CAMBRIAN-ORDOVICIAN BIOSTRATIGRAPHIC INVESTIGATIONS, GREAT NORTHERN PENINSULA, WESTERN NEWFOUNDLAND

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ABSTRACT

Well preserved, early Late Cambrian (Dresbachian) trilobites were collected for the first time from previously unmapped limestone beds of the Petit Jardin Formation in the Western Blue Pond area, east of Bellburns, Great Northern Peninsula, Newfoundland.

Reconnaissance lithostratigraphic sectioning and biostratigraphic sampling of James and Eastern Whale Islands revealed that the rocks exposed there belong to different units from those previously mapped on these islands.

Early Ordovician (early Arenig) Zone G_2 trilobite faunas have been identified above newly discovered exposures of the Boat Harbour Formation "pebble bed" along Bateau Barrens Road and at Barbace Point (Port au Choix Peninsula).

Detailed biostratigraphic sampling for trilobites and conodonts was continued in the Boat Harbour and Catoche Formations at Eddies Cove West and on Barbace and Catoche Points on the Port au Choix Peninsula. During the investigations on Catoche Point, three graptolite horizons were discovered, two of which were previously unknown. These horizons have resulted in the confirmation of previously proposed correlations between the standard Early Ordovician trilobite and graptolite zonations of North America.

A previously unknown trilobite fauna was discovered in undolomitized limestone remnants of the uppermost part of the Catoche Formation exposed about 1.4 km northeast of Table Point. An Early Ordovician (late Arenig) Zone I to J age is suggested for these rocks.

A previously known graptolite horizon at the base of the Aguathuna Formation yielded Didymograptus nitidus - patulus. An Early Ordovician (late Arenig) ***Didymograptus protobifidus*** *Zone to* ***Didymograptus bifidus*** *Zone age is tentatively proposed for this horizon.*

INTRODUCTION

The Cambrian-Ordovician carbonate deposits of the Great Northern Peninsula have been the object of regional taxonomic-biostratigraphic studies aimed at correlating western Newfoundland trilobite faunas with those of the standard Cambrian and Ordovician trilobite zonations of North America (Palmer, 1977; Ross, 1951; Hintze, 1953). This report discusses new trilobite (and graptolite) material obtained between July and October, 1984, from Western Blue Pond, James and Eastern Whale Islands (St. John Bay), Eddies Cove West, Port au Choix Peninsula and north of Table Point (see Figure 1). This augments the work of Fortey (1979a), Stouge (1982) Boyce (1983a,b), and Stouge and Boyce (1983).

LITHOSTRATIGRAPHY

Lithostratigraphic divisions of the Cambrian-Ordovician platformal sequence that were studied belong to the Petit Jardin, Boat Harbour, Catoche and Aguathuna Formations; these are described by Knight (this volume).

CAMBRIAN BIOSTRATIGRAPHIC INVESTIGATIONS

Well preserved trilobites were obtained for the first time from previously unmapped stromatolitic, oolitic, burrowed, flaser bedded and pebbly limestone beds of the Petit Jardin Formation on the western shore and 1.2 km west of Western Blue Pond (Figure 1). The trilobites collected include *Arapahoia* sp., *Coosella* sp. cf. *C. helena* Lochman, *Terranovella* sp. cf. *T. obscura* Lochman and *Welleraspis* sp.. They are indicative of an early Late Cambrian (Dresbachian) *Cedaria-Crepicephalus* Zone age, and are correlative with similar faunas obtained from the Port au Port Peninsula (Lochman, 1938; Kindle and Whittington, 1965), Bear Cove Point, just north of Deadman's Cove (St. Barbe Coast) (Boyce, 1978; Boyce *in* Stouge and Boyce, 1983) and the south shore of Hawkes Bay (Knight and Boyce, 1984).

