# Lower Carboniferous ostracodes from the Maritimes Basin of eastern Canada: A review

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Lower Carboniferous ostracode assemblages of marine affinity occur in sediments of the Codroy Group in southwestern Newfoundland and the Windsor Group in central Nova Scotia. Three ostracode assemblages are defined from Nova Scotia and five from Newfoundland. The assemblages are described from biohermal and non-biohermal limestones and fine-grained siliciclastic lithologies. The assemblages can be characterised by their responses to varying degrees of physiological stress, and are dominated by members of the Paraparchitacea, although bairdiaceans, hollinomorph and kirkbyacean palaeocopids and kloedenellaceans may be locally abundant.

In the Maritimes Basin, the combined effects of tectonism, eustatic fluctuation and a semi-arid climate resulted in palaeoenvironments that were characterised by low temporal and spatial stability. As a consequence, total ostracode species richness relative to individual species abundances was low, and often expressed in the development of low grade communities that were controlled more by physical (allogenic) rather than biological (autigenic) parameters. Under these conditions the eurytopic paraparchitaceans were capable of producing large populations in physically harsh palaeoenvironments, whereas the more stenotopic bairdiaceans and palaeocopes only occurred when conditions were favourable.

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Les sédiments des groupes de Codroy (sud-ouest de Terre-Neuve) et de Windsor (centre de la Nouvelle-Ecosse) renferment des assemblages d'Ostracodes, à affinité marine, du Carbonifère inférieur. On reconnaît trois assemblages en Nouvelle-Ecosse et cinq à Terre-Neuve. Ces assemblages proviennent de calcaires (biohermaux ou non) et de lithologies siliciclastiques à grain fin. On peut caractériser ces assemblages par leurs réponses aux divers degrés de stress physiologique. On y note la prédominance des représentants des Paraparchitacea malgré l'abondance locale des bairdiacés, des paléocopidés hollinomorphes et kirkbyacés ainsi que des kloedenellacés.

Dans le Bassin des Maritimes, la conjonction de divers facteurs (tectonisme, fluctuations eustatiques, climat semi-aride) se traduisit par des paléomilieux caractérisés par une stabilité spatiale et temporelle faible. En conséquence, la richesse spécifique totale des Ostracodes était basse par rapport aux abondances spécifiques individuelles et s'exprimait souvent part le développement de communautés immatures contrôlées par des paramètres plus physiques (allogènes) que biologiques (autogènes). Dans ces conditions, les paraparchitacés eurytopiques pouvaient peupler abondamment les paléomilieux physiquement exigeants, alors que les bairdiacés et les paléocopes (qui étaient plus sténotopiques) n'étaient présents que dans des biotopes favorables.

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## INTRODUCTION

During the lower Carboniferous, the Maritimes Basin was an evolving, strike-slip basin (Bradley, 1982; Knight, 1983), which was subdivided into a number of subbasins separated by arches (Howie and Barss, 1975). For most of its depositional history (from late Devonian to late Carboniferous), the Maritimes Basin and its constituent subbasins, was a fluvial depocentre. Transgressive marine inundation of the basin occurred during deposition of the Windsor Group of Nova Scotia (Bell, 1929; Giles, 1981) and the Codroy Group of Newfoundland (Bell, 1948; Baird and Cote, 1964; Knight, 1983), (Fig. 1). During the transgressive episodes the Maritimes Basin was an epicontinental embayment of the northern Hercynian Ocean (Dewey, 1985).

The occurrence of red siliciclastics, evaporites, limestones and coals within the basin suggests an arid to semi-arid climate (Bell, 1929; Schenk, 1969; Van de Poll, 1978; Van der Zwan, 1981), which, together with the effects of eustacy and tectonism resulted in a broad range of palaeoenvironments. Non-marine deposition occurred in alluvial fan, fluvial and lacustrine settings. Coastal palaeoenvironments included deltaic, brackish marginal-marine and hypersaline sabkhas. Marine conditions are represented by nearshore, open and restricted palaeoenvironments as well as biohermal settings. The ostracodes which form the focus of this study are described from a variety of siliciclastic and carbonate, marine and near-marine palaeoenvironments.

