formation, the Boat Harbour Formation and the Catoche Formation. Each biozone (assemblage, interval, or lineage zone) is named for its most common or distinctive species. The base of each zone is defined by the first appearance datum (FAD) of this species; the top is defined by the base of the succeeding zone. These zones are considered reliable and characteristic references for the Canadian Series in the region.

Seven trilobite zones can be distinguished. These zones are based on 129 collections, representing 96 horizons. The zones, in descending order are:

Canadian Series
Cassinian Stage
Benthamaspis gibberula *Interval Zone*
Strigigenalis caudata *Lineage Zone*
Jeffersonian Stage
Strigigenalis brevicaudata *Lineage Zone*
Demingian Stage
Randaynia saundersi *Interval Zone*
Leiostegium proprium *Interval Zone*
Hystricurus oculilunatus *Interval Zone*
Gasconadian Stage
Parahystricurus *sp. I Assemblage Zone*

Conodont assemblage zones from the St. George Group have earlier been defined from the Port au Port region, whereas five informal faunas were established in the Boat Harbour and Port au Choix areas. Four conodont zones are defined in the Eddies Cove West area; these zones are based on an additional 49 samples, all of which are derived from trilobite-bearing horizons. The zones, in descending order are as follows:

Canadian Series
Cassinian Stage and upper Jeffersonian Stage
Oepikodus communis *Interval Zone*
Jeffersonian Stage
Drepanoistodus concavus *Interval Zone*
Demingian Stage
Macerodus dianae *Interval Zone*
Striatodontus prolificus *Interval Zone*

[1] Geological Survey of Denmark and Greenland, GEUS, Department of Stratigraphy, Thoravej 8, DK-2400 Copenhagen NV, Denmark

The lowermost fauna from the Watts Bight Formation has not been revised; it is correlated with the Polycostatus falsioneotensis–Rossodus tenuis *and* Rossodus manitouensis– Polycostatus sulcatus *Assemblage zones.*

The Parahystricurus sp. I *(trilobite) Zone correlates with the* Polycostatus falsioneotensis–Rossodus tenuis *and* Rossodus manitouensis–Polycostatus sulcatus *(conodont) zones. The* Hystricurus oculilunatus *(trilobite) and* Striatodontus prolificus *(conodont) zones correspond closely, and the* Leiostegium proprium *and* Randyania saundersi *(trilobite) zones correlate with the* Macerodus dianae *(conodont) Zone. The* Strigigenalis brevicaudata *(trilobite) Zone comprises all of the* Drepanoistodus concavus *(conodont) Zone; the succeeding* Strigigenalis caudata *and* Benthamaspis gibberula *(trilobite) zones are contained in the extensive* Oepikodus communis *(conodont) Zone. This use of two tightly constrained and precisely correlated zonations, is a powerful biostratigraphic tool.*

INTRODUCTION

In the summer of 1976, Dr. I. Knight began systematic field mapping of the western Newfoundland Cambrian–Ordovician carbonate platform sequence. He began with detailed lithostratigraphic studies of several poorly known but critical sections. Simultaneously, one of us, WDB, performed detailed biostratigraphic sampling of these sections. Although it was not a widespread practice in those days, conodont samples were collected routinely from as many macrofossil horizons as possible, particularly in the Ordovician part of the sequence. These conodont samples were processed at the Geological Survey laboratories in St. John's; the residues were then forwarded to SS for analysis.

It is well established that dating and correlation of Early Ordovician marine platform sediments in Newfoundland and, indeed, in all of North America are successfully done using trilobites and conodonts. Early attempts to compare the two fossil groups from the Early Ordovician St. George Group of western Newfoundland (Figure 1) were presented by Stouge and Boyce (1983) and again later by Williams *et al.* (1987) and Boyce (1989), but the precise ties between the two fossil groups have not as yet been established. This cooperative work integrates trilobite and conodont data for the first time and produces a close comparison of the two faunal groups. This was done by extracting conodonts from samples that were collected from trilobite-bearing horizons in several well documented localities in western Newfoundland (Knight, 1983, 1991; Knight and James, 1987, 1988).

The objective of this report is to outline the trilobite and conodont biostratigraphy of the Eddies Cove West area (Figure 2). Two sections were investigated. The first, Section 4 of Knight (1991, pages 107-115), starts east of Fish Point and continues westward through Old Man Cove to Hunters Point. The second, Section 8 of Knight (1991, pages 122-126), immediately and conformably overlies the first section, and extends westward from Hunters Point through Bustard Cove to Back Arm. The latter is the stratotype section of the Catoche Formation (Knight and James, 1987, 1988; Knight, 1991), which Woodard (1957) erroneously assigned to the Table Head Group.

The investigated sections are important as they represent practically the only complete sequence through the Boat Harbour and Early Catoche formations of the St. George Group in northwestern Newfoundland. The sampling has yielded many trilobites (Boyce, 1979, 1983a, b, 1985, 1986, 1989; Boyce *et al.*, 1988), and the often high yield of conodonts in many of the beds (Stouge, 1982) allows for a precise calibration of the two biostratigraphic schemes. About 200 samples were collected from the sections. Only the trilobites and conodonts that have been recovered from the upper Watts Bight, the Boat Harbour and the Early Catoche formations are examined.

STRATIGRAPHIC SETTING

The St. George Group of western Newfoundland overlies the Port au Port Group (James *et al.*, 1989) and is in turn conformably or disconformably overlain by the Table Head Group (Stenzel *et al.*, 1990; Stouge, 1984). It is divided into four formations, in ascending order, the Watts Bight Formation, the Boat Harbour Formation, the Catoche Formation and the Aguathuna Formation (Knight and James, 1987, 1988) (Figure 3).

The Watts Bight Formation consists of up to 89 m of cyclic subtidal and peritidal sequences characterized by large thrombolite mounds (Knight and James, 1987, 1988). The formation is mostly dolomitized in the type area at Watts Bight, along the St. Barbe coast (Figure 1). Only the uppermost 23.41 m are exposed in the immediate vicinity of Eddies Cove West (Knight, 1991, page 116).

The Boat Harbour Formation is characterized by cyclic shoaling-upward peritidal and subtidal sequences consisting of stromatolites, thrombolites and grainstones (Knight and James, 1987, 1988). The formation is between 120 and 156 m thick; in the Eddies Cove West area it is 104.44 m thick (Knight, 1991, page 107). The Boat Harbour Formation is divided into two members: the (informal) lower member and the (upper) Barbace Cove Member (Knight and James, 1988; Boyce, 1989).

The Catoche Formation consists of subtidal cyclic shallowing-upward sequences having an increasingly open-