ORDOVICIAN BIOSTRATIGRAPHIC INVESTIGATIONS

James and Eastern Whale Islands (St. John Bay) were visited for reconnaissance

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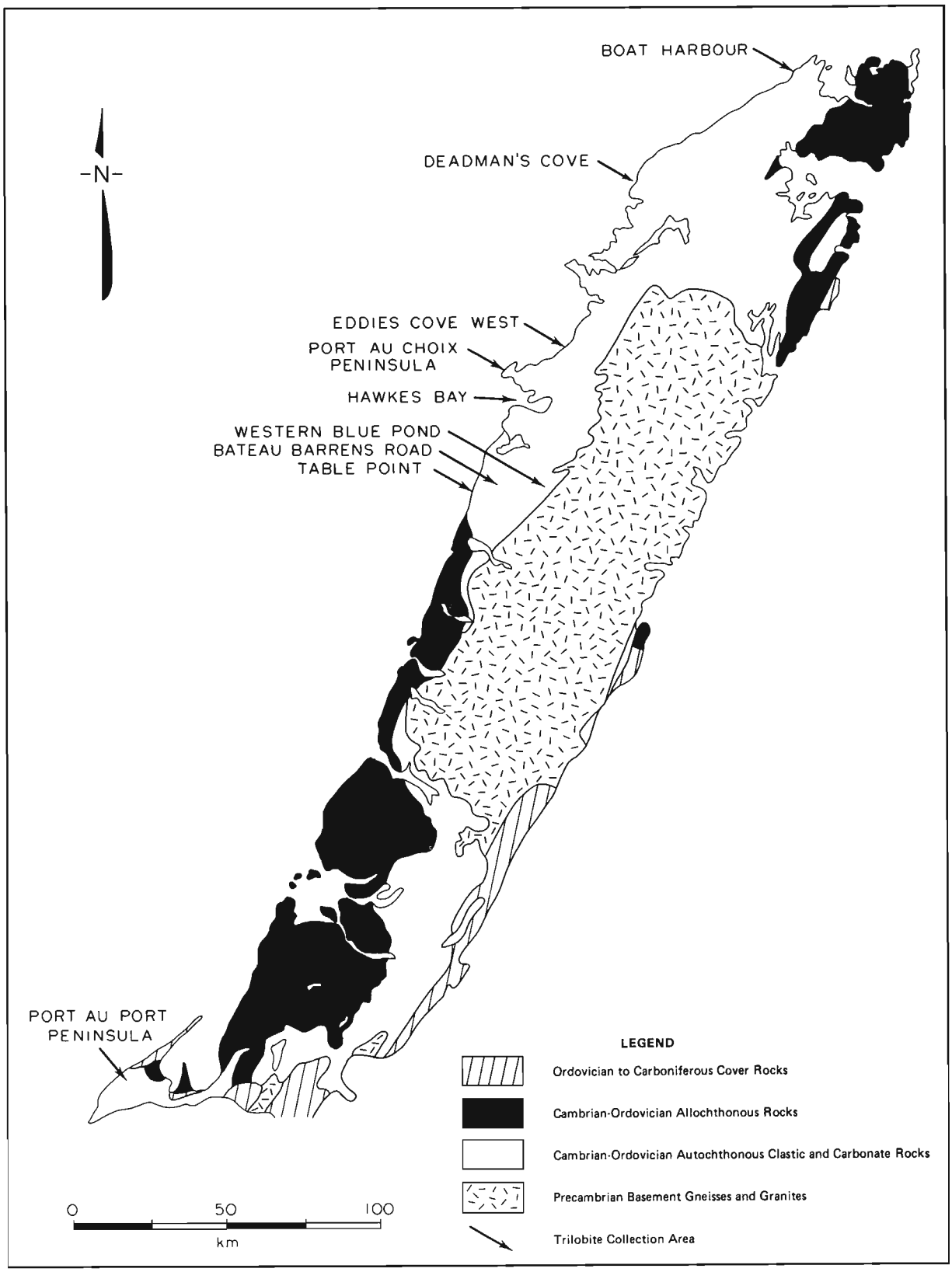

Figure 1: *Geological elements and trilobite collection areas of western Newfoundland.*

lithostratigraphic sectioning and biostratigraphic sampling. Limestones exposed on James Island were investigated to determine if they represented undolomitized remnants of the Watts Bight Formation as speculated by Knight and Boyce (1984, Figure 1). Lithologies and fossils found there, however, are typical of the Boat Harbour Formation below the "pebble bed" disconformity of Knight (1977, 1978, 1980, 1983), Boyce (1978, 1979, 1983a,b), Stouge (1982), Boyce et al. (1983) and Stouge and Boyce (1983). The following fossils were collected:

Trilobita
Hillyardina levis Boyce, 1983b
Hystricurus pseudoculilunatus Boyce, 1983b
Parahystricurus smithiae Boyce, 1983b
Randaynia saundersi Boyce, 1983b

Gastropoda
Lecanospira
Ophileta

Burrowed limestones, thrombolitic boundstones and parted limestones exposed on the northeastern tip of Eastern Whale Island proved to belong to the Catoche Formation rather than the uppermost Boat Harbour Formation as indicated by Knight and Boyce (1984, Figure 1). Fossils recovered are indicative of a higher stratigraphic interval well within the Catoche Formation. They include:

Trilobita
Bathyurellus abruptus Billings, 1865
Benthamaspis conica Fortey, 1979a
Bolbocephalus convexus (Billings, 1865)
Isoteloides peri Fortey, 1979a
Jeffersonia angustimarginata Boyce, 1983b
Petigurus nero (Billings, 1865)
Strigigenalis caudata (Billings, 1865)

Cephalopoda
Cassinoceras/Piloceras sp.

