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Palaeoecology of a hypersaline Carboniferous ostracod fauna

Chris P. Dewey
Department of Geology and Geography, Mississippi State University,
Mississippi State, MS 39762, U.S.A.

ABSTRACT–A high abundance, low diversity ostracod fauna has been collected from the Lower Carboniferous Dimock and Phillips limestones in Nova Scotia, Canada. The ostracod fauna consists of *Paraparchites* sp. aff. *P. kellettae* Sohn and *Beyrichiopsis lophota* Copeland, as well as rare specimens of *Acratia acuta* (Jones & Kirkby), *Bythocypris aequalis* (Jones & Kirkby), and *Chamishaella suborbiculata* (Munster).

Growth parameters for the dominant ostracod, *Paraparchites* sp. aff. *P. kellettae*, show that a multi-generation, progenetic, parthenogenetic population developed. This reproductive strategy caused rapid population growth and thereby allowed the species to take advantage of the available environmental resources.

When considered together, the ostracod fauna and the sedimentology indicate that physiologically stressful hypersaline conditions prevailed. The combined data therefore provide evidence for hypersalinity tolerance and heterochronous development amongst Carboniferous ostracods.

INTRODUCTION

Lower Carboniferous deposits in the Maritime Basin of Nova Scotia, Canada, document a series of eustatically controlled, transgressive-regressive cycles (Giles, 1981). Tectonic activity resulted in the development of several interconnected sub-basins (Howie & Barss, 1975; Bradley, 1982). Consequently, the complex interaction of eustacy, tectonism and climate resulted in a range of palaeoenvironments that include alluvial fan, fluvial, brackish marginal-marine and hypersaline coastal sabkhas, as well as open and restricted marine settings. Most of these environments can be characterised by low temporal and spatial stability. According to Stearns (1976), Gould (1977) and McKinney (1986), unstable environments are often associated with heterochroneity amongst living and fossil organisms. Stearns (1976) noted that parthenogenesis may occur in organisms that inhabit cyclic environments where the period of cyclicity is greater than the life cycle of the inhabitants. Stearns also suggested that several clutches may be produced per season in cyclic environments where the cyclic conditions are unpredictable. Using the term r-selection, Gould (1977) defined behavioural traits such as progenetic heterochroneity and rapid population growth as being distinctive of unstable environments.

The Maritime Basin provides an ideal opportunity to study ecological tolerance and the effect of physiologically stressful conditions upon Carboniferous ostracod communities and populations.

Several ostracod assemblages have been described from the Lower Carboniferous of the Maritime Basin (Dewey, 1983, 1985, in press). Most of the assemblages are dominated by paraparchitacean ostracods, which are often considered to be indicative of nearshore environments (van Ameron *et al.*, 1970; Becker *et al.*, 1974; Bless, 1983).

This paper examines the paraparchitacean-dominated ostracod fauna of a carbonate sabkha environment from the Windsor Group of the Minas-Shubenacadie Sub-Basin in Nova Scotia (Fig. 1).

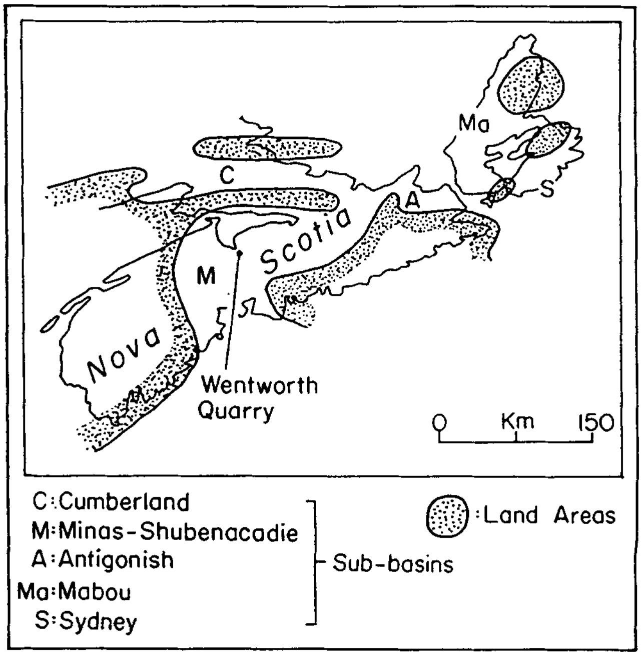

Fig. 1. Carboniferous Sub-Basins of Nova Scotia.

STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS

The Windsor Group is an internally and geographically complex stratigraphic unit because the development of formational terminology has tended to focus on the localised lithologies of each sub-basin. The Windsor Group is correlated with the Upper Mississippian of Midcontinental U.S.A. and the Visean of Europe, using foraminifera and palynomorphs (Mamet, 1970; Utting, 1980). For purposes of this study the formational terminology applied in the Shubenacadie Sub-Basin (*sensu* Giles, 1981) is used as a reference section (Fig. 2) because the sub-basin contains an almost uninterrupted succession through the Windsor Group in the general study area.

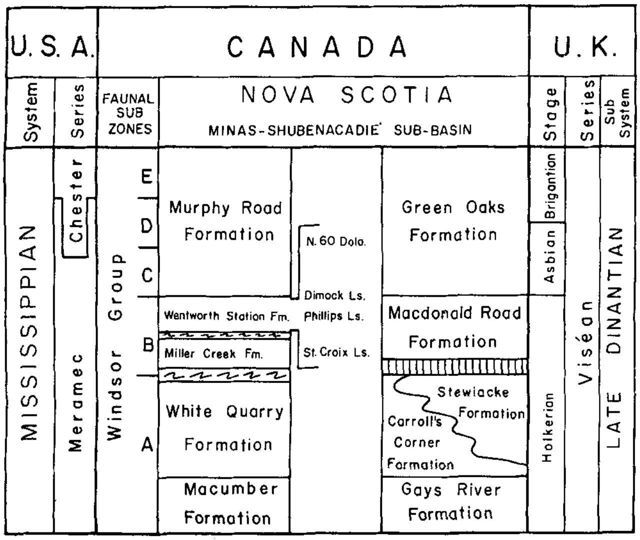

Fig. 2. Stratigraphic subdivisions of the Windsor Group.

The MacDonald Road Formation of the Shubenacadie Sub-Basin is considered to be laterally equivalent to the Miller Creek and Wentworth Station Formations which are the focus of this study in the Windsor type area. Both the Miller Creek and Wentworth Station consist of a repetitive series of anhydrites and gypsum, carbonates and fine grained siliciclastics. Megafaunal evidence indicates that the MacDonald Road and its lateral equivalents can be correlated with the Windsor B faunal subzone (Bell, 1929; Moore & Ryan, 1976).

The type localities for both of these formations are in working quarries near the town of Windsor, at the western end of the Minas-Shubenacadie Sub-Basins (Fig. 3). The Wentworth Station Formation is a 50m thick predominantly evaporite-bearing cyclic unit that contains four limestone-siltstone-evaporite triplets (Fig. 4). Each of the limestones represents intertidal environments and the thick evaporites represent the

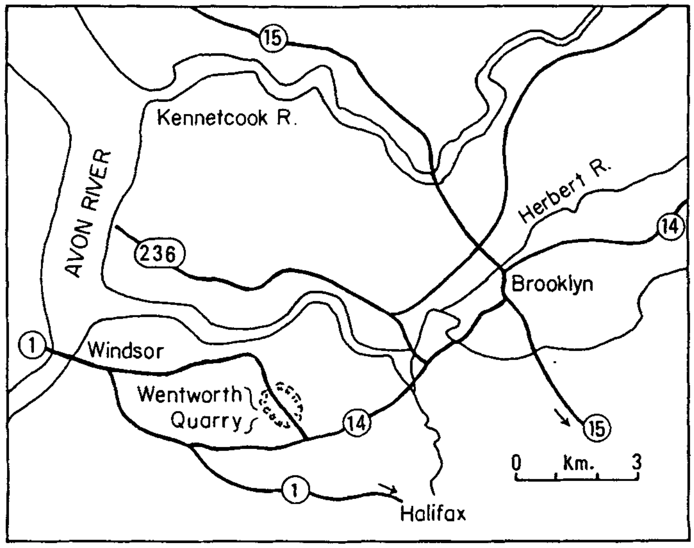

Fig. 3. Location of the study area.

supratidal environments of a coastal sabkha (Geldsetzer *et al.*, 1980). The fine grained red-brown siliciclastics may be interpreted as distal sediments from alluvial fan deposits. According to Geldsetzer *et al.* (1980), the limestones represent short-lived transgressive events, whereas the evaporites represent regressive phases associated with sabkha progradation.