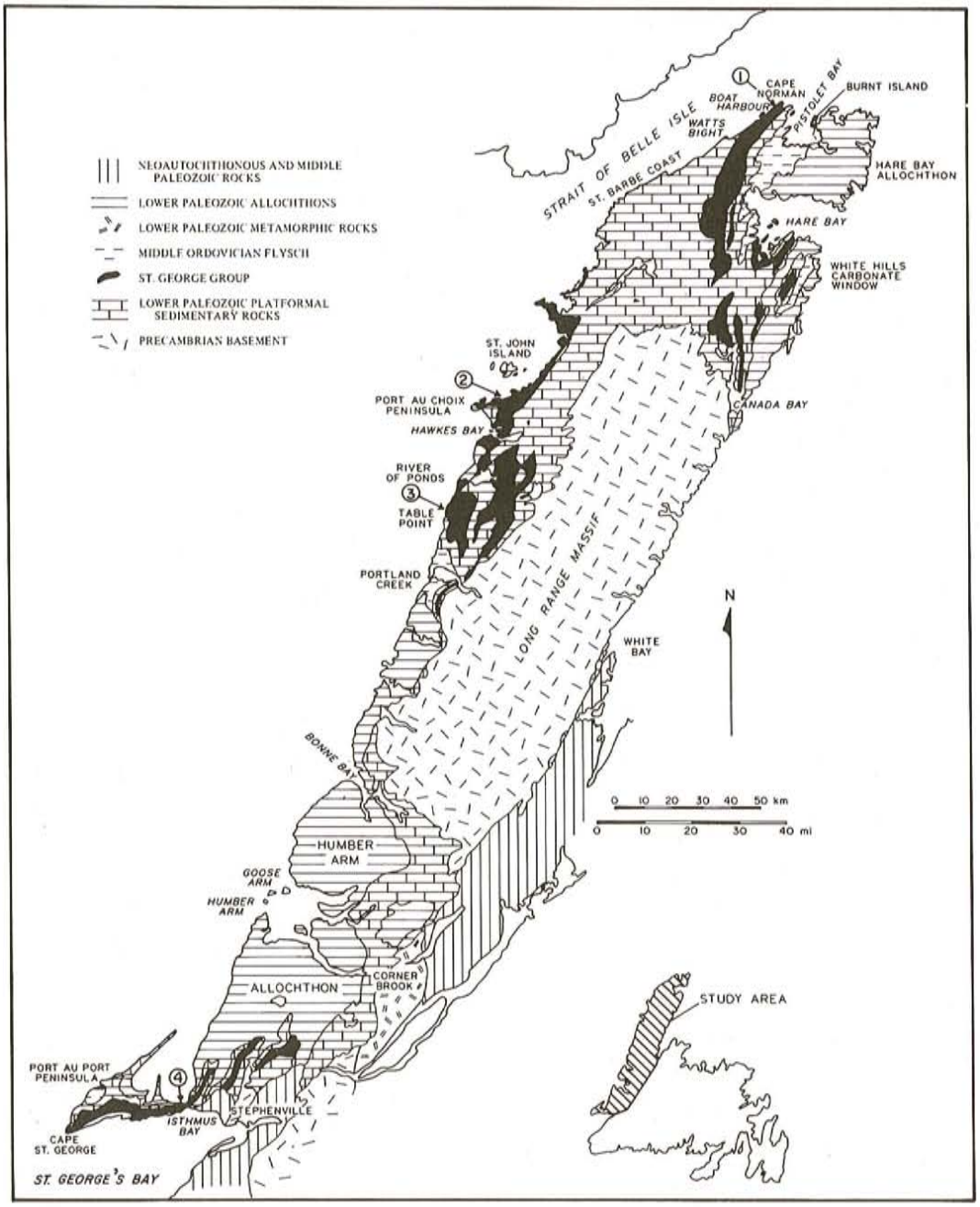


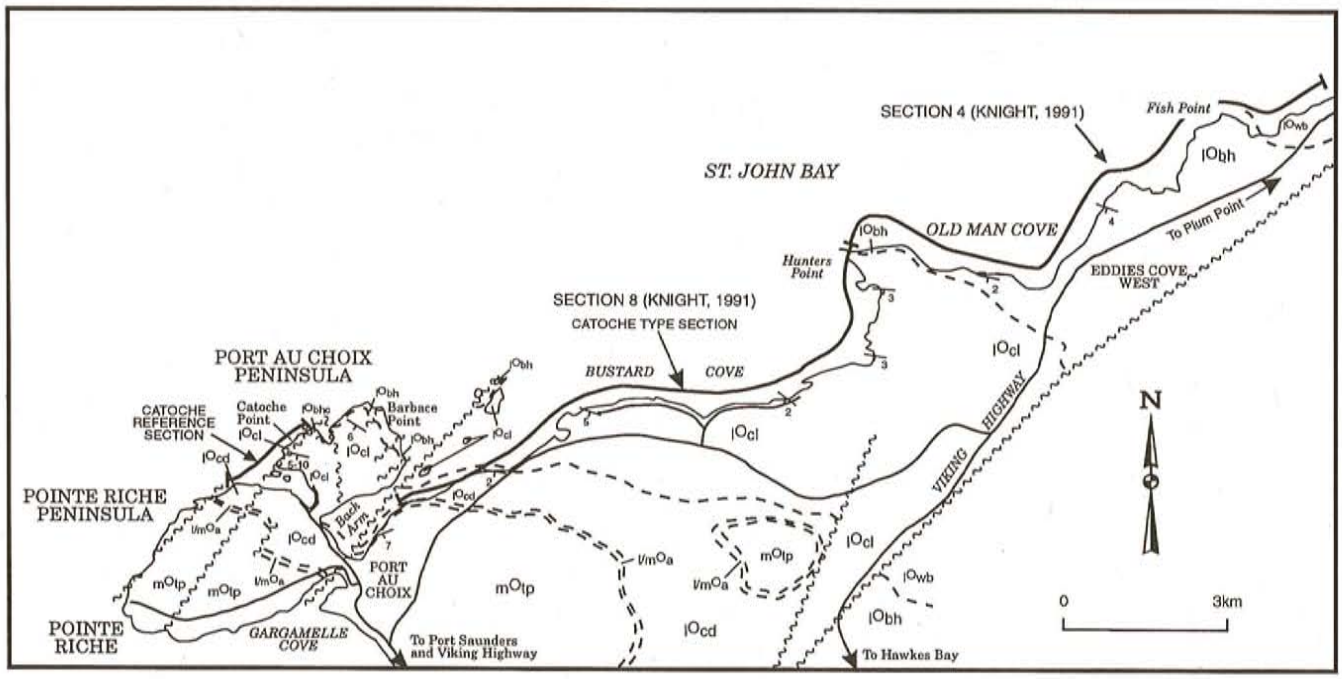
Figure 1. *Geological terranes and outcrop distribution of the St. George Group in western Newfoundland (from Knight and James, 1987, 1988). Number 2 indicates the location of the Eddies Cove West area.*

marine influence up through the section. The middle portion of the formation is characterized by subtidal argillaceous limestones, which earlier have been referred to the informal Laignet Point member (Knight, 1977a, b; Stouge, 1982). In the area around Port au Choix, the upper subtidal Catoche Formation is almost completely replaced by dolomites. The formation is 160.34 m thick in the Eddies Cove West area (Knight, 1991, page 122).

The Aguathuna Formation includes peritidal to supratidal deposits that are cyclic dolomites and mostly barren for fossils. The sediments include dolostone, limestone and shales having a total thickness of about 63 m; in the Eddies Cove West area, the Aguathuna Formation is only 5.07 m thick (Knight, 1991, page 130). Lamination and mudcracks are present throughout the unit. The sediments of the Aguathuna Formation were deposited in the late Canadian and into the early Whiterockian.

CHRONOSTRATIGRAPHIC NOMENCLATURE

The status of the Canadian Series of the Ordovician System is currently under debate. Hintze (*in* Ross *et al.*, 1982)



LEGEND

mOss	UNNAMED MIDDLE ORDOVICIAN SANDSTONE
	TABLE HEAD GROUP (MIDDLE ORDOVICIAN)
mObc	BLACK COVE FORMATION
mOtc	TABLE COVE FORMATION
mOtp	TABLE POINT FORMATION
	ST. GEORGE GROUP (LOWER-MIDDLE ORDOVICIAN)
l/mOa	AGUATHUNA FORMATION
lOc	CATOCHE FORMATION -d DOLOSTONE -l LIMESTONE
lObh	BOAT HARBOUR FORMATION
lOwb	WATTS BIGHT FORMATION
	CAMBRIAN
Epp	PORT AU PORT GROUP

SYMBOLS

- Stratigraphic boundary
- Fault
- Bedding, dip shown
- Road with direction shown to nearest community

Figure 2. *Detailed geology and location of sections in the Eddies Cove West area (modified from Knight and James, 1987, 1988). Section 4 of Knight (1991, pages 107–115) occurs immediately east of and conformably underlies Section 8 of Knight (1991, pages 122–126), which is indicated as the Catoche Type Section.*

proposed that the "Canadian Series" be replaced by the "Ibexian Series". Subsequently, Ross *et al.* (1993) abandoned the Canadian stages of Flower (1964, 1978) and proposed their own. The Ibexian Series is defined on the basis of successions situated in the western United States (*see* Ross *et al.*, 1982), but faunal differences between the east and the west North American regions exist; correlating the east North American faunas with the west North American faunal succession is not always possible or obvious (e.g., Brett and Westrop, 1996, pages 411-412; Loch, 1995; Williams *et al.*, 1987). The Canadian Series and its stages can, however, be applied with success for the Newfoundland successions (Boyce, 1989) and for lateral contemporaneous and similar Early Ordovician successions in eastern North America (e.g., Loch, 1995). Thus in this report the Canadian Series and its stages are applied as the chronostratigraphic reference for the Early Ordovician succession in western Newfoundland.

TRILOBITE BIOSTRATIGRAPHY

Billings (1865), Fortey (1979), Boyce (*in* Stouge and Boyce, 1983) and Boyce (1989) are responsible for the major contributions to the systematic knowledge of the trilobite faunas of the St. George Group. Raymond (1913, 1925),

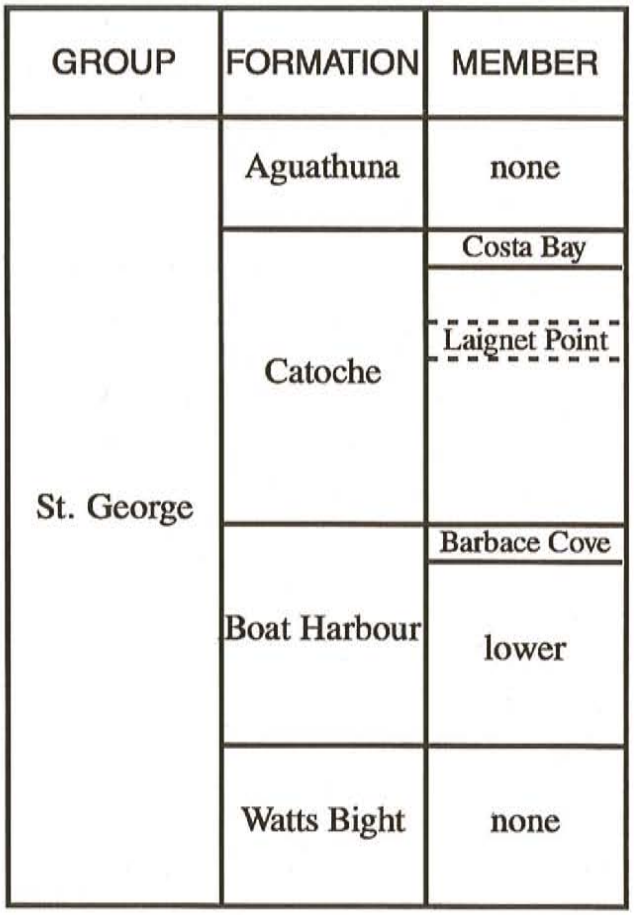


Figure 3. *Lithostratigraphic subdivisions of the St. George Group (Knight and James, 1987, 1988). The Laignet Point member is an informal unit (Knight, 1977a,b; Stouge, 1982).*

Whittington (1953) and Boyce *et al.* (1988) described and/or illustrated lesser components of the St. George faunas.

The trilobite faunas of the uppermost Watts Bight Formation and the lower member of the Boat Harbour Formation are low diversity, rich in individuals, dominated by hystricurids, and indicative of relatively restricted nearshore conditions.

In the Barbace Cove Member of the Boat Harbour Formation, and in the Catoche Formation, the composition of the faunas is substantially different. The faunas are higher in diversity, poorer in individuals, dominated instead by bathyurids, and indicative of less restricted, more open marine conditions.

Boyce (1989) proposed three Early Ordovician trilobite-based zones in the Boat Harbour and Catoche formations of the Boat Harbour–Cape Norman area (Figure 1; Table 1).

Table 1. Trilobite zones from the St. George Group (from Boyce, 1989)

Canadian Series	
Cassinian Stage	*Strigigenalis caudata* Zone
Jeffersonian Stage	*Strigigenalis brevicaudata* Zone
Demingian Stage	*Randaynia saundersi* Zone

At Eddies Cove West (Figure 2), the succession is far more complete. Boyce (1989) was not able to zone the lower 45 m of the Boat Harbour Formation at Boat Harbour, i.e., below the *Randaynia saundersi* Zone; however, this has proven possible at Eddies Cove West. Furthermore, the uppermost beds of the underlying Watts Bight Formation are also exposed in the Eddies Cove West area. In addition, most of the Catoche Formation and the entire Aguathuna Formation are developed here. Consequently, it has proven possible to emend the *Strigigenalis caudata* Zone of Boyce (1989), and introduce a new zone in the Catoche Formation. The two zones in the Catoche Formation include the lower (now restricted) *Strigigenalis caudata* Zone and the new and younger *Benthamaspis gibberula* Zone.