Gastropoda
Maclurites spp.

Knight (this volume) discovered another exposure of the Boat Harbour Formation "pebble bed" along Bateau Barrens Road (Figure 1). Dolomitic limestones, a short distance above this horizon in two locations, yielded abundant articulate brachiopods and the following trilobites:

Isoteloides peri Fortey, 1979a
Strigigenalis brevicaudata Boyce, 1983b

These two species are characteristic of the early Arenig Ross-Hintze Zone G_2 fauna in the interval between the "pebble bed" and the base of the Catoche Formation in Boat Harbour (Boyce, 1983b).

Detailed biostratigraphic sampling for trilobites and conodonts was continued in the Boat Harbour and Catoche Formations exposed at Eddies Cove West and at Barbace and Catoche Points on Port au Choix Peninsula (Figure 1), augmenting the work of Fortey (1979a), Stouge (1982), Boyce (1983a,b) and Stouge and Boyce (1983).

Boyce (1983a,b) identified *Tesselacauda* sp. cf. *T. depressa sensu* Demeter (1973; Plate 1, Figures 5, 6) from a thrombolitic boundstone bed towards the base of the Boat Harbour Formation north of Eddies Cove West. This identification was based on an incomplete cranidium which did not show the genal angles. However, five cranidia recovered in 1984, which are more complete, all display well developed genal spines more characteristic of the genus *Rossaspis*. The cranidia, however, appear to be transitional between those of *Rossaspis pliomeris* Demeter, 1973 (Plate 2, Figures 1-4) and *Tesselacauda depressa* Ross, 1951 *sensu* Demeter (1973; Plate 1, Figures 5, 6) and final generic assignment of the species must await the recovery of pygidia.

Rossapis pliomeris Demeter is indicative of Ross-Hintze Zone D to earliest Zone E; *Tesselacauda depressa* Ross is indicative of Zone E (Demeter, 1973, page 43, Text - Figure 3).

At Barbace Point, four additional horizons were sampled in the Boat Harbour Formation above the newly discovered Barbace Point "pebble bed" (Knight, this volume) and below the base of the Catoche Formation. The following were obtained:

Trilobita
Bolbocephalus convexus (Billings, 1865)
Grinnellaspis newfoundlandensis Boyce, 1983b
Isoteloides peri Fortey, 1979a
Jeffersonia angustimarginata Boyce, 1983b
Peltabellia knighti Boyce, 1983b
Petigurus nero (Billings, 1865)
Strigigenalis brevicaudata Boyce, 1983b

At Boat Harbour, the same fauna occurs above the "pebble bed" and below the Catoche Formation; it is indicative of an Early Ordovician (early Arenig) Zone G_2 age (Boyce, 1983b).