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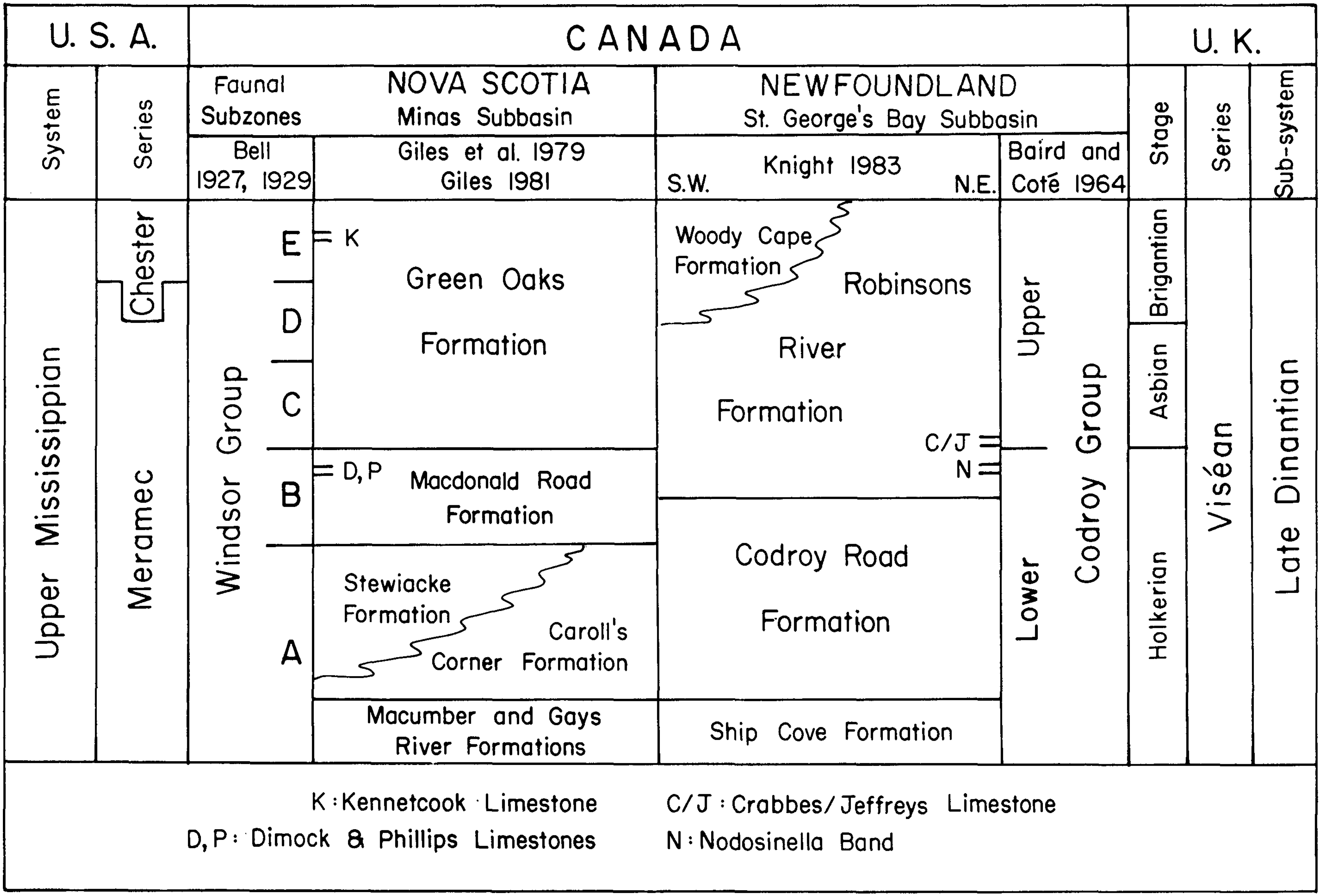


Fig. 1. Stratigraphic subdivisions of the Windsor and Codroy Groups.