The limestones, which are the focus of this study, can be very fossiliferous but constitute less than 10% of the formational sediment. The Dimock and Phillips Limestones are thin dark grey-brown bioclastic wackestones which contain a high abundance, low diversity fauna of ostracods associated with the bryozoan *Paleocrisidia* and rare gastropods. The paucispecific biota and marked absence of corals and echinoderms in the limestones indicate that the transgressive waters were not of normal (35‰) marine salinity (Bosellini & Hardie, 1973; Boucot, 1981). Taken together, the sedimentological association with sabkha evaporites and the paucispecific fauna indicate that the transgressive limestones developed under hypersaline conditions.

OSTRACOD FAUNA

A high abundance, low diversity ostracod fauna was collected from bedding plane surfaces in the Phillips and Dimock Limestones. The ostracod fauna consists of only five species. More than 75% of the fauna in each limestone unit is composed of *Paraparchites* sp. aff. *P. kellettae* Sohn; an additional 20% of the fauna is composed of the fringed kloedenellacean *Beyrichiopsis lophota* Copeland, which is closely allied to the European form *B. plicata* (Jones & Kirkby). *Acratia acuta* (Jones & Kirkby), *Chamishaella suborbiculata* (Munster), and *Bythocypris aequalis* (Jones & Kirkby)

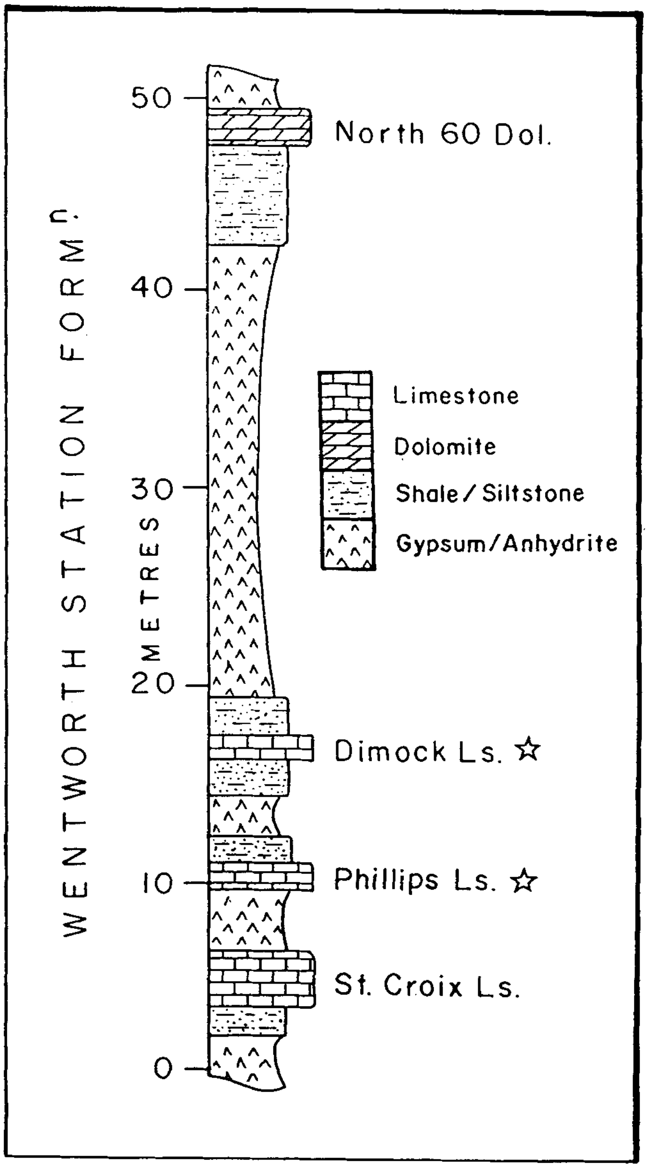

Fig. 4. Lithological profile of the Wentworth Station Formation.

are rare components of the fauna, but *B. aequalis* is absent from the Phillips Limestone. *A. acuta* and *C. suborbiculata* are common species in ostracod assemblages elsewhere in the Maritime Basin (Dewey, 1983, 1985, in press), however, their reduced occurrence in the Wentworth Station Formation may indicate that they were nearing their ecological limits. It is important to note the complete absence of the genus *Bairdia* or any related genera. *Bairdia* is considered to be a stenohaline form, indicative of normal marine salinities (Kornicker, 1961; Kaesler, 1982).