In total, seven trilobite zones can be distinguished in the Watts Bight, Boat Harbour and Catoche formations of the St. George Group (Table 2). These zones are based on 129 collections, representing 96 horizons. Each zone is defined according to the recommendations given in Salvador (1994) and the zones are specified as assemblage, interval or lineage zones. Each zone is named for its most common or distinctive species; the base of each zone is defined by the first appearance datum (FAD) of this species. The top of each zone is automatically defined by the base of the succeeding zone. Following Boyce (1989), in the zonal lists that follow, species that continue from underlying zones are indicated by "–"; those that continue into overlying zones are indicated by "+". The definition of each zone is outlined below.

Table 2. Canadian Trilobite Zonation of the St. George Group, western Newfoundland

Canadian Series	
Cassinian Stage	*Benthamaspis gibberula* Zone
	Strigigenalis caudata Zone
Jeffersonian Stage	*Strigigenalis brevicaudata* Zone
Demingian Stage	*Randaynia saundersi* Zone
	Leiostegium proprium Zone
	Hystricurus oculilunatus Zone
Gasconadian Stage	*Parahystricurus* sp. I Zone

Most of the taxa in these zones have been illustrated by Billings (1865), Raymond (1913, 1925), Whittington (1953), Fortey (1979), Stouge and Boyce (1983), Boyce *et al.* (1988) and Boyce (1989).

Parahystricurus sp. I Assemblage Zone

Reference Section. Section 4 of Knight (1991, pages 107-115) at Eddies Cove West, western Newfoundland, Canada. The base of the zone is 1.24 m above the base of Unit 9 of the Watts Bight Formation (Knight, 1991, page 114), i.e., 19.91 m above the base of Section 4 of Knight (1991) and 3.50 m below the base of the Boat Harbour Formation.

Definition. The *Parahystricurus* sp I Zone is characterized by *Parahystricurus* (= ?*Hystricurus*) sp. I (Ross, 1951).

Characterization. Parahystricurus (= ?*Hystricurus*) sp. I (Ross, 1951) is the only species recorded from the zone.

Assigned collections. ECW-001.

Age. Canadian Series; Gasconadian Stage.

Geographical extent. The *Parahystricurus* sp I Zone is also recognizable on South Brent Island in Hare Bay; the nominate taxon also occurs there at the top of the Watts Bight Formastion (Boyce, 1989, page 14).

Correlation outside Newfoundland. The *Parahystricurus* sp. I Zone probably correlates with Ross (1951)-Hintze (1953) Zone C, based on the common occurrence of *Parahystricurus* (= ?*Hystricurus*) sp. 1 (Ross, 1951).

Hystricurus oculilunatus Interval Zone

Reference Section. Section 4 of Knight (1991, pages 107-115) at Eddies Cove West, western Newfoundland, Canada. The base of the zone is the base of Unit 6 of the Boat Harbour Formation (Knight, 1991, page 114), i.e., 3.24 m above the base of the Boat Harbour Formation.

Definition. The *Hystricurus oculilunatus* Zone is is defined as the interval from the FAD of *Hystricurus oculilunatus* Ross, 1951 to the FAD of *Leiostegium proprium* Boyce, 1989.

Characterization. The *Hystricurus oculilunatus* Zone is characterized by the following species:

+*Hystricurus oculilunatus* Ross, 1951
+*Parahystricurus smithiae* Boyce, 1989

Assigned collections. ECW-002 to ECW-007.

Age. Canadian Series; Demingian Stage.

Geographical extent. The *Hystricurus oculilunatus* Zone is also recognizable on North Brent Island in Hare Bay.

Correlation outside Newfoundland. The *Hystricurus oculilunatus* Zone is correlated with Ross-Hintze Zone E, based on the occurrence of *Hystricurus oculilunatus* Ross, 1951.

Leiostegium proprium Interval Zone

Reference Section. Section 4 of Knight (1991, pages 107-115) at Eddies Cove West, western Newfoundland, Canada. The base of the zone is the base of Unit 20 of the Boat Harbour Formation (Knight, 1991, page 113), i.e., 17.53 m above the base of the Boat Harbour Formation.

Definition. The *Leiostegium proprium* Zone is defined as the interval from the FAD of *Leiostegium proprium* Boyce, 1989 to the FAD of *Randaynia saundersi* Boyce, 1989.

Characterization. The *Leiostegium proprium* Zone is characterized by the following species:

-, +*Hystricurus oculilunatus* Ross, 1951
-, +*Parahystricurus smithiae* Boyce, 1989
Leiostegium proprium Boyce, 1989
Tesselacauda sp. cf. *T. depressa* Ross, 1951
Hystricurus deflectus Heller, 1954
Paraplethopeltis seelyi (Whitfield, 1889)
+*Hillyardina levis* Boyce, 1989

Assigned collections. ECW-008 to ECW-016.

Age. Canadian Series; Demingian Stage.

Geographical extent. Species indicative of the *Leiostegium proprium* Zone also occur on North Brent Island in Hare Bay (Boyce, 1989, page 14). In 1988, I. Knight and S. Ash (of the provincial Geological Survey) collected *Tesselacauda* sp. cf. *T. depressa* Ross, 1951 from beds near the main wharf in Boat Harbour (Figure 1), below Boyce's (1989) section, indicating the presence of the *Leiostegium proprium* Zone at Boat Harbour.

Correlation outside Newfoundland. The *Leiostegium proprium* Zone is correlated with Ross-Hintze Zone E, based on the occurrence of:

Hystricurus oculilunatus Ross, 1951
Tesselacauda sp. cf. *T. depressa* Ross, 1951

Randaynia saundersi Interval Zone (Boyce, 1989), Emended

Reference Section. Boat Harbour composite Section (Boyce, 1989), western Newfoundland, Canada.

Definition. The *Randaynia saundersi* Zone is defined as the interval from the FAD of *Randaynia saundersi* Boyce, 1989 to the FAD of *Strigigenalis brevicaudata* Boyce, 1989.

Characterization. The *Randaynia saundersi* Zone (Boyce, 1989) is characterized by the following species:

-*Hystricurus oculilunatus* Ross, 1951
-*Parahystricurus smithiae* Boyce, 1989

-*Hillyardina levis* Boyce, 1989
Randaynia saundersi Boyce, 1989

None of the taxa of this zone range into the overlying *Strigigenalis brevicaudata* Zone.

Assigned collections. ECW-017 to ECW-024.

Age. Canadian Series; Demingian Stage.

Geographical extent. At Eddies Cove West, the base of the *Randaynia saundersi* Zone is 0.57 m above the base of Unit 61 of the Boat Harbour Formation (Knight, 1991, page 110), i.e., 45.83 m above the base of the Boat Harbour Formation. Boyce (1989, pages15, 17) also identified the zone on various islands in Brig Bay and St. John Bay and in the Hawkes Bay–River of Ponds Lake area.

Correlation outside Newfoundland. The *Randaynia saundersi* Zone is correlated with Ross-Hintze Zone E to Zone F, based on the occurrence of *Hystricurus oculilunatus* Ross, 1951 (*see* Boyce, 1989).

Remarks. The *Randaynia saundersi* Zone was formerly defined as a range zone by Boyce (1989), with the Boat Harbour composite section as reference section; the definition of the zone is changed to an interval zone.

Strigigenalis brevicaudata Lineage Zone (Boyce, 1989), Emended

Reference Section. Boat Harbour Composite Section (Boyce, 1989) at Boat Harbour, western Newfoundland, Canada.

Definition. The base of the zone is defined by the first appearance of *Strigigenalis brevicaudata* Boyce, 1989; the top is placed at the first evolutionary appearance of *Strigigenalis caudata* (Billings, 1865).

Characterization. The *Strigigenalis brevicaudata* Zone (Boyce, 1989) is characterized by the appearance of completely new species, when compared with the fauna from below. These new species are:

Bolbocephalus stevensi Boyce, 1989
Strigigenalis brevicaudata Boyce, 1989
+*Isoteloides peri* Fortey, 1979
+*Bolbocephalus convexus* (Billings, 1865)
+*Peltabellia crassimarginata* (Cullison, 1944)
Peltabellia willistoni Lochman, 1966
Ischyrotoma parallela Boyce, 1989
+*Jeffersonia angustimarginata* Boyce, 1989
+*Petigurus* sp. nov. A Boyce, 1989
+*Petigurus nero* (Billings, 1865)
Benthamaspis hintzei Boyce, 1989
Uromystrum affine (Poulsen, 1937)
Petigurus groenlandicus Poulsen, 1937
+*Catochia ornata* Fortey, 1979
Grinnellaspis newfoundlandensis Boyce, 1989
Grinnellaspis sp. nov.
+*Benthamaspis conica* Fortey, 1979
+*Ischyrotoma anataphra* Fortey, 1979

Assigned collections. ECW-025 to ECW-043.

Age. Canadian Series; (latest) Jeffersonian Stage (compare with Loch, 1995).

Geographical extent. In Section 4 at Eddies Cove West, the base of the *Strigigenalis brevicaudata* Zone is the base of Unit 108 of the Boat Harbour Formation (Knight, 1991, page 108), i.e., 95.16 m above the base of the Boat Harbour Formation.

Besides Boat Harbour and Eddies Cove West, this zone is also recognizable at Barbace Point, Port au Choix Peninsula.

Correlation outside Newfoundland. The *Strigigenalis brevicaudata* Zone correlates with Ross-Hintze Zone G_2, based on the common occurrence of the following (*see* Boyce, 1989):

Benthamaspis hintzei Boyce, 1989.
Petigurus sp. nov. A Boyce, 1989

Remarks. Boyce (1989) defined this zone as a range zone. Lineage zones have been considered as special type of range zones (Hedberg, 1976), but the recommendation in Salvador (1994), i.e., separating lineage zones from range zones is followed herein.