## HISTORY OF STUDY

The first reference to Carboniferous ostracodes in the Maritimes Basin was by Dawson (1868) in the second edition of "Acadian Geology." In 1879, Dawson published a note on some ostracodes in the Peter Redpath Museum that had been described by Jones and Kirkby. Jones and Kirkby (1884) followed the note with descriptions of ostracodes from Nova Scotia that had been sent to them by Dawson from the Horton Group and from the coal measures at Joggins. These data, together with further descriptions of *Carbonita* from the Mabou Coal Field on Cape Breton Island (Jones and Kirkby, 1889), form the basis of ostracode study in the Maritimes Basin. Bell (1929) described the first ostracodes from Windsor Group sediments of Nova Scotia, and described some more material from the Horton Group (Bell, 1960). Copeland (1957) described an extensive, predominantly freshwater ostracode fauna from the Canso, Riversdale, Cumberland and Pictou Groups in Nova Scotia; and Bless and Jordan (1971) erected a new genus, *Copelandella*, in a re-description of material from the Horton Group. Dewey (1983a), provided the first detailed taxonomic and palaeoecological study of marine ostracodes in the lower Carboniferous strata of the Maritimes Basin.

Samples for ostracode analysis (Dewey, 1983a) were collected from lower Carboniferous strata in five areas of southwestern Newfoundland and central Nova Scotia (Fig. 2). The samples were collected from limestones and shales that represent marine and near-marine conditions within the basin. Discussions of the Newfoundland ostracode assemblages are given in Dewey (1983b) and the Nova Scotia assemblages are described in Dewey (1987, 1988). This paper presents a regional palaeoecological synthesis of these data using the taxonomy in Dewey and Fahraeus (1987).

## CARBONIFEROUS OSTRACODE PALAEOECOLOGY

Ostracodes have been used widely to determine distance from shore, bathymetry and conditions of palaeosalinity in Carboniferous palaeoenvironments. At least three distinct types of ostracode fauna existed during late Palaeozoic time, (van Ameron *et al.*, 1970; Becker, 1980; Bless, 1983): (i) *Carbonita*-type faunas, indicative of freshwater conditions (Pollard, 1966; Bless and Pollard, 1973), (ii) Entomozoacean-Tricorninid-type faunas, indicative of deep basinal environments (Becker *et al.*, 1975; Becker, 1982, 1984), including the "ecotype de Thuringe" of Lethiers and Crasquin (1987), and (iii) Paraparchitacean, bairdiacean, palaeocope and kloedenellacean faunas, indicative of a range of environments from marginal marine to outer shelf. An extensive literature exists concerning the distribution of these types of faunas (see for example: van Ameron *et al.*, 1970; Becker *et al.*, 1974; Haack and Kaesler, 1980; Kaesler, 1982; Bless, 1983; Crasquin, 1984; Melnyk and Maddocks, 1988). Comprehensive studies that evaluate the ecological tolerance and significance of individual genera and species are however, few.

The study of ostracode faunas from the Maritimes Basin provides an opportunity to examine the distribution of "shallow marine" faunas in a variety of palaeoenvironments that were associated with varying degrees of physiological stress.

## NOVA SCOTIAN ASSEMBLAGES

Ostracodes were collected from three transgressive marine carbonate units within the Windsor Group. Ostracodes were collected from a biostromal limestone in the Gays River Formation in Antigonish County, from carbonate-siltstone-evaporite triplets in a lateral equivalent of the MacDonald Road Formation in Hants County and from the Kennetcook Limestone in the uppermost Green Oaks Formation of Hants County (Figs. 1, 2). (For detailed sampling data refer to Dewey, 1983a or Dewey and Fahraeus, 1987.)

### Assemblage A

This assemblage (Table 1) was derived from a massive, buff-coloured, micritic limestone in the Gays River Formation in Antigonish County (Dewey, 1988). The bioclastic association developed over a drowned granodioritic pluton, which acted as a topographic high during the first marine transgression of Windsor time (Geldsetzer *et al.*, 1980). A varied invertebrate fauna consists of ostracodes, brachiopods, bryozoans, conulariids, bivalves and gastropods, but corals and crinoids are notably absent. Nine species of ostracode are present, of which 75% of the individuals are represented by the paraparchitaceans *Chamishaella suborbiculata* (Munster, 1830) and *Shishaella moreyi* Sohn, 1971. Bairdiaceans form only about 10% of the ostracode fauna and the only palaeocope present is *Amphissites* sp. aff. *A. centronotus* (Ulrich and Bassler, 1906), which represents 3% of the fauna. Paraparchitaceans have been described from nearshore marine environments of various salinities (Sohn, 1971; van Ameron *et al.*, 1970; Robinson, 1978; Bless, 1983), whereas bairdiaceans are only recorded from stable, shallow, subtidal, normal marine salinity environments (Kornicker, 1961; Ferguson, 1962, 1974; Kaesler, 1982; Crasquin, 1984). The ostracode association suggests a shallow marine shelf environment; however, the lack of corals or crinoids together with the overlying evaporites that occur throughout the area, also suggest an abnormally saline environment. Ostracode assemblage A is contemporaneous with Newfoundland Assemblages I and II (Dewey, 1983b).

