A cautionary note on the use of invertebrate trace fossils for correlation in the Triassic-Jurassic Fundy Group

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ABSTRACT

Red-bed strata generally considered to be of Triassic age are present in outcrop at Point Lepreau and St. Martins, New Brunswick. These successions preserve assemblages of invertebrate trace fossils that are similar to one another. Some authors have taken this as evidence that the successions are of similar age. However, all ichnotaxa that are common to the two successions (*Ancorichnus* cf. *ancorichnus*, *Gordia marina*, *Palaeophycus* isp., *Planolites* isp., and *Skolithos* isp.) are long-ranging forms that provide no useful age constraints in Triassic strata and cannot support the suggested correlation. Similarities between the ichnofaunas reflect the continental depositional setting of the two successions, in which trace-makers produced a *Scoyenia* ichnofacies. This does not falsify correlation between the Point Lepreau and St. Martins successions, which can be supported on other grounds. Instead, it reinforces the need for caution when using trace fossils for biostratigraphic purposes in much of the stratigraphic record.

RÉSUMÉ

Des couches de roches rouges dont on estime généralement qu'elles remontent au Trias affleurent à Point Lepreau et à St. Martins, au Nouveau-Brunswick. Ces suites pétrographiques préservent des assemblages de traces de fossiles d'invertébrés qui se ressemblent. Certains auteurs ont considéré qu'il s'agissait là d'une preuve que ces séquences sont plus ou moins du même âge. Toutefois, les traces de fossiles propres aux deux séquences (*Ancorichnus* cf. *ancorichnus, Gordia marina*, *Palaeophycus* isp., *Planolites* isp., et *Skolithos* isp.) sont des formes de longues durées qui n'offrent aucun indice utile de datation dans les strates du Trias; il est donc impossible de soutenir la corrélation alléguée. Les similitudes qui apparaissent dans les traces de fossiles d'invertébrés correspondent à un phénomène de sédimentation de deux séquences dans lesquelles les traces d'organismes ont produit un ichnofaciès de l'espèce *Scoyenia*. Par ailleurs, cela n'infirme en rien la corrélation entre les séquences de Point Lepreau et de St. Martins, laquelle peut être établie par d'autres indices. De fait, cela met encore plus en lumière le devoir de prudence lorsqu'il s'agit d'utiliser dans une large mesure des fossiles à l'état de traces à des fins d'analyse biostratigraphique pour l'établissement d'une fiche stratigraphique.

[Traduit par la redaction]

INTRODUCTION

Triassic strata in southern New Brunswick are part of the Fundy Group (Klein 1962) and crop out mainly as sea-cliff exposures at scattered localities along the northern margin of the Fundy Basin (e.g., Powers 1916; Klein 1962; Wade *et al*. 1996; Tanner 2000). Notably thick exposures are at Point Lepreau and St. Martins, where the strata historically assigned a Triassic age are more than 2.5 km thick (Nadon 1981). Correlation between these successions, and with those elsewhere, has been challenging due to a paucity of datable micro- or macrofossils. Thus, any viable source of chronostratigraphic control has been eagerly sought. Some authors have suggested that invertebrate trace fossils reported by MacNaughton (1990) can be used to correlate parts of the Lepreau and St. Martin's successions. These include an authoritative overview of Fundy Basin stratigraphy (Wade *et al*. 1996) and the Government of New Brunswick's online "Bedrock Lexicon of New Brunswick" (New Brunswick Department of Natural Resources 2010).

In certain contexts, trace fossils can be a valuable source of biostratigraphic data (e.g., Crimes 1970, 1975, 1987; Seilacher 1970, 2008; MacNaughton 2007). In this note, however, we argue that the trace fossil assemblages described by MacNaughton (1990) do not meet necessary prerequisites to

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be valid for stratigraphic correlation. The issue around the specific stratigraphic correlation is a relatively minor one and the correlation may be valid on other grounds. In discussing it, our goal is to emphasize the principles that underpin the viable use of trace fossils in biostratigraphy.

STRATIGRAPHIC CONTEXT

Red-bed strata at Point Lepreau belong to the Lepreau Formation (Wright and Clements 1943) and consist of conglomerate, breccia, sandstone, siltstone, and mudstone of alluvial-fan to braided-fluvial origin (Nadon 1981; MacNaughton and Pickerill 1995). They contain probable Pennsylvanian-aged lithoclasts (Alcock 1959), but no fossil evidence has been found for their age, so their assignment to the Triassic must be considered tentative. Red beds along the Lepreau River have been included in the Lepreau Formation by some workers and have yielded vertebrate trackways that Sarjeant and Stringer (1978) assigned to the ichnogenus *Isocampe*. Based on that assignment, those authors inferred a Late Triassic age for the Lepreau River red beds. Subsequently, palynology (Stringer and Burke 1985) and tectonic considerations (Park *et al*. 1994) indicated that these strata probably are of Carboniferous age. They have been assigned to the Balls Lake Formation (Carboniferous) by McLeod and Johnson (1998). We follow their assignment and exclude the Lepreau River red beds from the present discussion.