Strigigenalis caudata Lineage Zone (Boyce, 1989), Emended

Reference Section. Section 8 of Knight (1991, pages 122-125), Bustard Cove to Back Arm, western Newfoundland, Canada. The base of the zone is 2.03 m above the base of Unit 5a of the Catoche Formation (Knight, 1991, page 125), i.e., 18.75 m above the base of the Catoche Formation.

Definition. The base of the *Strigigenalis caudata* Zone is placed at the first evolutionary appearance of *Strigigenalis caudata* (Billings, 1865) from its immediate ancestor, *Strigigenalis brevicaudata* Boyce, 1989. The top is at the first appearance datum (FAD) of *Benthamaspis gibberula* (Billings, 1865).

Characterization. The newly restricted *Strigigenalis caudata* Zone is characterized by the following species:

-*Isoteloides peri* Fortey, 1979
-, +*Bolbocephalus convexus* (Billings, 1865)
-*Peltabellia crassimarginata* (Cullison, 1944)
-, +*Jeffersonia angustimarginata* Boyce, 1989

-, +*Petigurus* sp. nov. A Boyce, 1989
-, +*Petigurus nero* (Billings, 1865)
-*Catochia ornata* Fortey, 1979
-*Benthamaspis conica* Fortey, 1979
-, +*Ischyrotoma anataphra* Fortey, 1979
+*Strigigenalis caudata* (Billings, 1865)
+*Uromystrum* sp. cf. *U. affine* (Poulsen, 1937)
+ *Grinnellaspis flabelliformis* (Fortey, 1979)[2]
+*Bathyurellus abruptus* Billings, 1865
+*Bathyurellus platypus* Fortey, 1979
+*Strotactinus insularis* (Billings, 1865)
+*Jeffersonia timon* (Billings, 1865)
+*Jeffersonia* sp. undet.
+*Isoteloides canalis* (Whitfield, 1886)[3]

Assigned collections. ECW-044 to ECW-054.

Age. Canadian Series; Cassinian Stage (i.e., Boyce, 1989).

Geographical extent. This zone has been recognized on the basis of direct evidence at Barbace Point and Catoche Point on Port au Choix Peninsula and in the White Hills on the Port au Port Peninsula.

Correlation outside Newfoundland. The *Strigigenalis caudata* Zone partly correlates with Ross-Hintze Zone G_2, based on the common occurrence of the following (*see* Fortey, 1979; Boyce, 1989):

Petigurus sp. nov. A Boyce, 1989
Strotactinus insularis (Billings, 1865)

At Catoche Point, *Carolinites tasmaniensis* (Etheridge, 1919)[4] =*Carolinites genacinaca nevadensis* Hintze, 1953 of Fortey (1979, Figure 11) and Williams *et al.* (1987, Figure 2) occurs in the uppermost part of the zone, indicative of a Ross-Hintze Zone H age (Fortey, 1979; Williams *et al.*, 1987; Boyce, 1989).

Remarks. Boyce (1989, this report) considers the first appearance of *Strigigenalis caudata* (Billings, 1865), (i.e., the base of the *Strigigenalis caudata* Zone) as the base of the Cassinian Stage of the Canadian Series. This extremely widespread species occurs in western Newfoundland, Québec, Pennsylvania, Missouri–Arkansas and Oklahoma (Boyce, 1989; Loch, 1995; Desbiens *et al.*, 1996).

Benthamaspis gibberula Interval Zone

Reference Section. Section 8 of Knight (1991, pages 122-126). The base of the zone is 0.21 m above the base of Unit 8c of the Catoche Formation (Knight, 1991, page 124), i.e., 45.90 m above the base of the Catoche Formation.

Definition. The base of the *Benthamaspis gibberula* Zone is defined by the FAD of *Benthamaspis gibberula* (Billings, 1856).

Characterization. The *Benthamaspis gibberula* Zone is characterized by the following species:

-*Bolbocephalus convexus* (Billings, 1865)
-*Jeffersonia angustimarginata* Boyce, 1989
-*Petigurus* sp. nov. A Boyce, 1989
-*Petigurus nero* (Billings, 1865)
-*Ischyrotoma anataphra* Fortey, 1979
-*Strigigenalis caudata* (Billings, 1865)
-*Uromystrum* sp. cf. *U. affine* (Poulsen, 1937)
-*Grinnellaspis flabelliformis* (Fortey, 1979)
-*Bathyurellus abruptus* Billings, 1865
-*Bathyurellus platypus* Fortey, 1979
-*Strotactinus insularis* (Billings, 1865)
-*Jeffersonia timon* (Billings, 1865)
-*Jeffersonia* sp. undet.
-*Isoteloides canalis* (Whitfield, 1886)
Benthamaspis gibberula (Billings, 1865)
Bolbocephalus kindlei Boyce, 1989
Illaenus sp. nov.
Catochia glabra Fortey, 1979
Grinnellaspis marginiatus (Billings, 1865)
Bathyurellus sp. undet.
Gen. et sp(p). undet.

Assigned collections. ECW-055 to ECW-096.

Age. Canadian Series; Cassinian Stage.

Geographical extent. This zone can also be recognized at Burnt Island in Pistolet Bay, at Catoche Point on Port au Choix Peninsula, along the south shore of Hawkes Bay, and east of Parsons Pond.

---

[2] Brett and Westrop (1996) suppressed the genus *Punka* Fortey, 1979, and assigned all existing species to the genus *Grinnellaspis* Poulsen, 1946.

[3] *Isoteloides latimarginatus* Fortey, 1979 was synonymized with *Isoteloides canalis* (Whitfield, 1886) by Brett and Westrop (1996).

[4] Jell and Stait (1985, pages 40-41) demonstrated that both *Carolinites bulbosus* Kobayashi, 1940 and *Carolinites genacinaca nevadensis* Hintze, 1953 are junior synonyms of *Carolinites tasmaniensis* (Etheridge, 1919).

Correlation outside Newfoundland. The *Benthamaspis gibberula* Zone correlates with Ross-Hintze Zone H, based on the common occurrence of the following (*see* Fortey, 1979; Boyce, 1989):

Benthamaspis gibberula (Billings, 1865)
Bolbocephalus kindlei Boyce, 1989

Correlative strata at Catoche Point, Port au Choix Peninsula (Figure 1) have yielded the following taxa, also indicative of a Ross-Hintze Zone H age (Fortey, 1979; Williams *et al.*, 1987):

Benthamaspis gibberula (Billings, 1865)
Carolinites tasmaniensis (Etheridge, 1919)
Opipeuter sp. cf. *O. angularis* (Young, 1973)

Fortey (1979) and Boyce (1989) erroneously identified *Benthamaspis gibberula* (Billings,1865) and *Strigigenalis caudata* (Billings, 1865) from New York–Vermont (Brett and Westrop, 1996).

Remarks. The top of the zone is so far undetermined.

CONODONT BIOSTRATIGRAPHY

Previous studies of conodonts from St. George Group on western Newfoundland deal with ages ranging from Canadian and to Whiterockian. These papers include Barnes and Tuke (1970), Fåhraeus (1970) Stouge (1982, 1984), Stouge (*in* Stouge and Boyce, 1983), Ji and Barnes (1988, 1989, 1990, 1993, 1994a,b) and Stait and Barnes (1991).

Forty-nine samples collected from trilobite-bearing horizons in the Eddies Cove West area were analyzed for conodonts. One sample was obtained from the Watts Bight Formation; the Boat Harbour Formation and the Catoche Formation yielded twenty and twenty-eight samples, respectively. Most of these horizons produced conodonts, although the yield has been variable. This common occurrence allows for a precise correlation of the disparate zonations within the St. George Group.

WATTS BIGHT FORMATION

The conodont faunas of the Watts Bight Formation are diverse (Ji and Barnes, 1994a), but toward the top of the formation the yield and diversity diminishes. Samples from the upper part of the Watts Bight Formation typically are barren or low yielding in the study area. *Variabiloconus bassleri* (Furnish, 1938) is the only taxon present. The species has been recorded from Unit 9, which is approximately 20 to 21 m above the base of the section (Knight, 1991, page 114).

BOAT HARBOUR FORMATION

The conodont faunas of the Boat Harbour Formation generally are of low diversity. However, the fauna of the lower subtidal member is of relatively higher diversity than that of the overlying Barbace Cove Member.

Lower Member

At 3.24 m above the base of the Boat Harbour Formation (ECW-002, the base of Fauna 1 of Stouge, 1982), i.e., at the base of Unit 6 of Knight (1991, page 114), the following taxa first appear:

Colaptoconus? *bolites* (Repetski, 1982)
Drepanoistodus nowlani s.l. Ji and Barnes, 1994a
Paltodus n. sp. A (pars = *Drepanoistodus nowlani sensu* Ji and Barnes, 1994a)
Polycostatus minutus Ji and Barnes, 1994a
Polycostatus prolificus s.l. Ji and Barnes, 1994a

At 16.5 m above the base (ECW-007), in Unit 19 of Knight (1991, page 119), this assemblage is associated with the characteristic taxa *Macerodus dianae* Fåhraeus and Nowlan, 1978 and "*Colaptoconus*" *floweri* (Repetski, 1982); this horizon forms the base of Fauna 2 of Stouge (1982). "-*Colaptoconus*" *floweri* (Repetski, 1982) has a constricted range in the Boat Harbour Formation, and it has its last appearance datum (LAD) at about 45 m from the base of the formation (ECW-016), in Unit 60 of Knight (1991, page 110).

At 29 m (ECW-12), in Unit 38 of Knight (1991, page 112), *Colaptoconus priscus* (Ji and Barnes, 1994a) and *Paltodus* n. sp. B (pars = *Drepanoistodus nowlani sensu* Ji and Barnes, 1994a) first appear. The newcomers and the members of the older assemblage continue to 64 m above the base of the formation (ECW-020), in Unit 84 of Knight (1991, page 109), where *Macerodus gracilis* Ji and Barnes, 1994a and *Macerodus dianae* (advanced) appear.