### Assemblage B

This assemblage (Table 1) was collected from the dark brown, micritic, Dimock and Phillips Limestones (Fig. 1) in Hants County (Dewey, 1987, 1988). The limestones contain a very high abundance, low diversity fauna of ostracodes, rare brachiopods and the ?bryozoan *Palaeocrisidia*. The Dimock and Phillips Limestones each occur at the base of a carbonate-siltstone-evaporite triplet. The evaporites developed on supratidal sabkhas and the limestones represent marginal marine conditions (Geldsetzer *et al.*, 1980). The ostracode fauna consists of only five species, of which more than 75% is composed of *Paraparchites* sp. aff. *P. kellettae* Sohn, 1971 and *Chamishaella suborbiculata*. The sedimentological evidence (Geldsetzer *et al.*, 1980) supports the idea that high abundances of paraparchitaceans may be related to salinity-stressed environments (Sohn,

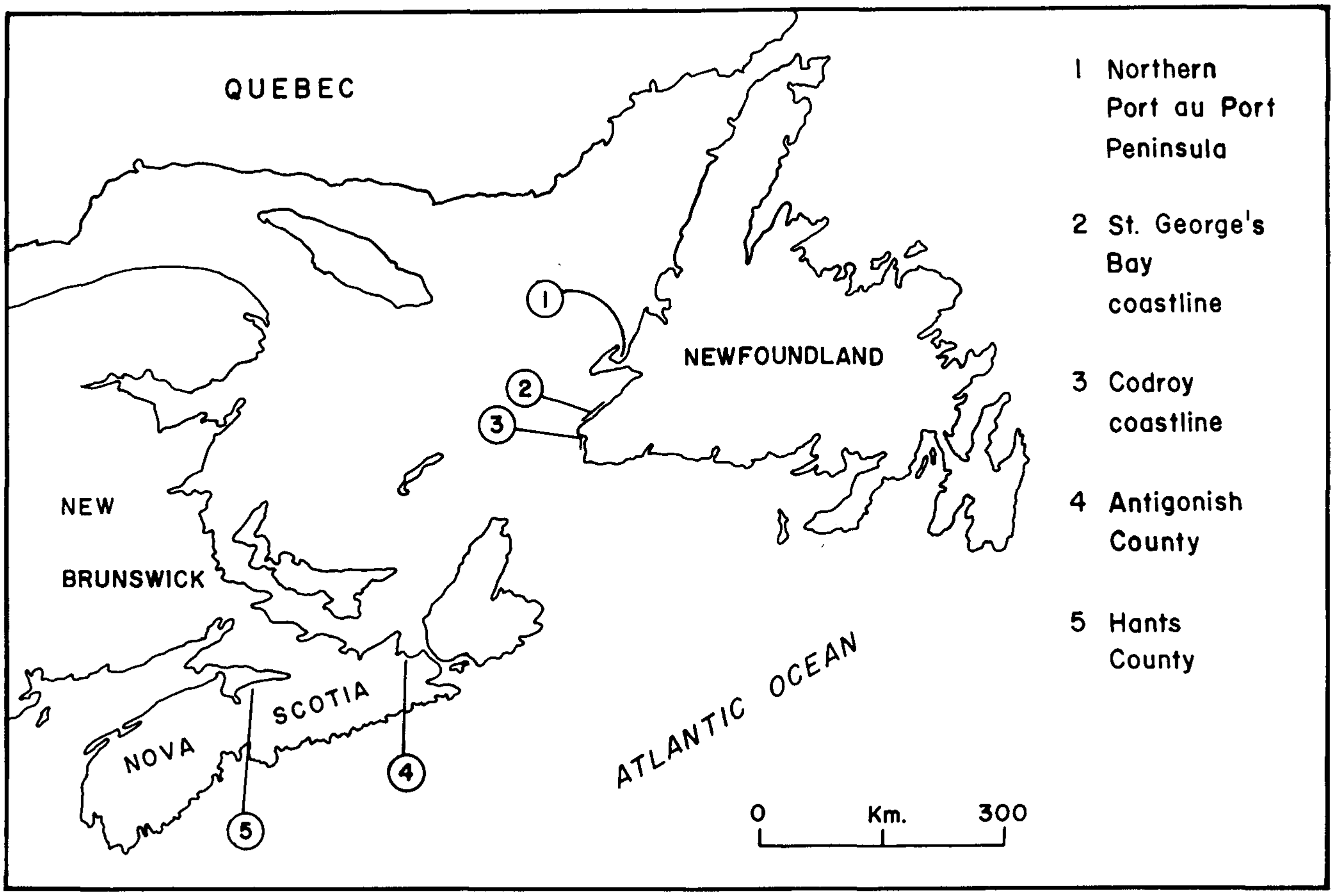


Fig. 2. Location of study area.

1971; Robinson, 1978; Bless, 1983; Dewey, 1987). A further 20% of the fauna is composed of *Beyrichiopsis lophota* Copeland, 1957. *Beyrichiopsis* is thought to be an indicator of marginal marine environments (Becker *et al.*, 1974) and its occurrence in Nova Scotian materials (Copeland, 1957; Dewey, 1987) may indicate a broad salinity tolerance in such environments. Growth curves for *Paraparchites* sp. aff. *P. kellettae* and *B. lophota* indicate that the assemblage is an *in situ*, multi-generation fauna, and that *Paraparchites* sp. aff. *P. kellettae* exhibits progenic parthenogenesis (Dewey, 1987). The ostracode fauna is typical of a low level community and the very large populations of a few species probably reflects a lack of inter-specific competition due to the exclusion of stenotopic specialists, rather than a nutrient rich environment (Levinton, 1970). The assemblage is therefore interpreted as occurring in a nearshore hypersaline carbonate environment where opportunistic euryhaline species could thrive in abundance whereas less tolerant species were unable to survive.