Around St. Martins three formations generally have been considered to be of Triassic age; they are summarized here from Nadon (1981) and Nadon and Middleton (1985). As at Point Lepreau, red beds are prevalent. The basal unit is the Honeycomb Point Formation, which is dominated by breccia, sandstone, and minor shale that record deposition mainly on alluvial fans. Overlying this is the Quaco Formation, a distinctive unit of pebble to cobble conglomerate with very well-rounded clasts. It was deposited in a large fluvial system. The succession is capped by the Echo Cove Formation, which contains breccia, conglomerate, sandstone, and shale. It records braided-fluvial and alluvial-fan depositional environments. Palynomorphs from the upper part of the Echo Cove Formation are of Carnian (early Late Triassic) age (Wade *et al*. 1996). Olsen *et al*. (2000; see also Olsen and Et-Touhami, 2008) referred to unpublished paleomagnetic data as evidence that the Honeycomb Point Formation is of Late Permian age but considered the two overlying formations to be Triassic.

Based on the palynological data, Wade *et al*. (1996) correlated the Triassic succession at St. Martins with the Wolfville Formation of Nova Scotia. They considered the Lepreau Formation probably to be equivalent to the lower Wolfville Formation. Alternatively, if the unpublished paleomagnetic data referred to by Olsen *et al*. (2000) are correct, then the Honeycomb Point Formation may be older than the Wolfville Formation. Olsen and Et-Touhami (2008) considered the Lepreau Formation to be a probable correlative of the Honeycomb Point Formation. Resolution of these issues is beyond the scope of the present note and the Lepreau and Honeycomb Point formations are likely to be correlative, whichever interpretation proves to be correct.

In their discussion of the Lepreau Formation, however, Wade *et al*. (1996, p. 209) argued that "…detailed ichnological studies suggest a correlation with the Late Triassic Honeycomb Point Formation further to the northeast (MacNaughton 1990)". This argument also appears in the entry for "Lepreau Formation" in the Government of New Brunswick's "Bedrock Lexicon of New Brunswick" (New Brunswick Department of Natural Resources 2010). It is this use of the trace-fossil assemblages for long-distance correlation that is problematic.

COMPARISON OF ICHNOFAUNAS

Although the Lepreau and Honeycomb Point formations may well be correlative, their invertebrate ichnofaunas provide no support for the correlation. The Triassic ichnofaunas at Point Lepreau and St. Martins are listed in Table 1. Data for Point Lepreau are for the entire Lepreau Formation at that locality and are taken from MacNaughton and Pickerill (1995), a work that slightly updated the observations of MacNaughton (1990). Data for St. Martins are mainly from the Honeycomb Point Formation, but also include material from the upper part of the Echo Cove Formation, and are taken from MacNaughton (1990). The Lepreau ichnofauna is markedly more diverse, although several of the ichnotaxa in that list were recorded only from single occurrences (MacNaughton 1990). Of the ichnotaxa present on both lists, *Palaeophycus* isp., *Planolites* isp., and cf. *Skolithos* isp. are common in both successions. *Taenidium* isp. is rare in both successions, whereas *Ancorichnus* cf. *ancorichnus* is of moderate abundance at Point Lepreau but rare at St. Martins. *Gordia marina* is known from one specimen at each locality.

MacNaughton (2007) has summarized three general situations where trace fossils are useful biostratigraphically, and the Triassic assemblages can be considered in light of these. First, an ichnotaxon can have a restricted stratigraphic range. An example of this is the ichnogenus *Oldhamia*. Its ichnospecies have characteristic radiating, flabellate, or dendritic morphologies and most are restricted to the Cambrian (e.g., Seilacher *et al*. 2005). By contrast, all ichnotaxa present in both the Lepreau Formation and the Honeycomb Point Formation are long-ranging forms, as indicated by the selected references. *Palaeophycus* isp., *Planolites* isp., and *Skolithos* isp. range from the latest Ediacaran (Crimes 1987) to the Pleistocene (D'Alessandro and Bromley 1986; Pemberton and Jones 1988). *Taenidium* isp. ranges from the Ordovician to the Pleistocene (Keighley and Pickerill 1994). *Gordia marina* has a range from at least the Cambrian (Crimes and Anderson, 1985) to the Eocene (Uchman 2001). The ichnospecies *Ancorichnus ancorichnus* is known mainly from the Jurassic of Greenland (Keighley and Pickerill 1994), but has also been reported from Cambrian-Ordovician strata in Argentina (Poiré *et al*. 2003). Note also that material studied by MacNaughton (1990) was