At 75 m (ECW-022), in Unit 97 of Knight (1991, page 108), the following taxa first appear:

Drepanoistodus sp. A
Juanognathus? sp. A Stouge, 1982
Striatodontus lanceolatus Ji and Barnes, 1994a

Barbace Cove Member

The conodont fauna of the Barbace Cove Member (Fauna 3 of Stouge, 1982) is markedly different from that of the lower member of the Boat Harbour Formation. Many genera, including *Macerodus* and *Polycostatus*, and nearly all the species characteristic of the lower member have disappeared. This abrupt change in the conodont faunas occurs at the base of Unit 108 of Knight (1991, page 108), i.e., 95.16 m above the base of the Boat Harbour Formation (ECW-025). Newcomers include:

Colaptoconus multiplicatus (Ji and Barnes, 1994a)
Colaptoconus quadraplicatus (Branson and Mehl, 1933)
Drepanoistodus concavus (Branson and Mehl, 1933)
Drepanoistodus sp. C
Scolopodus cornutiformis s.l. (Branson and Mehl, 1933)
Stultodontus costatus (Ethington and Brand, 1981)
Tropodus comptus s.l. (Branson and Mehl, 1933)
Paltodus sp. C.

Of the above, *Drepanoistodus concavus* (Branson and Mehl, 1933) and *Colaptoconus* spp. account for more than 60 percent of the total number of conodont elements present, and species diversity is typically low.

Within the uppermost 3 m of the Boat Harbour Formation or at 102 m (ECW-033 – the base of Fauna 4 of Stouge, 1982), diversity increases, *Oepikodus communis* (Ethington and Clark, 1964) and *Paraserratognathus ovatus* (Ji and Barnes, 1994a) first appear, and *Stultodontus costatus* (Ethington and Brand, 1981) and *Tropodus comptus* s.l. (Branson and Mehl, 1933) become abundant.

CATOCHE FORMATION

The stratotype section of the Catoche Formation (Section 8: Bustard Cove to Back Arm of Knight, 1991, pages 122-126) has been investigated; all levels are given in metres from the base of the formation.

In the lower Catoche Formation, conodonts are more abundant than in the Boat Harbour Formation. Furthermore, the fauna becomes diverse, with an increase in species from the base and toward the top.

The lower 4 m include a fauna that persists from below, and the species composition is the same as the fauna from the top beds of the Boat Harbour Formation. A short interval with low diversity is noted before *Cristodus loxoides* Repetski, 1982, *Protoprioniodus* sp. A (*sensu* Stouge, 1982) and *Drepanodus arcuatus* Pander, 1856 appear within the unit and the diversity increases from 7.5 m (ECW-039), in Unit 3c of Knight (1991, page 126) and upsection, along with a strong increase in the yield of conodonts. This increase in diversity initiates with the appearance of *Parapanderodus carlae* (Repetski, 1982). This faunal composition persists until 40.6 m (ECW-053), in Unit 6m of Knight (1991, page 124), where *Fahraeusodus marathonensis* s.l. (Bradshaw, 1969) and *Paroistodus parallelus* (Pander, 1856) appear. *Protopanderodus leonardii* Serpagli, 1974 and *Oelandodus elongatus* (Lindström, 1955) constitute a minor component of the fauna in this interval.

The upper investigated interval from about 70 m (ECW-067), in Unit 10j of Knight (1991, page 123), and including the samples ECW-088 to ECW-090, is marked by a characteristic faunal succession and change in fauna. The base of Fauna 5 of Stouge (1982) is indicated by the first appearance of *Oepikodus* sp. cf. *O. communis* (Ethington and Clark, 1964) *sensu* Stouge, 1982 at 70 m (ECW-067). This species is succeeded shortly after by *Stultodontus* sp. cf. *S. costatus* at 72 m (ECW-070), in Unit 10l of Knight (1991, page123). This turnover of species is associated with the appearance of the following taxa:

Protopanderodus sulcatus (Lindström, 1955)

Protoprioniodus sp. cf. *P. aranda* Cooper, 1985

Tropodus sp. cf. *T. comptus* (Branson and Mehl, 1933) – this taxon includes *Paltodus sweeti* Serpagli, 1974 (*sensu* Stouge, 1982)

Another new species of *Oepikodus* (*Oepikodus* n. sp. A) appears at nearly the same level (ECW-071B), in Unit 10l of Knight (1991, page 123), and it extends up to the top of the investigated part of the section at 94 m (ECW-095, ECW-096). *Bergstroemognathus extensus* (Graves and Ellison, 1941) is the most remarkable newcomer in the fauna within the formation. It appears at 88 m (ECW-088), in Unit 12c of Knight (1991, page 122), and is a characteristic taxon of the informal Laignet Point member (Stouge, 1982). *Berstroemognathus extensus* (Graves and Ellison, 1941) is associated with *Polonodus*? *corbatoi* (Serpagli, 1974) (*sensu* Stouge and Bagnoli, 1988) and ?*Reutterodus andinus* Serpagli, 1974 (*sensu* Ethington and Clark, 1981). The topmost three samples are also characterized by the appearance in small numbers of *Oelandodus elongatus* (Lindström, 1955) and *Protoprioniodus nyinti* Cooper, 1985.

CONODONT ZONES

Conodont faunas from western Newfoundland constitute formally established biozones and informal faunas and associations (Stouge, 1982; Stait and Barnes, 1991; Ji and Barnes, 1994a). The assemblages include conodonts that are characteristic of either shallow-water (SW) or deep-water (DW) facies (Stouge, 1982; Ji and Barnes, 1994a,b). The formally defined conodonts zones of Ji and Barnes (1994a) are applied when possible, but comments about the definitions of the zones are included. Two conodont (interval) zones are newly defined within the lower Boat Harbour Formation, because the *Glyptoconus floweri–Glyptoconus bolites* and *Striatodontus prolificus–Striatodontus lanceolatus* Assemblage Zones of Ji and Barnes (1994a) are biofacies dependant (Ji and Barnes 1994b) and are not useful as distinct biostratigraphic units in the succession. The informal Faunas 3 to 5 (Stouge, 1982) are formally defined as interval zones.

Polycostatus falsioneotensis–Rossodus tenuis Assemblage (SW) and *Rossodus manitouensis–Polycostatus sulcatus* Assemblage (SW) Zones, Ji and Barnes (1994a)

Remarks. The oldest conodonts recorded in this study are all referred to *Variabiloconus bassleri* (Furnish, 1938); the species is from the uppermost part of the Watts Bight Formation. This species ranges from the *Polycostatus falsioneotensis–Rossodus tenuis* Assemblage (SW) Zone into the basal part of the *Rossodus manitouensis–Polycostatus sulcatus* Assemblage (SW) Zones of Ji and Barnes (1994a). The assemblage zones correspond with the *Cordylodus angulatus* (DW) Zone (Ji and Barnes, 1994a).

Assigned collections. ECW-001.

Age. Canadian Series; Gasconadian Stage.

Geographical extent. The *Polycostatus falsioneotensis–Rossodus tenuis* Zone has been established from the upper Watts Bight Formation and the *Rossodus manitouensis–Polycostatus sulcatus* Zone is from the lowermost Boat Harbour Formation in the Port au Port District (Ji and Barnes, 1994a).

Variabiliconus bassleri (Furnish, 1938) is known from unnamed units in Bonne Bay (Stouge, 1982) and from the Canada Bay area (Stouge, 1982).

Correlation outside Newfoundland. The conodont species is known from Fauna C of Ethington and Clark (1971) and from the *Loxodus bransoni* Interval of Ethington and Clark (1981). Species of the two zones are widely distributed in North America (*see* summary in Ethington and Clark, 1981; Repetski, 1982 and Ji and Barnes, 1994a). The *Loxodus bransoni* Interval corresponds to upper trilobite Zone B and Zone C of Hintze (1953, 1973) in the Ibex, Utah sections.

Striatodontus prolificus Interval Zone

Synonymy. Fauna 1, Stouge 1982; *Glyptoconus floweri–Glyptoconus bolites* Assemblage (SW) Zone (pars) and *Drepanoistodus nowlani–Macerodus dianae* Assemblage (DW) Zone (pars) of Ji and Barnes (1994a).

Reference Section. Section 4 of Knight (1991, pages 107-115), Eddies Cove West, western Newfoundland, Canada; the base of the zone is 3.24 m above the base of the Boat Harbour Formation, i.e., at the base of Unit 6 of Knight (1991, page 114).

Definition. This zone is defined as the interval from the first appearance datum (FAD) of *Striatodontus prolificus* Ji and Barnes, 1994a to the FAD of *Macerodus dianae* Fåhræus and Nowlan, 1978.

Characterization. Striatodontus prolificus Ji and Barnes, 1994a, appears at the base of the zone. *Colaptoconus bolites* (Repetski, 1982), *Colaptoconus priscus* (Ji and Barnes, 1994a) and *"Drepanoistodus" nowlani* Ji and Barnes, 1994a, and *Striatodontus lanceolatus* Ji and Barnes, 1994a, first appear within the zone. All species extend into the following zone.

Assigned collections. ECW-002 to ECW-006.

Age. Canadian Series; Demingian Stage.

Geographical extent. The zone has been recognized from the Boat Harbour Formation in several sections on Port au Port Peninsula (Ji and Barnes, 1994a) and from the Boat Harbour area, northwestern Newfoundland (Stouge, 1982).

Correlation outside Newfoundland. The fauna may correlate with the *"Scolopodus" quadraplicatus–Scolopodus rex* Interval of Ethington and Clark (1981), which constitutes the basal Fauna D of Ethington and Clark (1971). *Colaptoconus bolites* (= *"Scolopodus" quadraplicatus sensu* Ethington and Clark , 1981; = *Oneotodus* sp. A Stouge, 1982 and Gen. nov. B sp. nov. A Stouge, 1982) is so far the only shared species.