### Assemblage C

This assemblage (Table 1) was derived from the massively bedded, buff-coloured bioclastic Kennetcook Limestone (Fig. 1) in Hants County (Dewey, 1988). The limestone contains a rich fauna of brachiopods, gastropods, bivalves, bryozoans, corals, tentaculitids, crinoid ossicles, forams and twelve species of ostracodes. The sedimentologic and faunal evidence suggests a low energy, shallow subtidal environment of near normal marine salinity (Moore, 1967).

The dominant ostracodes in this assemblage are members of the Subfamily Bairdiinae, which, represented by *Bairdia brevis* Jones and Kirkby, 1867, *Bairdia* sp. L. Sohn, 1960 and *Bairdiacypris quartziana* Egorov, 1953 constitute 42% of the fauna. A co-dominant group is the Palaeocopida which accounts for 37% of the fauna. The most common palaeocope is *Kirkbya novascotica* Dewey and Fahraeus, 1987 although rare individuals of "*Gortanella*" sp. are also present. The association of bairdiaceans and kirkbyaceans in Late Palaeozoic faunas indicates stable, offshore, normal marine salinity environments (van Ameron *et al.*, 1970; Becker *et al.*, 1974; Kaesler, 1982).

The assemblage does not exhibit a high species diversity, but the presence of corals, crinoids and forams would suggest that salinity-stress was not a factor in determining the assemblage composition.

## NEWFOUNDLAND ASSEMBLAGES

Ostracodes occur in marine and near-marine carbonate and siliciclastic sediments of the Codroy Group (Fig. 1). Ostracodes were collected from a biohermal limestone and grey micrites in the Ship Cove Formation, from limestone and shale in the lower part of the Robinsons River Formation and from dark shale within the Woody Cape Formation. (For detailed sampling locations see Dewey, 1983a or Dewey and Fahraeus, 1987).