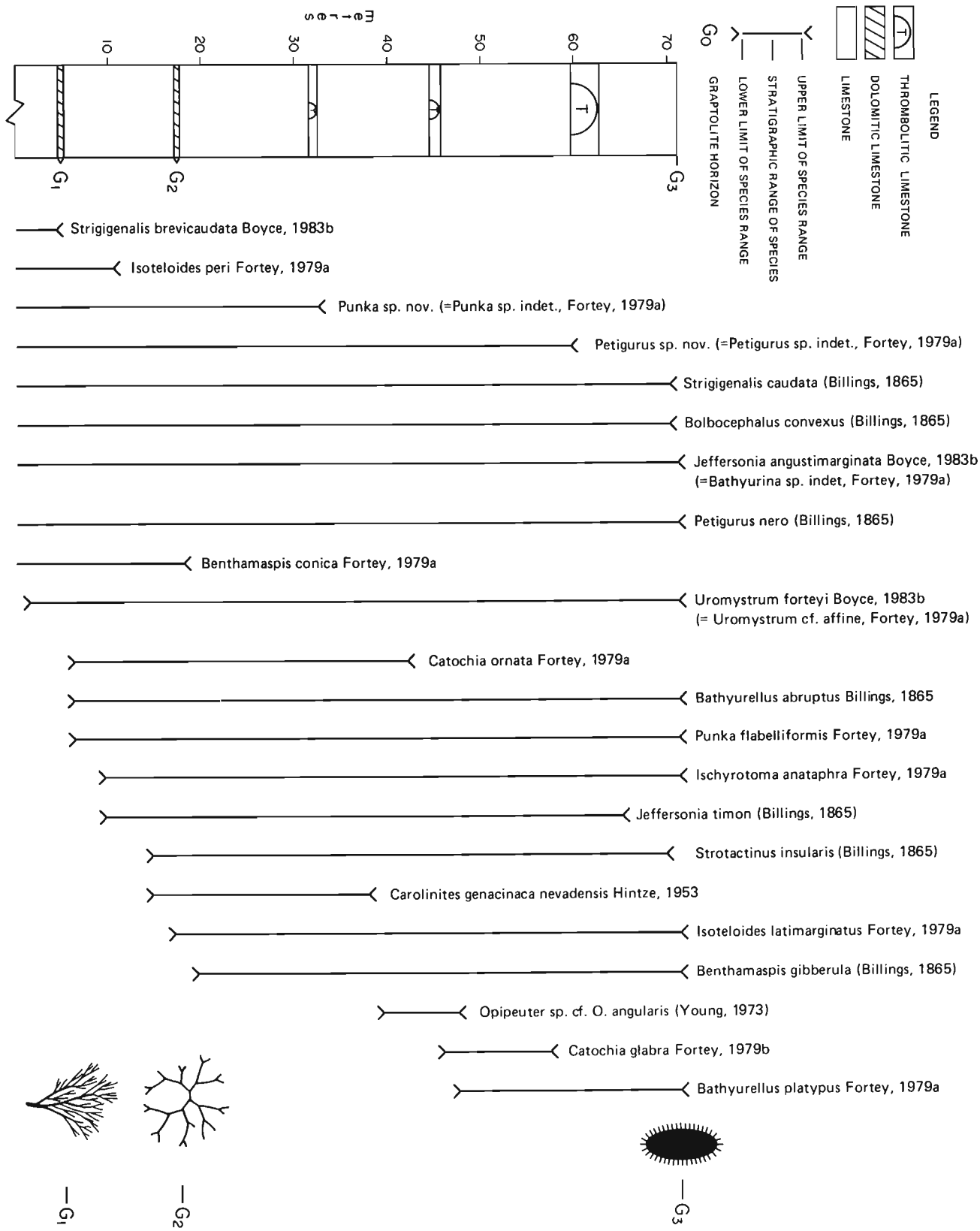

Figure 2: *Preliminary revised trilobite biostratigraphy of the Catoche Formation at Catoche Point, Port au Choix Peninsula. Range of* ***Carolinites genacinaca nevadensis*** *Hintze after Fortey (1979a, Figure 11). Graptolite horizons: G_1 - dendrograptid, G_2* ***Clonograptus flexilis*** *(Hall), G_3 -* ***Pseudophyllograptus/Phyllograptus*** *sp.*

The type section of the Catoche Formation was the object of detailed biostratigraphic sampling for trilobites and conodonts for four weeks in September and October, 1984. The section, exposed at Catoche Point (south of Barbace Cove), was previously investigated by Dr. R.A. Fortey of the British Museum (Natural History). Fortey (1979a) described and illustrated twenty-one trilobite species (thirteen of which were new - including two new genera) obtained from thirteen fossiliferous horizons in the 70 m thick section. The author sampled forty-five fossiliferous horizons over the same interval. The tighter sample spacing resulted in a considerable revision of the biostratigraphic ranges of the trilobite species; most have substantially longer ranges than indicated by Fortey (1979a, Figure 11). The revised trilobite biostratigraphy is shown in Figure 2.

During the resampling of the Catoche Formation, three graptolite horizons were discovered, two of which are new. These horizons are shown in Figure 2 with the type of graptolite present in each. The lowest horizon (G_1) yielded a "nondiagnostic dendrograptid" (Dr. S.H. Williams, personal communication, 1984). The middle horizon (G_2) yielded *Clonograptus* (an identification confirmed by Drs. R.K. Stevens and S.H. Williams (personal communications, 1984); this horizon was originally discovered by Dr. L.M. Cumming of the Geological Survey of Canada, who obtained and illustrated well preserved *Clonograptus flexilis* (Hall) from it (Cumming, 1967, Figure 2). The highest horizon (G_3) yielded several specimens which resemble *Phyllograptus*. Because of their incomplete nature, however, it is impossible to discern whether they are *Phyllograptus* or *Pseudophyllograptus* (Dr. S.H. Williams, personal communications, 1984).