Remarks. This interval zone corresponds precisely with Fauna 1 of Stouge (1982). The *Striatodontus prolificus* Zone is included in the lower part of the *Glyptoconus floweri–Glyptoconus bolites* Assemblage Zone of Ji and Barnes (1994a) and only the lower boundary coincides. The zone corresponds to the lower fraction of the *Drepanoistodus nowlani–Macerodus dianae* Assemblage (DW) Zone *sensu* Ji and Barnes (1994a), which covers the interval from the FAD of *"Drepanoistodus" nowlani* Ji and Barnes, 1994a, to the FAD of *Macerodus dianae* Fåhraeus and Nowlan, 1978.

Macerodus dianae Interval Zone

Synonymy. Fauna 2, Stouge (1982); *Striatodontus prolificus–Striatodontus lanceolatus* Assemblage (SW) Zone (pars) and *Drepanoistodus nowlani–Macerodus dianae* Assemblage (DW) Zone (pars) of Ji and Barnes (1994a).

Reference Section. Section 4 (Knight, 1991, pages 107-115), Eddies Cove West, western Newfoundland, Canada. The base of the zone is 16.5 m above the base of the Boat Harbour Formation, in Unit 19 of Knight (1991, pages 119).

Definition. The zone is defined as the interval from the FAD of *Macerodus dianae* Fåhræus and Nowlan, 1978 to the FAD of *Drepanoistodus concavus* (Branson and Mehl, 1933).

Characterization. The base of the zone is placed at the horizon where *Macerodus dianae* Fåhræus and Nowlan, 1978 first appears. *Colaptoconus floweri* (Repetski, 1982) has a characteristic and constricted range within the lower part of the zone, whereas *Macerodus gracilis* Ji and Barnes, 1994a, appears higher in the zone.

Striatodontus prolificus s.l. Ji and Barnes, 1994a, *Striatodontus lanceolatus* Ji and Barnes, 1994a, *"Drepanoistodus" nowlani* s.l. Ji and Barnes, 1994a, *Colaptoconus bolites* (Repetski, 1982) and *Colaptoconus priscus* (Ji and Barnes, 1994a) range into the zone.

Assigned collections. ECW-007 to ECW-024.

Age. Canadian Series; Demingian Stage.

Geographical extent. The *Macerodus dianae* Zone is recorded from the Boat Harbour, the Hare Bay, and the Port au Port areas (Stouge, 1982; Ji and Barnes, 1994a). The *Macerodus*

dianae Zone is recognized from Bed 8, Cow Head Group, where it is assigned to a Lancefieldian 2 age (Fåhræus and Nowlan, 1978, Williams *et al.*, 1994).

Correlation outside Newfoundland. The *Macerodus dianae* Zone correlates with Fauna D of Ethington and Clark (1971). It corresponds with the lower fraction of the *Macerodus dianae–Acodus deltatus* Interval of Ethington and Clark (1981).

Remarks. The *Striatodontus prolificus–Striatodontus lanceolatus* Assemblage (SW) Zone of Ji and Barnes (1994) can be recognized as the interval from the disappearance of (LAD) *Colaptoconus bolites* (Repetski, 1982) up to the "Pebble Bed" unconformity. This interval is contained within the *Macerodus dianae* interval.

The *Drepanoistodus nowlani–Macerodus dianae* Assemblage (DW) Zone of Ji and Barnes, (1994a) mostly corresponds with the *Macerodus dianae* Zone. Taxonomic differencies in the understanding of *Drepanoistodus nowlani* Ji and Barnes, 1994a makes the recognizion of the assemblage zone uncertain.

Drepanoistodus concavus Interval Zone

Synonymy. Fauna 3 (Stouge, 1982); *Protopanderodus inconstans–Scolopodus subrex* Assemblage (SW) Zone and the *Acodus delicatus–Acodus? primus* Assemblage (DW) Zone of Ji and Barnes (1994a).

Reference Section. Section 4, Eddies Cove West, western Newfoundland, Canada. The base of the zone is the base of Unit 108 of Knight (1991, page 108), i.e., 95.16 m above the base of the Boat Harbour Formation.

Definition. The base of the zone is defined by the FAD of *Drepanoistodus concavus* (Branson and Mehl, 1933). The top of the zone is marked by the FAD of *Oepikodus communis* (Ethington and Clark, 1964).

Characterization. The zone is characterized by the appearance of *Drepanoistodus concavus* (Barnson and Mehl, 1933), *Colaptoconus quadraplicatus* (Branson and Mehl, 1933) and *"Scolopodus" cornutiformis* (Branson and Mehl, 1933).

Several taxa appear within this zone, including *"Acodus" bransoni* (Ethington and Clark, 1981), *Tropodus comptus* (Branson and Mehl, 1933), *Diaphorodus deltatus* (Lindström, 1955 *sensu* Ethington and Clark, 1981)(rare in the Eddies Cove West Region), *Colaptoconus multicostatus* (Ji and Barnes, 1994a), *Parapanderodus emarginatus* (Barnes and Tuke, 1970), *Parapanderodus* spp., *Stultodontus costatus* (Ethington and Brand, 1981) and a new species of *Drepanoistodus* Lindström, 1971. Most the species range into the following zone.

Assigned collections. ECW-025 to ECW-031.

Age. Canadian Series; Jeffersonian Stage.

Geographical extent. The zone has been identified in the Boat Harbour–Cape Norman area (Barnes and Tuke, 1970; Stouge; 1982) and at Port au Choix (Stouge, 1982) and in Port au Port area (Ji and Barnes, 1994a).

Correlation outside Newfoundland. The *Drepanoistodus concavus* Zone is contained within Fauna D of Ethington and Clark (1971) and occupies the upper part of the *Acodus deltatus–Macerodus dianae* Interval of Ethington and Clark (1981).

Oepikodus communis Interval Zone

Synonymy. Faunas 4 and 5 (Stouge, 1982); *Parapanderodus carlae–Stultodontus ovatus* Assemblage (SW) Zone (pars) and *Oepikodus communis–Protoprioniodus simplicissimus* Assemblage (DW) Zone (pars) of Ji and Barnes (1994a).

Reference Section. Section 4 (Knight, 1991, pages 107-115), Eddies Cove West, western Newfoundland, Canada. The base of the zone occurs at the base of Unit 119 of Knight (1991, page 107), i.e., 101.82 m above the base of the Boat Harbour Formation, and 2.62 m below the base of the Catoche Formation.

Definition. Interval from the FAD of *Oepikodus communis* (Ethington and Clark, 1964). Top of the zone is not defined.

Characterization. Oepikodus communis (Ethington and Clark, 1981) appears at the base of the zone.

The nominate species is succeeded by the appearance of many species including: *Drepanodus arcuatus* Pander, 1856, *Parapanderodus carlae* (Repetski, 1982), *Protoprioniodus* sp. cf. *P. cowheadensis* Stouge and Bagnoli, 1988, *Paraserratognathus ovatus* (Ji and Barnes, 1994a), *Paraserratognathus pygmaeus* (Ji and Barnes, 1994a), *Drepanoistodus sp.*, *Diaphorodus sp.*, New Genus 2 Ethington and Clark, 1981, *Paroistodus parallelus* (Pander, 1856), *Scolopodus kuwanoi* Stouge and Bagnoli, 1988, *Diaphorodus? russoi* (Serpagli, 1974), *Fahraeusodus marathonensis* (Bradshaw, 1969), *Protopanderodus leonardii* Serpagli, 1974, *Oelandodus elongatus* (Lindström, 1955), *Drepanoistodus* sp. aff. *D. forceps* (Lindström, 1955), *Paltodus* sp. aff. *P. subaequalis* (Pander, 1856), *Parapanderodus* spp., *Tropodus* sp. cf. *T. comptus* (Branson and Mehl, 1933), *Oepikodus* sp. cf. *O. intermedius* Serpagli, 1974 *(sensu* Stouge, 1982), *Stultodontus* sp. cf. *S. costatus* (Ethington and Brand, 1981), *Oepikodus* n. sp. A, *Protopanderodus gradatus* Serpagli, 1974, *Scandodus furnishi* Lindström, 1955, *?Reutterodus andinus* Serpagli, 1974 *sensu* Ethington and Clark, 1981, *Polonodus? corbatoi*

(Serpagli, 1974), *Oistodus* sp. 2 s.f. Ethington and Clark, 1981, *Bergstroemognathus extensus* (Graves and Ellison, 1941) and *Parapaltodus* sp.

All species from the zone below including *"Acodus" bransoni* (Ethington and Clark, 1981), *Drepanoistodus concavus* (Branson and Mehl, 1933), *Colaptoconus quadraplicatus* (Branson and Mehl, 1933), *Stultodontus costatus* (Ethington and Brand, 1981) extend into the zone.

Age. Canadian Series, Jeffersonian and Cassinian Stages.

Assigned collections. ECW-033 and ECW-034 in Section 4 of Knight at Eddies Cove West. ECW-035 to ECW-090 in Section 8 of Knight (1991) from Bustard Cove to Back Arm.

Geographical extent. The zone is widespread and has been recorded from the Boat Harbour–Cape Norman area (Barnes and Tuke; 1970; Stouge, 1982), north of Table Point (Stouge, 1982), in Hare Bay (Stouge, 1982), at Port au Choix (Stouge, 1982) and on Port au Port Peninsula (Ji and Barnes, 1994a).

Correlation outside Newfoundland. The *Oepikodus communis* Zone corresponds with Fauna E of Ethington and Clark (1971) and with the *Oepikodus communis– "Microzarkodina" marathonensis* Interval of Ethington and Clark (1981). *Oepikodus* is widely spread over North America and the zone corresponds with the *Oepikodus communis* Zone (pars) of Ethington and Repetski (1984).

The increasing number of North Atlantic province conodont species suggests that a major transgression is under development and the zone can indirectly be correlated with the *Prioniodus elegans* Zone and the basal part of the *Oepikodus evae* Zone (Stouge and Bagnoli, 1988).

Remarks. The zone may be subdivided into two lineage zones on the basis of *Tropodus comptus* (Branson and Mehl, 1933) and *Tropodus* n. sp. or at the level where *Oepikodus* n. sp. A appears.