Table 1. Distribution of ostracodes in marine assemblages of the Windsor and Codroy Groups.

| | ASSEMBLAGE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NOVA SCOTIA | | | NEWFOUNDLAND | | | | |
| OSTRACODE SPECIES | A | B | C | I | II | III | IV | V |
| "*Copelandella*" sp. | | | | | | x | | x |
| *Gortanella* sp. | | | x | | | | x | |
| *Aechmina* sp. | | | | x | | | | |
| *Kirkbya novascotica* Dewey and Fahraeus, 1987 | | | x | | | | | |
| *Amphissites* (*Amphidites*) *aguathunaensis* Dewey and Fahraeus, 1987 | | | | x | | | | |
| *Amphissites* sp. aff. *A. centronotus* (Ulrich and Bassler, 1906) | x | | | | ? | | | |
| *Youngiella* sp. | | | | x | x | | | |
| *Bairdia* sp. L. Sohn, 1960 | x | | x | x | | | | |
| *Bairdia brevis* Jones and Kirkby, 1867 | | | x | | | | | |
| *Bairdiacypris quartziana* Egorov, 1953 | | | x | | | | | |
| *Bairdiacypris striatiformis* Dewey and Fahraeus, 1987 | | | | x | x | | | |
| *Acratia acuta* (Jones and Kirkby, 1895) | x | x | x | x | x | x | x | |
| *Acratia* sp. A. | | | | x | | | | |
| *Acratia* sp. B. | | | | x | | | | |
| *Bythocypris aequalis* Jones and Kirkby, 1886 | x | x | x | | | x | | x |
| *Monoceratina antiqua* (Jones and Kirkby, 1886) | | | | x | | | | |
| *Monoceratina youngiana* (Jones and Kirkby, 1886) | | | x | | | | | |
| *Geisina* sp. | | | | | | x | | x |
| *Beyrichiopsis cornuta* Jones and Kirkby, 1886 | | | x | | | | | |
| *Beyrichiopsis lophota* Copeland, 1957 | | x | | | | | | |
| *Sulcella levisulcata* Dewey and Fahraeus, 1987 | x | | | x | x | x | | x |
| *Healdia* sp. | | | | x | | | | |
| *Healdianella* sp. | x | | x | x | | | | |
| *Paraparchites* sp. aff. *P. kellettae* Sohn, 1971 | | x | | | | | | |
| *Chamishaella suborbiculata* (Munster, 1830) | x | x | x | x | x | x | x | x |
| *Chamishaella inverticoriformis* Dewey and Fahraeus, 1987 | | | | x | x | x | | |
| *Shemonaella scotoburdigalensis* (Hibbert, 1836) | | | | x | | | | x |
| *Shishaella moreyi* Sohn, 1975 | x | | | x | x | | | |
| *Shivaella* sp. | | | | x | x | | | |
| *Polycope spinula* Dewey and Fahraeus, 1987 | x | | x | x | | | | |

**Assemblage I**

This is the most species-rich assemblage of the present study (Table 1) and is based upon samples from a buff-coloured, biohermal limestone that infilled a karsted terrain on the northern Port au Port Peninsula (Fig. 2). The assemblage is dominated by smooth and spinose paraparchitaceans, which as a group comprise more than 80% of the ostracode fauna and include *Chamishaella suborbiculata*, *C. inverticoriformis* Dewey and Fahraeus, 1987, *Shemonaella scotoburdigalensis* (Hibbert, 1836), *Shishaella moreyi*, and rare *Shivaella* sp. The species *C. suborbiculata* dominates, and contributes ten times more individuals to the assemblage than any other single species. Bairdiaceans, including three species of *Acratia* together with *Bairdia* sp. *L*, and *Bairdiacypris striatiformis* Dewey and Fahraeus, 1987 as well as a kirkbyacean, *Amphissites (Amphidites) aguathunaensis* Dewey and Fahraeus, 1987, are indicative of shallow shelf conditions.

A subassemblage, derived from plant-bearing sandstones associated with the biohermal limestones, includes a few individuals of *C. suborbiculata* and *S. moreyi* together with *Acratia acuta* (Jones and Kirkby, 1895).