In terms of Berry's (1960) Marathon, Texas graptolite zonation, *Clonograptus flexilis* (Hall) ranges from the *Adelograptus - Clonograptus* Zone to the *Tetragraptus fruticosus* -4 branched Zone. Braithwaite (1976, page 52, Figure 10) also records *C. flexilis* from the top of Ross-Hintze Zone G_2 in Utah (see Figure 3). Fortey (1979, page 64, 102, 104) identified a cranidium of *Benthamaspis conica* Fortey which Berry (1960; Plate 7, Figures 1, 3) had illustrated (under a different name) from the *Tetragraptus fruticosus* -4 branched Zone. At Catoche Point, *C. flexilis* occurs within the range of *B. conica* (see Figure 2). This evidence implies at least a partial correlation between Ross-Hintze Zone G_2 and Berry's *Tetragraptus fruticosus* -4 branched Zone, the latter being equivalent to the lower half of the Arenig *Didymograptus deflexus* Zone of Great Britain (Jackson, 1964; Skevington, 1963, 1968, 1973) - see Figure 4. This is in accord with the conclusions of Flower (1978), Fortey (1979a) and Boyce (1983b).

In terms of Berry's (1960) graptolite zonation, *Pseudophyllograptus/Phyllograptus* ranges from the *Tetragraptus fruticosus* -4 branched Zone to the *Glyptograptus* cf. *G. teretiusculus* Zone. Braithwaite (1976, page 52, Figure 10) records *Phyllograptus* species (now assigned to *Pseudophyllograptus*) as ranging from the top of Ross-Hintze Zone G_2 to the top of Zone K - see Figure 3. Fortey (1976) showed that in Spitsbergen the range of the trilobite *Carolinites genacinaca nevadensis* Hintze extends into Berry's (1960) *Tetragraptus fruticosus* -3 and 4 branched Zone; *Carolinites genacinaca nevadensis* also occurs in Ross-Hintze Zone H (Hintze, 1953). Fortey (1979a, pages 100-102) also recognized *Benthamaspis gibberula* (Billings) as occurring in Zone H. At Catoche Point *Pseudophyllograptus/Phyllograptus* occurs stratigraphically above *C. genacinaca nevadensis* but associated with *B. gibberula*. The above data suggest that Ross-Hintze Zone H and Berry's *Tetragraptus fruticosus* -3 and 4 branched Zone are largely correlative and, therefore, both equivalent to the upper half of the Arenig *Didymograptus deflexus* Zone of Great Britain-Scandinavia (Jackson, 1964; Skevington, 1963, 1968, 1973) - see Figure 4. This agrees with the conclusions of Flower (1978), Fortey (1979a) and Boyce (1983b).

Undolomitized limestone remnants of the uppermost Catoche Formation exposed approximately 1.4 km northeast of Table Point yielded a previously unknown trilobite fauna. The following species were obtained:

Benthamaspis sp. cf. *B. diminutiva* Hintze, 1953
Bolbocephalus sp. undet.
Gen. et spp. undet.
Goniotelina sp. nov.
Ischyrotoma sp. undet.
Isoteloides sp. undet.
Jeffersonia sp. cf. *J.jenii* Cullison, 1944
? *Strotactinus* sp. undet.

This new fauna ranges through approximately 8 m of strata; its top occurs about 10 m below a distinctive graptolite horizon which occurs at the base of the Aguathuna Formation (see below). The fact that the closest stratigraphically underlying trilobite fauna is of demonstrable Ross-Hintze Zone H age (Fortey, 1979a; Boyce, 1983a, this report) suggests that the new fauna is younger. The presence of *Benthamaspis* sp. cf. *B. diminutiva* Hintze