CORRELATION OF TRILOBITE AND CONODONT ZONES

Based on data from the Boat Harbour (Boyce, 1989; Stouge, 1982) and Eddies Cove West areas, the following trilobite–conodont correlation can be concluded (Figure 4):

The *Parahystricurus* sp. I (trilobite) Zone corresponds to the *Polycostatus falsioneotensis–Rossodus tenuis* and the *Rossodus manitouensis–Polycostatus sulcatus* Assemblage (SW) Zones and are assigned to the Gasconadian Stage of the Canadian Series. It is likely that the strata of the upper Watts Bight Formation in the study area are within the latter conodont zone.

The *Hystricurus oculilunatus* (trilobite) Zone almost exactly coincides with the new *Striatodontus prolificus* (conodont) Zone in the Eddies Cove Section. Both zones are assigned to the Demingian Stage of the Canadian Series.

The *Leiostegium proprium* and *Randaynia saundersi* (trilobite) zones together correlate with the whole of the *Macerodus dianae* (conodont) Zone. A subdivision of the *Macerodus dianae* (conodont) Zone could be based on *"Colaptoconus" floweri* (Repetski, 1982), which has a range correponding with the extent of the *Leiostegium proprium* (trilobite) Zone. In this case, the upper subdivision of the *Macerodus dianae* (conodont) Zone would be characterized by the appearance of *Macerodus gracilis* Ji and Barnes, 1994a, and would correlate with the *Randyania saundersi* (trilobite) Zone. All the biozones extend up to the "Pebble–Bed" unconformity within the Boat Harbour Formation.

The *Strigigenalis brevicaudata* (trilobite) Zone comprises the whole of the *Drepanoistodus concavus* (conodont) Zone and also includes the lower part of the *Oepikodus communis* (conodont) Zone. The interval is referred to uppermost part of the Jeffersonian Stage of the Canadian Series.

The succeeding *Strigigenalis caudata* (trilobite) Zone has a constricted range within the *Oepikodus communis* (conodont) Zone. The FAD of *Strigigenalis caudata* (Billings, 1865) marks the base of Cassinian Stage of the Canadian Series (Boyce, 1989); so far the base of the stage cannot be distinguished by using conodonts.

The *Benthamaspis gibberula* (trilobite) zone of the Cassinian Stage, Canadian Series correlates with the *Oepikodus communis* (conodont) Zone. The base of the zone almost coincides with the FADs of *Fahraeusodus marathonensis* (Bradshaw, 1969), *Tropodus* sp. A and *Oepikodus* sp. cf. *O. communis* (Ethington and Clark, 1964) and further subdivision of the *Oepikodus communis* (conodont) Zone is possible on the basis of *Tropodus* species. The *Benthamaspis gibberula* (trilobite) Zone comprises the characteristic interval with *Bergstroemognathus extensus* (Graves and Ellison, 1941) (=Fauna 5 of Stouge, 1982).

ACKNOWLEDGMENTS

This work is part of a long term cooperative project between I. Knight, D. Boyce and S. Stouge. Financial support for fieldwork to S. Stouge from the Carlsberg Foundation, Copenhagen, Denmark, is gratefully acknowledged. S. Stouge publishes this report with the permission of the Director of the Geological Survey of Denmark and Greenland. Boyce gratefully acknowledges the fossil collecting expertise of J.S. Ash (1984–1993) and C. Pinsent (1984). J.S. Ash, P.W. Delaney, J.P. Hayes and C. Pinsent competently processed the conodont samples through the years. Both authors thank Dr.

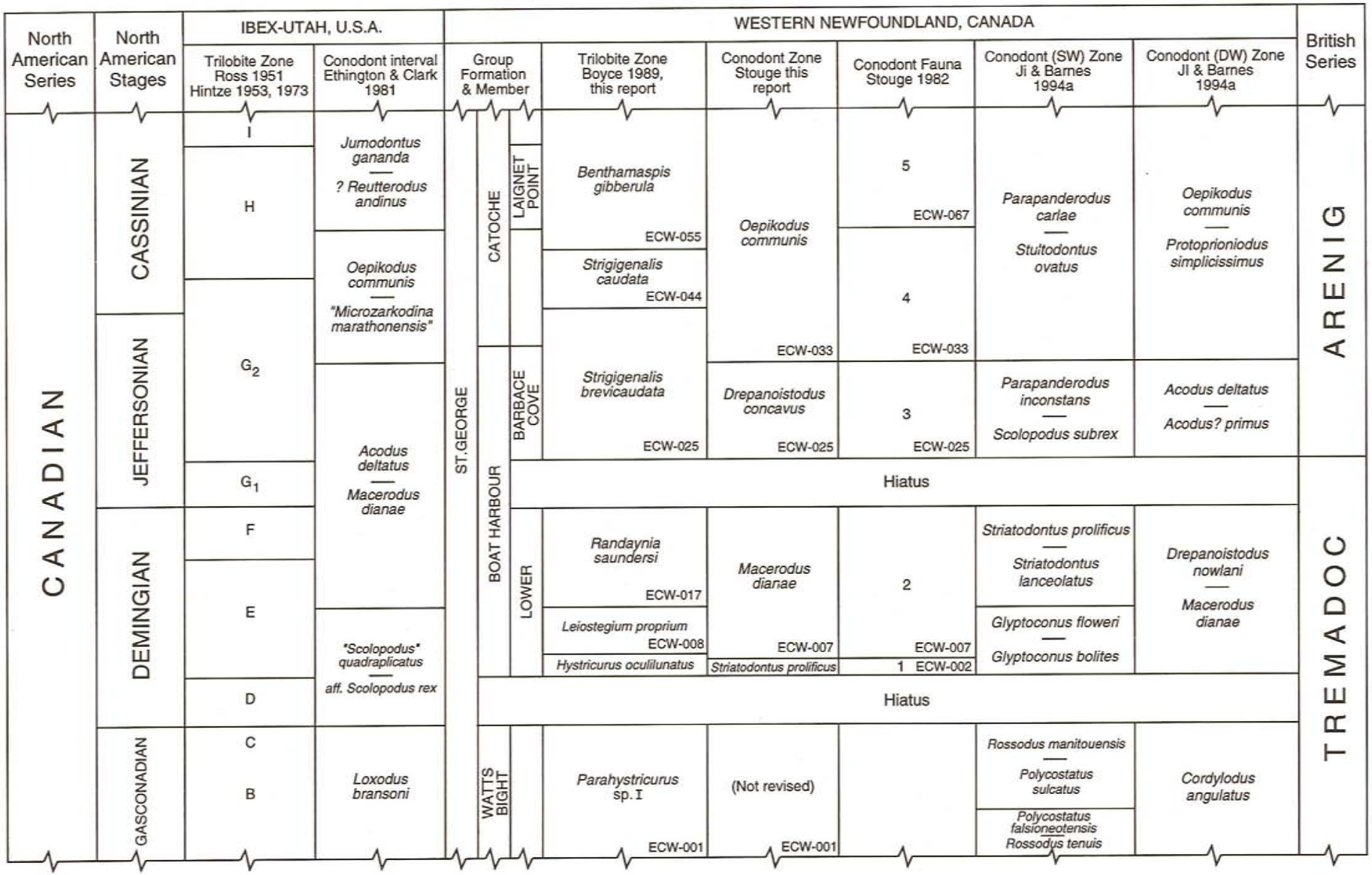


Figure 4. *Correlation of trilobite and conodont zones of the St. George Group in the Eddies Cove West area.*

I. Knight for helpful discussions and his keen interest in the sampling during various stages of this work. Joanne Rooney provided her usual word-processing expertise. Ken Byrne, Dave Leonard, Tony Paltanavage and Terry Sears skillfully produced the figures. Special thanks are extended to Steve Colman-Sadd who reviewed the manuscript.

REFERENCES

Barnes, C.R. and Tuke, M.F.
1970: Conodonts from the St. George Formation (Ordovician), northern Newfoundland. Geological Survey of Canada, Bulletin 187, pages 79-97.

Billings, E.
1865: Palaeozoic fossils. Volume 1. Containing descriptions and figures of new or little known species of organic remains from the Silurian rocks. 1861–1865. Geological Survey of Canada, Separate Report, 426 pages.

Boyce, W.D.
1979: Further developments in western Newfoundland Cambro–Ordovician biostratigraphy. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 79-1, pages 7-10.

1983a: Preliminary Ordovician trilobite biostratigraphy of the Eddies Cove West – Port au Choix area, western Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 11-15.

1983b: Early Ordovician trilobite faunas of the Boat Harbour and Catoche Formations (St. George Group) in the Boat Harbour – Cape Norman area, western Newfoundland. Unpublished M.Sc. thesis, Memorial University of Newfoundland, St. John's, Newfoundland, 272 pages.

1985: Cambrian–Ordovician biostratigraphic investigations, Great Northern Peninsula, western Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 85-1, pages 60-70.

1986: Ordovician biostratigraphic investigations, Great Northern Peninsula, western Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 86-1, pages 161-168.

1989: Early Ordovician trilobite faunas of the Boat Harbour and Catoche formations (St. George Group) in the Boat Harbour–Cape Norman area, Great, Northern Peninsula, western Newfoundland. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 89-3, 169 pages.

Boyce, W.D., Ash, J.S. and Knight, I.
1988: Biostratigraphic studies of Ordovician carbonate rocks in western Newfoundland, 1987. *In* Current Research. Newfoundland Department of Mines, Mineral Development Division, Report 88-1, pages 75-83.

Brett, K.D. and Westrop, S.R.
1996: Trilobites of the Lower Ordovician (Ibexian) Fort Cassin Formation, Champlain Valley region, New York State and Vermont. Journal of Paleontology, Volume 70, pages 408-427.

Desbiens, S., Bolton, T.E. and McCracken, A.D.
1996: Fauna of the Lower Beauharnois formation (Beekmantown Group, Lower Ordovician), Grande–île, Québec. Canadian Journal of Earth Sciences, Volume 33, pages 1132-1153.