The biohermal ostracode fauna, together with the high abundance, low diversity macro-invertebrate fauna dominated by bryozoans, brachiopods and microbial communities, but lacking in echinoderms and corals (Dix, 1982; Dix and James, 1987), is suggestive of environmental salinity stress. Dix (1982), and Dix and James (1987) suggest that the associated plant-bearing sandstones were deposited by the episodic influx of sediment-laden fresh-water, which therefore lowered the local salinity. During calm weather when fluvial influx was minimal, hypersaline conditions may have developed (Dix and James, 1987). It is possible therefore, that the paraparchitacean-dominated faunas of Assemblage I are a result of fluctuating salinities, rather than raised or lowered salinities *per se*.

An alternative suggestion for carbonate mound development in the lower Codroy Group of the Port au Port Peninsular, is that they developed as hydrothermal vent associations (von Bitter *et al.*, 1988). In this case, it is unlikely that salinity would play such an important role in determining the nature of the biotic associations. The vent association model would explain the lack of calcareous algae (Dix and James, 1987), the "large ?worm tubes" (Dix, 1982) and also the sulphide and sulphate mineralisation (Dix, 1982; von Bitter *et al.*, 1988). The model would also represent a unique occurrence for Carboniferous ostracode faunas.

This assemblage is contemporaneous with Assemblage II and Nova Scotia Assemblage A.

**Assemblage II**

This assemblage (Table 1) is laterally equivalent to Assemblage I and occurs on the northern Port au Port Peninsula in an eight-metre sequence of grey, laminated, peloidal micrites containing solution collapse features. The upper units of the section have a lower ostracode diversity than the lower units and contain *C. suborbiculata*, *S. moreyi*, *Shivaella* sp. and *A. acuta*. In addition to these, the lower units contain *Youngiella* sp., a poorly preserved species of *Amphissites*, and *Sulcella levisulcata* Dewey and Fahraeus, 1987, all of which occur in similar proportions. The assemblage shows a progressive reduction in both diversity and individual abundances, from the base to mid section and then diversity begins to increase again, though not to the initial levels (Dewey, 1983a). Dix (1982) suggests that the depositional environment was a broad, shallow, hypersaline basin. The paraparchitacean-dominated ostracode fauna indicates that the basin never had truly normal marine salinity waters within it, and furthermore, that the palaeoenvironmental conditions deteriorated progressively after the initial transgression and then improved slightly during deposition of the uppermost units.

**Assemblage III**

This assemblage (Table 1) occurs in the grey shales of the *Nodosinella* Band (Fig. 1) in the region of the St. George's Bay coastline (Fig. 2). The assemblage is derived from units equivalent to Lithofacies M of the Robinsons River Formation (Knight, 1983). The shales are interpreted as being deposited in a restricted marine environment such as a back-barrier lagoon that was subject to occasional high energy deposition and variations in salinity (Knight, 1983). The ostracode fauna is relatively sparce, although some samples do show high abundances (Dewey, 1983a). *C. suborbiculata*, *A. acuta* and *S. levisulcata*, occur in almost equal proportions although *Chamishaella* still dominates. *Geisina* sp. and "*Copelandella*" are rare components of the assemblage that do not occur in Assemblage I or II. Pollard (1969) suggested a brackish-water affinity for *Geisina*, and Bless and Jordan (1971) stated that *Copelandella* is a nearshore marine form that might occur in brackish or even fresh water. The low diversity of the paraparchitacean-dominated ostracode fauna, coupled with the occurrence of a few individuals of brackish species, suggests that this assemblage also developed under conditions of varying salinity.

**Assemblage IV**

Ostracodes of Assemblage IV (Table 1) occur sparsely in the shaley limestones of the Crabbes-Jeffreys Limestone (Fig. 1). The Crabbes-Jeffreys limestone is equivalent to Lithofacies R of the Robinsons River Formation (Knight, 1983). The sparse ostracode assemblage includes *C. suborbiculata*, *A. acuta* and "*Gortanella*" sp. The presence of the hollinomorph "*Gortanella*" sp., is indicative of stable, normal marine salinity conditions. The absence of *Bairdia* is significant, however a nearshore marine association characterised by the presence of velate palaeocopes but lacking in bairdiaceans has been proposed by several authors (von Ameron *et al.*, 1970; Kaesler, 1982). Due to the small numbers of individuals present, it is not certain whether the assemblage is *in situ*.