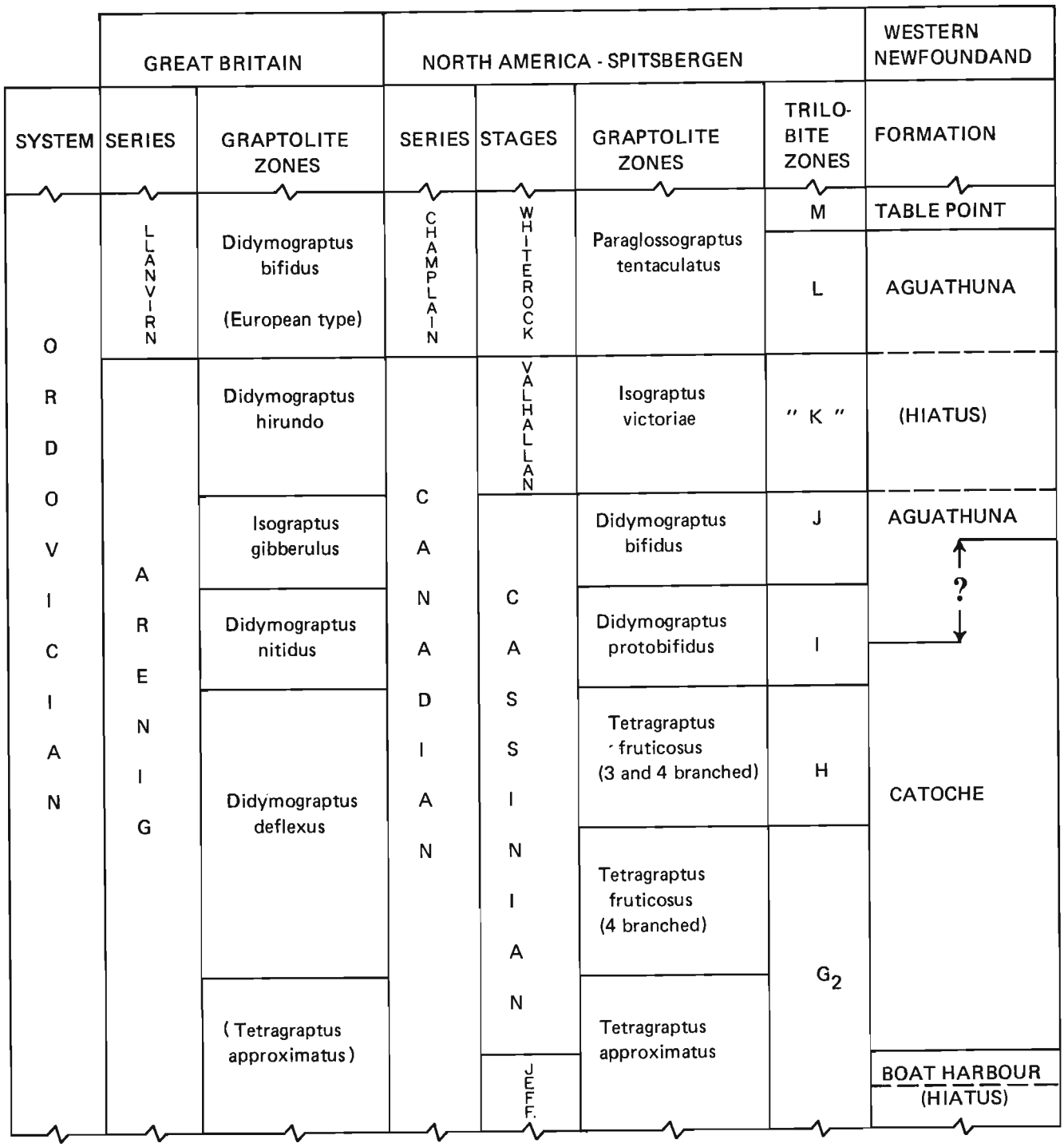

Figure 4: *Summary of correlations proposed in this report. Correlation of North American - Spitsbergan trilobite and graptolite zones after Fortey (1976, 1979a,b, 1980) and Boyce (1983b). Correlation of British and North American graptolite zones after Skevington (1963, 1968, 1973) and Jackson (1964). Usage of Valhallan Stage after Fortey (1979b, 1980). Correlation of Aguathuna Formation partly after Stouge (1982). CHAMPLAIN. = Champlainian, JEFF. = Jeffersonian.*