Ostracods that inhabit hypersaline environments can be demonstrated to be euryhaline (van Morkhoven, 1962; Sandburg, 1964; Gramman, 1971). This is illustrated by the euryhaline tendencies of the dominant elements of the Wentworth Station fauna. Firstly, the paraparchitaceans exhibit a range of salinity tolerance from brackish to hypersaline (Coryell & Rogatz, 1932; Copeland, 1957; Sohn, 1971; Robinson, 1978; Dewey, 1983, in press, herein). Secondly, previous descriptions of *Beyrichiopsis lophota* and the closely allied form *B. plicata* (Copeland, 1957; Robinson, 1978; ten Have, 1982) suggest that both species are diagnostic of brackish environments, and may be found in association with the freshwater genus *Carbonita*. The present occurrence of *B. lophota* in a hypersaline environment indicates a euryhaline tolerance.

The high individual abundances of a few species within this assemblage probably reflects a lack of competition with stenohaline species that cannot tolerate raised salinities, rather than a high nutrient supply (Levinton, 1970).

The low diversity and very high abundance, together with the generic character of the ostracod fauna, support the interpretation that the Dimock and Phillips limestones were not deposited under normal marine conditions. The combined lithological and palaeontological data clearly indicate a hypersaline setting.

OSTRACOD POPULATIONS

The very rich ostracod samples make it possible to examine the ways in which the fauna responded to the physiologically stressful conditions of a hypersaline environment.

Growth plots (Figs. 5,6) for *Beyrichiopsis lophota* and *Paraparchites* sp. aff. *P. kellettae* indicate that *in situ* multi-generation faunas developed during each transgressive phase. The scattergram for *Paraparchites* sp. aff. *P. kelletae* (Fig. 5) indicates that a full growth sequence is present. Heteromorphs are marked by a posterior broadening of female carapaces, which is visible as a distinct trend deviation in the length:width ratio. Even by allowing growth factors in excess of 1.26 (Przibram, 1931; Anderson, 1964), the sexual dimorphism visible in specimens larger than 1800 μm, cannot be attributed to adult sexual maturity. The heteromorphic character is therefore thought to be progenetic. Precocious sexual dimorphism has been noted in other ostracods (Guber, 1971; Whatley & Stephens, 1977; Rohr, 1979). The same growth chart shows that male technomorphs are very rare, which suggests that in these collections, *Paraparchites sp. aff.* P. kellettae is parthenogenetic. The occurrence of parthenogenesis in normally syngamic ostracods can be related to environmental stress and inter-instar competition (Bless & Pollard, 1975; van Harten, 1983). Despite the fact that collections were made on bedding plane surfaces it is unlikely that the collections represent a single contemporaneous population; however, the lack of instar

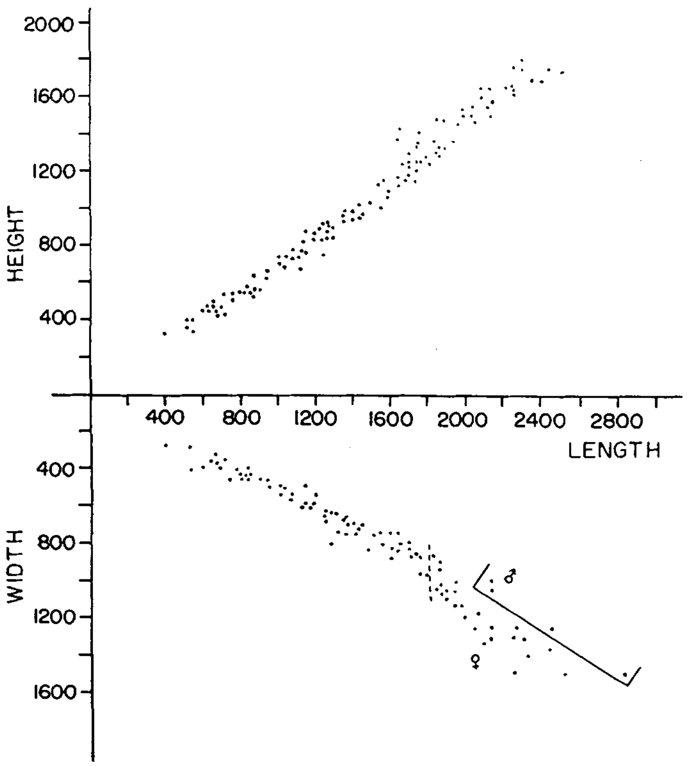

Fig. 5. Scattergram for growth of *Paraparchites* sp. aff. *P. kellettae*. All measurements in microns.