**Assemblage V**

The grey and black shales of the Woody Cape Formation in the Codroy coastline area (Fig. 2) occur within what is interpreted to be a deltaic sequence (Knight, 1983) and yield few ostracodes. *C. suborbiculata* is still the most common form, but is associated with *Geisina* sp. and "*Copelandella*" sp. The ostracodes associated with the Woody Cape Formation are indicative of restricted marginal marine conditions. The presence of *Geisina* and "*Copelandella*" may indicate brackish salinity.

## DISCUSSION

Ostracodes from lower Carboniferous strata of the Maritimes Basin occur in a variety of palaeoenvironments. Nova Scotia Assemblage C is dominated by bairdiaceans and kirkbyaceans and can therefore be considered to represent normal marine salinity, offshore, shelf conditions. Newfoundland Assemblage IV, contains hollinomorphs but no bairdiaceans and may be indicative of nearshore stable marine conditions.

All other assemblages are paraparchitacean-dominated. Nova Scotia Assemblage B and Newfoundland Assemblage II can be related to coastal hypersaline conditions and therefore indicate that paraparchitaceans were tolerant of raised salinities. Furthermore, in such palaeoenvironments the paraparchitaceans often produced large populations and behaved as opportunists. The occurrence of *B. lophota* in Nova Scotia Assemblage B indicates that this form, typically associated with brackish palaeoenvironments, exhibited a euryhaline tolerance.

Newfoundland Assemblages III and V are harder to evaluate. The abundance of paraparchitaceans and their association with brackish water indicators such as *Geisina* and "*Copelandella*" suggests a tolerance for a wide range of salinities. The scarcity of both *Geisina* and "*Copelandella*" in these assemblages may be a function of short-lived or unstable palaeoenvironments, whereas paraparchitaceans such as *Chamishaella suborbiculata* were capable of withstanding these conditions.

Nova Scotia Assemblage A is also paraparchitacean-dominated, but contains some bairdiaceans and a kirkbyacean, which may indicate an affinity to offshore marine conditions. The paraparchitacean dominance, given other associations demonstrated herein, is taken to indicate raised salinities. Of related interest is Newfoundland Assemblage I which contains a similar, but higher diversity fauna, and occurs in a biohermal association that also developed in a salinity-stressed palaeoenvironment. The contemporaneous development of Nova Scotia Assemblage A and Newfoundland Assemblages I and II in three different palaeoenvironments, during the first transgression of Windsor/Codroy time, coupled with the abundance of paraparchitaceans in all three assemblages, might indicate that the transgressive waters were not of normal marine salinity.

A new idea (von Bitter *et al.*, 1988) is that during the first marine transgression into the Maritimes Basin, the "Windsor Sea" contained numerous, ephemeral, hydrothermal vents which controlled both the depositional styles and biotic associations of early Windsor/Codroy time (von Bitter *et al.*, 1988).

## SUMMARY

Ostracode assemblages from marine and near-marine palaeoenvironments of the Windsor and Codroy Groups reveal much about the nature of Late Palaeozoic ostracode palaeoecology: (i) In keeping with previous studies, the occurrence of bairdiaceans and kirkbyaceans in significant numbers is indicative of offshore, normal marine salinity conditions; (ii) also, that a velate palaeocope (hollinomorph) fauna, devoid of bairdiaceans, occurs in nearshore, normal marine salinity conditions. (iii) Paraparchitaceans are ubiquitous, can exhibit a wide tolerance to salinity and may behave as opportunists in palaeoenvironments where salinity-stress restricts the occurrence of stenohaline normal marine forms. (iv) Large populations of paraparchitaceans resulting in the domination of an ostracode assemblage, may be taken as indicative of either raised or fluctuating salinities. (v) An anti-pathetic relationship can exist between the bairdiaceans and paraparchitaceans, which, in the Maritimes Basin is a function of competitive ability and ecological tolerance. This is in contrast to the development of a bairdiacean-parparchitacean ecozone in other areas of stable carbonate shelf sedimentation (Crasquin, 1984). (vi) Brackish water indicators such as the kloedenellaceans *Geisina* and *Beyrichiopsis* and the beyrichiomorph *Copelandella* may be tolerant of raised salinities, but rarely produce large populations in such environments.


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