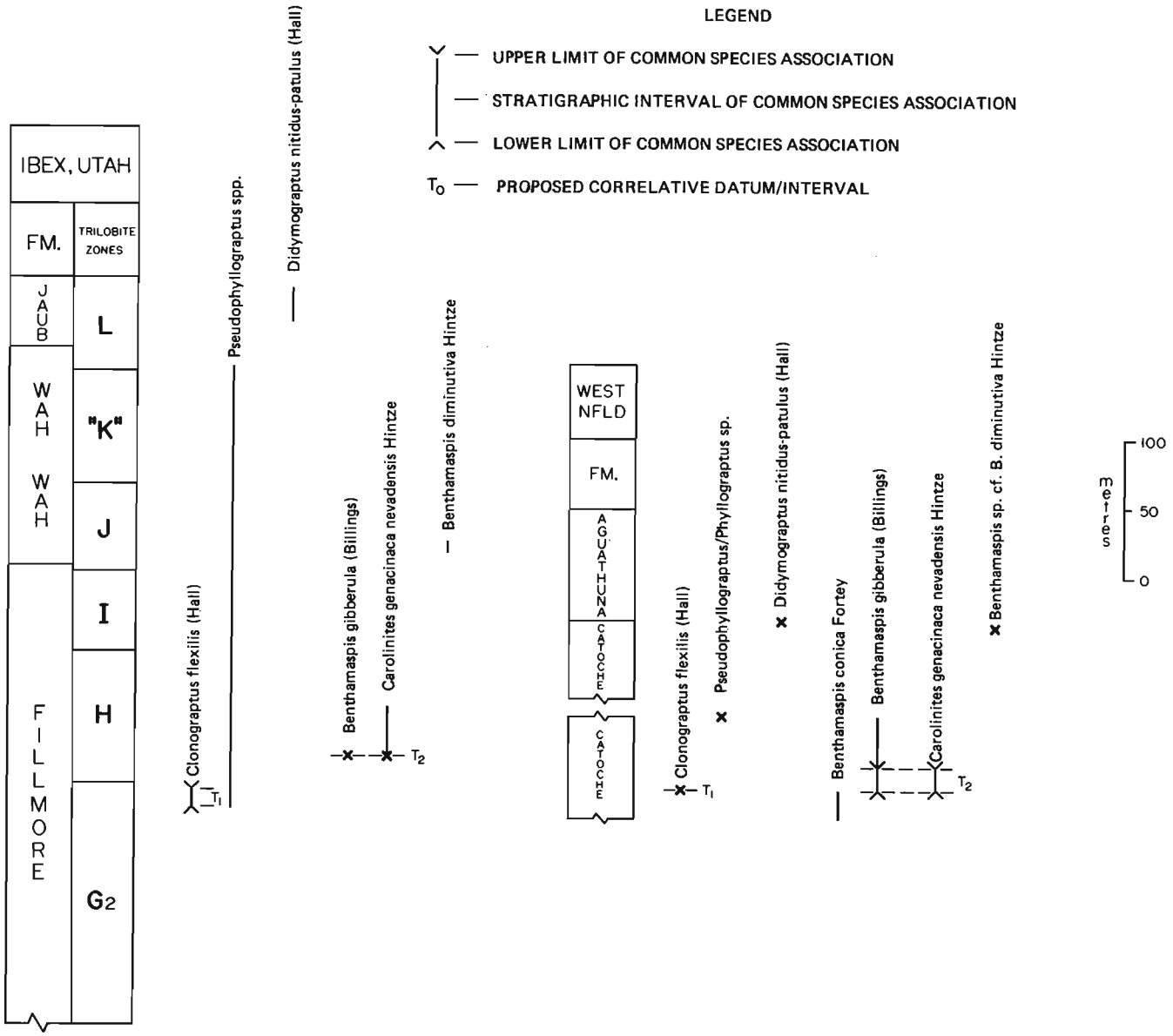

Figure 3: *Comparison and correlation of ranges of graptolite and trilobite species/species associations common to Ibex, Utah and Port au Choix-Table Point, western Newfoundland. Ibex graptolite data after Braithwaite (1976); trilobite data after Hintze (1953) and Young (1973). Western Newfoundland graptolite data after Ruedemann (1947), Cumming (1967) and Boyce (this report); trilobite data after Fortey (1979a) and Boyce (this report). Note: Zone "K" and the appropriate interval of the Wah Wah Formation are not to scale.*

and the genus *Goniotelina* may indicate an age as young as Zone J because, in Utah, *B. diminutiva* is restricted to Zone J (Hintze, 1953, page 142, 143; Plate XIII, Figures 9-12) (see Figure 3). Stouge (1982, page 10, also Figure 4) and Stouge (*in* Stouge and Boyce, 1983, Figure 2.2) record the following conodont species from the uppermost part of the Catoche Formation north of Table Point:

Scolopodus? gracilis Ethington and Clark
Oistodus inaequalis Lindstrom
Oepikodus communis (Ethington and Clark)
Drepanodus arcuatus Pander
Semiacontiodus asymmetricus (Barnes and Poplawski)
Microzarkodina marathonensis (Bradshaw)
Juanognathus variabilis Serpagli

These species also occur in the Pogonip Group at Ibex, Utah. Unfortunately, they do not provide any more biostratigraphic precision than the trilobites. With reference to Ethington and Clark (1981, Figure 3), the minimum range of the above species assemblage is Ross-Hintze Zone H to J. This suggests that the uppermost Catoche conodont assemblage is of a similar age. Because it occurs stratigraphically well above a proven Zone H trilobite fauna, however, it is more probably of Zone I or J age. This is in accord with Stouge (1982, Figure 5). Final determination of the age must await more detailed examination of the trilobites and analysis of the conodont samples.