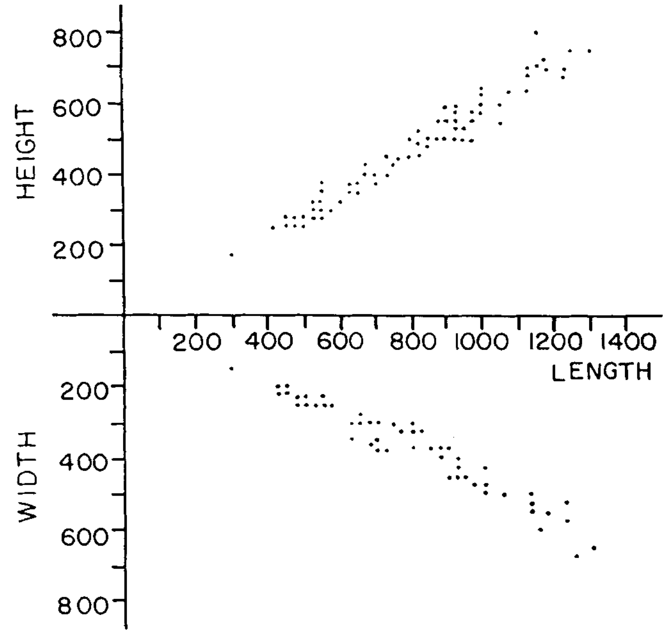

Fig. 6. Scattergram for growth of *Beyrichiopsis lophota*. All measurements in microns.

grouping might be attributed to continuous breeding cycles (Szczechura, 1971; Keen, 1977). It is also possible to postulate that inter-instar competition would play a strong role in the development of a parthenogenetic fauna (van Harten, 1983). The size of the populations, together with parthenogenesis and progenesis, suggests that a rapidly developing ostracod fauna was attempting to take advantage of the available environmental conditions. In this sense therefore, *Paraparchites* sp. aff. *P. kellettae* was behaving as an opportunist (Levinton, 1970; Whatley, 1983) in the Wentworth Station Formation.

Comparison of scattergrams for *B. lophota* and *P.* sp. aff. *P. kellettae* shows that the former is a much smaller species. Comparison of Wentworth Station specimens with published sizes of both *B. lophota* and *B. plicata* (Copeland, 1957; Robinson, 1978; ten Have, 1982) indicates that *B. lophota* reached full size in the Wentworth Station Formation and shows no evidence of stunting. The heteromorphic character is expressed by a slight posterior broadening, but the scattergram (Fig. 6) indicates that mature heteromorphs are rare, which is similar to the plot figured by ten Have (1982). Since *P.* sp. aff. *P. kellettae* is larger than *B. lophota*, the paucity of heteromorphs in the latter cannot be explained by carapace transport. The ratio of heteromorphs to technomorphs therefore suggests that *B. lophota* was syngamic in the Wentworth Station collections.

CONCLUSIONS

In the Dimock and Phillips limestones of the Windsor Group in Nova Scotia, euryhaline ostracods developed abundant, low diversity communities in physiologically stressful conditions. Since raised salinities prevented the occurrence of normal marine stenohaline forms, the ecological niche space and nutrient supply was available for use by the eurytopic forms. Consequently, a physiologically harsh environment became highly favourable to the development of large populations of a few euryhaline species and allowed the successsful development of transient, multi-generation faunas. Continuous breeding cycles, precocious sexual dimorphism and parthenogenesis ensured rapid population growth in *Paraparchites* sp. aff. *P. kellettae*, which was the most adaptable member of the community and allowed it to behave as an opportunist.

The nature of the environment was such that the development of ostracod populations was controlled more by physical factors than by biological ones.

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