Table 1. Comparison of Triassic ichnofaunas at Point Lepreau (Lepreau Formation) and St. Martins (Honeycomb Point and upper Echo Cove formations), New Brunswick. Dashed lines indicate ichnotaxa not observed at St. Martins. Data from MacNaughton (1990) and MacNaughton and Pickerill (1995).

Point Lepreau	St. Martins
Ancorichnus coronus	-----
Ancorichnus cf. *ancorichnus*	*Ancorichnus* cf. *ancorichnus*
Aulichnites isp.	-----
Cruziana problematica	-----
Fuersichnus isp.	-----
Gordia marina	*Gordia marina*
Palaeophycus striatus	-----
Palaeophycus isp.	*Palaeophycus* isp.
Planolites isp.	*Planolites* isp.
Rusophycus isp.	-----
Skolithos linearis	-----
cf. *Skolithos* isp.	cf. *Skolithos* isp.
Taenidium isp.	*Taenidium* isp.
"inclined meniscate burrows"	-----
"surface pit structures"	-----

assigned only tentatively to this ichnospecies and may be a poorly preserved variant of another ichnospecies.

A second scenario in which trace fossils are helpful in biostratigraphy arises when the timing of first-appearance is known for one or more ichnotaxa that can be used to constrain the age of a trace-fossil assemblage. For example, first-appearance data are key elements of Ediacaran-Cambrian trace-fossil biozones (Crimes 1987; MacNaughton and Narbonne 1999). Even long-ranging ichnotaxa or low-diversity ichnofaunas can provide this kind of age control in an appropriate situation (e.g., Pickerill and Fyffe 1999). However, the probable Triassic age of the Lepreau and Honeycomb Point formations is well within the age ranges of the ichnotaxa that are common to both successions. First-appearance data cannot be applied.

Finally, a group of trace-making organisms may evolve relatively rapidly, with the resulting changes in the animals' behaviour or morphology being reflected in their trace fossils. Vertebrate tracks (Lockley 1998) and traces produced by trilobites or other arthropods (Seilacher 1970) are notable examples of this. But the ichnotaxa that are common to both the Lepreau and Honeycomb Point formations are long-ranging, conservative forms that change little, if at all, over their stratigraphic range. Also, most of the ichnotaxa can be identified only to the ichnogenus level, whereas trace-fossil biostratigraphy works best when material can be identified to the ichnospecies level (MacNaughton 2007).

What then explains the similarities between the two ichnofaunas? Most significant is that all strata in the two successions were deposited in continental environments—mainly fluvial and alluvial fan settings (Nadon 1981; Nadon and Middleton 1985). With this in mind, MacNaughton (1990; see also MacNaughton and Pickerill 1995) analyzed the ichnofaunas of both successions and found that they fit well within the *Scoyenia* ichnofacies (Seilacher 1967; MacEachern *et al*. 2007). Ichnofacies are distinctive groupings of trace fossils that recur in space and time and reflect the behavioural responses of organisms to the ecological limiting factors that characterize particular environments (e.g., MacEachern *et al*. 2007). Thus, similarities between the Lepreau and Honeycomb Point formation ichnofaunas are readily explained in terms of similar depositional environments, and the effects of their environmental limiting factors on burrowing organisms. They reflect similar depositional ages only inasmuch as they comprise ichnotaxa characteristic of many late Paleozoic and Mesozoic continental successions (see review by Buatois and Mángano 2007).

CONCLUSIONS

Triassic strata at Point Lepreau (Lepreau Formation) and St. Martins (Honeycomb Point and Echo Cove formations) contain broadly similar ichnofaunas. Ichnotaxa common to both successions are long-ranging forms that provide no useful biostratigraphic control and, contrary to some suggestions, cannot be used to correlate these formations. Similarities in ichnofaunal composition are more likely to reflect similar depositional environments. This does not falsify correlation between the Lepreau and Honeycomb Point formations, which is supported by regional geological considerations (Wade *et al*. 1996; Olsen and Et-Touhami, 2008), but does emphasize the need for caution when applying trace fossils to biostratigraphic problems (MacNaughton 2007).

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