The graptolite horizon at the base of the Aguathuna Formation north of Table Point yielded many individuals of a species which the author identified as *Didymograptus patulus* (Hall). This horizon was originally studied by Ruedemann (1947, pages 341-342; Plate 55, Figure 22; Plate 56, Figure 17), who identified and described *D. patulus* from samples donated by Helgi Johnson. Subsequently, Lenz (personal communications, 1970 *in* Collins and Smith, 1975, page 403) reported "poorly preserved specimens of *Didymograptus* cf. *patulus* (Hall) and *Didymograptus* cf. *nitidus* (Hall)" from the same horizon and Erdtmann (1971, p. 1515, Table 1C) identified *Didymograptus patulus* from this locality (listed by him as Bateau Cove, Table Head). According to Ruedemann (1947, page 342) and Dr. S.H. Williams (personal communication, 1984), there is a marked intergradation in form between *D. patulus* and *Didymograptus nitidus* (Hall); it is the opinion of Dr. S.H. Williams (personal communication, 1984) that the two species can scarcely be distinguished and the best that one can do is to refer to them as *Didymograptus nitidus-patulus* group. Keeping this in mind, it is noteworthy that with respect to Berry's (1960) Marathon, Texas, graptolite zonation, *D. nitidus* ranges from the *Adelograptus - Clonograptus* Zone to the *Didymograptus protobifidus* Zone and *D. patulus* ranges from the *Tetragraptus fruticosus* -4 branched Zone to the *Didymograptus protobifidus* Zone. Fortey (1976) demonstrated a correlation of Ross-Hintze Zones I and J with Berry's (1960) *Didymograptus protobifidus* and *Didymograptus bifidus* Zones, respectively. However, Braithwaite (1976, page 52, Figure 10) also recorded both *D. nitidus* and *D. patulus* from the basal Whiterock Ross-Hintze Zone L in Utah (see Figure 3) which, according to Fortey (1979b, Text - Figure 3) correlates wih the basal Llanvirn European *Didymograptus bifidus* Zone, equivalent to Berry's *Paraglossograptus tentaculatus* (formerly *Hallograptus etheridgei*) Zone (Jackson, 1964; Skevington, 1963, 1968, 1973) - see Figure 4. Furthermore, Ruedemann (1947, page 341) reported that *D. patulus* "occurs in the Lower Llanvirn beds of the St. David's district in Wales associated with *D. bifidus, D. nicholsoni, ...*". This strongly suggests that *D. nitidus - patulus* has a greater range than was indicated by Berry (1960).

Because the basal Aguathuna Formation *D. nitidus-patulus* horizon occurs only about 10 m above possible Ross-Hintze Zone I to J trilobites and stratigraphically well above proven Ross-Hintze Zone H trilobites and probable *Tetragraptus fruticosus* -3 and 4 branched Zone graptolites, it is probably also of Ross-Hintze Zone I to J and *Didymograptus protobifidus* to *Didymograptus bifidus* Zone age (see Figure 4). This makes the fauna equivalent to the late Arenig *Didymograptus nitidus* to *Isograptus gibberulus* Zones of Great Britain (Jackson, 1964; Skevington, 1963, 1968, 1973). This is consistent with the fact that *D. nitidus-patulus* first appears in Bed 11 of the Cow Head Group (Kindle and Whittington, 1958) (Drs. R.K. Stevens and S.H. Williams, personal communications, 1984) which Whittington (1968, page 50, Table 4-1) correlated with Berry's Zones 4 to 7 (*Tetragraptus fruticosus* -4 branched to *Didymograptus bifidus* Zones). Lenz (personal communication, 1970 *in* Collins and Smith, 1975) assigned a latest *Tetragraptus fruticosus* -3 and 4 branched Zone age or a *Didymograptus protobifidus* Zone age to the basal Aguathuna Formation graptolite horizon; Erdtmann (1971, page 1515, Table 1C) tentatively assigned it a *Didymograptus protobifidus* Zone age.

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