Ethington, R.L. and Clark, D.L.
1971: Lower Ordovician conodonts in North America. *In* Symposium on Conodont Biostratigraphy. *Edited by* W.C. Sweet and S.M. Bergström. Geological Society of America Memoir, 127, pages 63-82.

1981: Lower and Middle Ordovician conodonts from the Ibex area, western Millard County, Utah. Brigham Young University Geology Studies, Volume 28, Part 2, 155 pages.

Ethington, R.L. and Repetski, J.E.
1984: Paleobiogeographic distribution of Early Ordovician conodonts in central and western United States. Geological Society of America, Special Paper 196, pages 89-101.

Fåhraeus, L.E.
1970: Conodont–based correlations of Lower and Middle Ordovician strata in western Newfoundland. Geological Society of America Bulletin, Volume 81, pages 2061-2076.

Fåhraeus, L.E. and Nowlan, G.S.
1978: Franconian (Late Cambrian) to Early Champainian (Middle Ordovician) conodonts from the Cow Head Group, western Newfoundland. Journal of Paleontology, Volume 52, pages 444-471.

Flower, R.H.
1964: The nautiloid Order Ellesmeroceratida (Cephalopoda). New Mexico Bureau of Mines and Mineral Resources, Memoir 12, 234 pages.

1978: St. George and Table Head cephalopod zonation in western Newfoundland. *In* Current Research, Part A. Geological Survey of Canada, Paper 78-1A, pages 217-224.

Fortey, R.A.
1979: Lower Ordovician trilobites from the Catoche Formation (St. George Group), western Newfoundland. Geological Survey of Canada, Bulletin 321, pages 61-114.

Hedberg, H.D.
1976: International Stratigraphic Guide – a guide to stratigraphic classification, terminology, and procedure. International Subcommission on Stratigraphic Classifiation (ISSC). John Wiley and Sons, New York, 200 pages.

Hintze, L.F.
1953: Lower Ordovician trilobites from western Utah and eastern Nevada. Utah Geological and Mineralogical Survey, Bulletin 48, 249 pages.

1973: Lower and Middle Ordovician stratigraphic sections in the Ibex area, Millard County, Utah. Brigham Young University Geology Studies, Volume 20, Part 4, pages 3-36.

1982: Ibexian Series (Lower Ordovician) type section, western Utah, U.S.A. *In* The Ordovician System in the United States – correlation chart and explanatory notes. *Edited by* R.J. Ross, Jr. *et al.* International Union of Geological Sciences, Publication Number 12, pages 7-10.

James, N.P., Stevens, R.K., Barnes, C.R. and Knight, I.
1989: Evolution of a Lower Paleozoic continental margin carbonate platform, northern Canadian Appalachians. *In* Controls on Carbonate Platforms and Basin Development. *Edited by* T. Crevelo, R. Sarg, J.F. Read and J.L. Wilson. Society of Economic Paleontologists and Mineralogists, Special Publication 44, pages 123-146.

Jell, P.A. and Stait, B.
1985: Tremadoc trilobites from the Florentine Valley Formation, Tim Shea area, Tasmania. Memoirs of the Museum of Victoria, Volume 46, Number 1, pages 1-34.

Ji, Z. and Barnes, C.R.
1988: Revision to apparatus reconstructions of Lower Ordovician, Midcontinent Province, conodonts. *In* First International Senckenberg Conference and fifth European Conodont Symposium (ECOS V), Contributions I. *Edited by* W. Ziegler. Courier Forschungsinstitut Senckenberg, Volume 102, pages 243-244.

1989: Preliminary Lower Ordovician conodont zonation in the Midcontinent Province. *In* Abstracts, 28th International Geological Congress, 2 of 3, pages 123-124.

1990: Apparatus reconstructions of Lower Ordovician conodonts from the Midcontinent Province. *In* First International Senckenberg Conference and fifth European Conodont Symposium (ECOS V), Contributions IV. *Edited by* W. Ziegler. Courier Forschungsinstitut Senckenberg, Volume 118, pages 333-352.

1993: A major conodont extinction event during the Early Ordovician within the Midcontinent Realm. Palaeogeography, Palaeoclimatology, Palaeoecology, Volume 104, pages 37-47.

1994a: Lower Ordovician conodonts of the St. George Group, Port au Port Peninsula, western Newfoundland, Canada. Palaeontographica Canadiana, Number 11, 149 pages.

1994b: Conodont paleoecology of the Lower Ordovician St. George Group, Port au Port Peninsula, western Newfoundland. Journal of Paleontology, Volume 68, pages 1368-1383.

Knight, I.
1977a: The Cambrian – Ordovician platformal rocks of the Northern Peninsula. *In* Report of Activities for 1976. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-1, pages 27-34.

1977b: Cambro–Ordovician platformal rocks of the Northern Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 77-6, 27 pages.

1983: Geology of Cambro–Ordovician rocks in parts of the Castors River, St. John Island and Port Saunders map sheets. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 1-10.

1991: Geology of Cambro–Ordovician rocks in the Port Saunders (NTS 12I/11), Castors River (NTS 12I/15), St. John Island (NTS 12I/14) and Torrent River (NTS 12I/10) map areas. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 91-4, 138 pages.

Knight, I. and James, N.P.
1987: The stratigraphy of the Lower Ordovician St. George Group, western Newfoundland: the interaction between eustasy and tectonics. Canadian Journal of Earth Sciences, Volume 24, pages 1927-1951.

1988: Stratigraphy of the Lower to lower Middle Ordovician St. George Group, western Newfoundland. Newfoundland Department of Mines, Mineral Development Division, Report 88-4, 48 pages.

Loch, J.D.
1995: An affirmation of the Jeffersonian Stage (Ibexian) of North America and a proposed boundary stratotype. *In* Ordovician Odyssey: short papers for the Seventh International Symposium on the Ordovician System. *Edited by* J.D. Cooper, M.L. Droser and S.C. Finney. The Pacific Section Society for Sedimentary Geology (SEPM), Book 77, pages 45-48.

Raymond, P.E.
1913: Revision of the species which have been referred to the genus *Bathyurus*. Geological Survey of Canada, Bulletin of the Victoria Memorial Museum, Volume 1, pages 51-69.

1925: Some trilobites of the lower Middle Ordovician of eastern North America. Harvard University Museum of Comparative Zoology Bulletin, Volume 67, Number 1, 181 pages.

Repetski, J.E.
1982: Conodonts from El Paso Group (Lower Ordovician) of westernmost Texas and southern New Mexico. New Mexico Bureau of Mines and Mineral Resources, Memoir 40, 121 pages.

Ross, R.J., Jr.
1951: Stratigraphy of the Garden City Formation in northeastern Utah and its trilobite faunas. Yale University, Peabody Museum of Natural History, Bulletin 6, 161 pages.

Ross, R.J., Jr., Adler, F.J., Amsden, T.W., Bergström, D., Bergström, S.M., Carter, C., Churkin, M., Cressman, E.A., Derby, J.R., Dutro, J.T., Jr., Ethington, R.L., Finney, S.C., Fisher, D.W., Fisher, J.H., Harris, A.G., Hintze, L.F., Ketner, K.B., Kolata, D.L., Landing, E., Neuman, R.B., Sweet, W.C., Pojeta, J., Jr., Potter, A.W., Rader, E.K., Repetski, J.E., Shaver, R.H., Thompson, T.L. and Webers, G.F.
1982: The Ordovician System in the United States – correlation chart and explanatory notes. International Union of Geological Sciences, Publication Number 12, 73 pages.

Ross, R.J., Jr., Hintze, L.F., Ethington, R.L., Miller, J.F., Taylor, M.E. and Repetski, J.E.
1993: The Ibexian Series (Lower Ordovician), a replacement for "Canadian Series" in North American chronostratigraphy. United States Geological Survey, Open–file Report 93-598, 75 pages.

Salvador, A.
1994: International Statigraphic Guide: a guide to stratigraphic classification, terminology, and procedure. Second Edition. International Union of Geological Sciences and Geological Society of America, Boulder, Colorado, 214 pages.

Stait, K.A. and Barnes, C.R.
1991: Conodont biostratigraphy of the upper St. George Group (Canadian to Whiterockian), western Newfoundland. *In* Advances in Ordovician Geology. *Edited by* C.R. Barnes and S.H. Williams. Geological Survey of Canada, Paper 90-9, pages 125-134.

Stenzel, S.R., Knight, I. and James, N.P.
1990: Carbonate platform to foreland basin: revised stratigraphy of the Table Head Group (Middle Ordovician), western Newfoundland. Canadian Journal of Earth Sciences, Volume 27, pages 14-26.

Stouge, S.
1982: Preliminary conodont biostratigraphy and correlation of Lower to Middle Ordovician carbonates of the St. George Group, Great Northern Peninsula, Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 82-3, 63 pages.

1984: Conodonts of the Middle Ordovician Table Head Formation, western Newfoundland. Fossils and Strata, Number 16, 145 pages.

Stouge, S. and Bagnoli, G.
1988: Early Ordovician conodonts from Cow Head Peninsula, western Newfoundland. Palaeontographia Italica, 75, pages 89-179.

Stouge, S. and Boyce, W.D.
1983: Fossils of northwestern Newfoundland and southeastern Labrador: conodonts and trilobites. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-3, 55 pages.

Whittington, H.B.
1953: North American Bathyuridae and Leiostegiidae (Trilobita). Journal of Paleontology, Volume 27, pages 647-678.

Williams, S.H., Boyce, W.D. and James, N.P.
1987: Graptolites from the Lower – Middle Ordovician St. George and Table Head groups, western Newfoundland, and their correlation with trilobite, graptolite, brachiopod and conodont zones. Canadian Journal of Earth Sciences, Volume 24, pages 456-470.

Williams, S.H., Barnes, C.R., O'Brien, F.H.C., and Boyce, W.D.

1994: A proposed global stratotype for the second series of the Ordovician System: Cow Head Peninsula, western Newfoundland. Bulletin of Canadian Petroleum Geology, 42, pages 219-231.

Woodard, H.H.

1957: Geology of the Port au Choix–Castor River area, Newfoundland. Newfoundland Geological Survey, Bulletin 10, 44 pages.