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Résumé de l'article

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The trace fossil *Yakutatia emersoni* from the Matapedia Basin of New Brunswick and southeast Gaspé - its first reported occurrence outside of Alaska

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The trace fossil *Yakutatia emersoni* is recorded and described from the Late Ordovician-Early Silurian Matapedia and Grog Brook groups of northwest New Brunswick and southwest Gaspé. The recording has three important consequences. First, it represents the first report of the trace fossil outside its type locality on Kodiak Island, Alaska. Second, it extends the stratigraphic range of the ichnospecies, previously known only from the Cretaceous, back to the Late Ordovician, probably Gamachian. Third, it confirms the preferred environment in which the producing organism inhabited as deep water marine.

On rapporte et décrit la trace fossile *Yakutatia emersoni* dans les groupes de Matapedia et de Grog de l'Ordovicien tardif au Silurien précoce du nord-ouest du Nouveau Brunswick et du sud-ouest de Gaspé. Trois conséquences importantes découlent de ce rapport: 1. On rapporte cette trace fossile pour la première fois hors de sa localité-type sur l'île de Kodiak, en Alaska; 2. Bien que cette ichnospèce ne soit connue qu'au Crétacé, on recule son étendue stratigraphique jusqu'à l'Ordovicien tardif (probablement jusqu'au Gamachien); 3. On confirme que l'organisme qui produisait cette trace préférait un environnement d'eau profonde.

[Traduit par le journal]

INTRODUCTION

Yakutatia is an enigmatic but distinctive spiralled graphoglyptid (Seilacher 1977) trace fossil ichnogenus currently represented by a single ichnospecies, *Yakutatia emersoni*, which was originally collected and described by Ulrich (1904) from the Cretaceous Kodiak Formation of Kodiak Island, Alaska. Ulrich (1904) originally referred to the trace fossil as *Gyrodendron emersoni*, but at a later date Hantzschel (1962) changed the name to *Yakutatia emersoni* as *Gyrodendron*, unbeknownst to Ulrich, had previously been utilized by Quenstedt (1880) for a scleractinian coral (Wells 1956). Until recently the nature of *Yakutatia* and its detailed occurrence was poorly known. McCann and Pickerill (1986), however, recently re-examined type, topotype and other material from Kodiak Island, and, in addition to providing a more complete morphological description of the trace fossil, concluded that, at least in Alaska, it was associated with a lobe fringe environment of a large submarine fan. They also noted that the trace fossil had never been described from outside of its type location.

The purpose of this short paper is, therefore, to report the first occurrence of *Yakutatia emersoni* outside of Alaska. The recording is also important because,

first, it extends the stratigraphic range of the trace fossil to the Late Ordovician, probably Gamachian, and second, it confirms the preferred (and only known) environment in which the producing organism inhabited as deep water marine.

LOCATION AND STRATIGRAPHY

Specimens described herein form part of an extensive and diverse collection of trace fossils made over the previous several years from northwest New Brunswick and southeast Gaspé. Although preliminary reports on these collections have been previously made by Pickerill (1980, 1986) and Pickerill and Forbes (1980), no detailed and systematic studies have yet been undertaken, though this particular aspect is currently in preparation. All the collections are from the Aroostock-Matapedia Carbonate Belt of Ayrton *et al.* (1969), also known as the Aroostook Anticlinorium (Rodgers 1970), the Aroostook-Matapedia Trough (Bradley 1983) and herein, following Fyffe *et al.* (1981), referred to as the Matapedia Basin. This basin comprises a narrow tectonostratigraphic zone extending from eastern Gaspé through New Brunswick and into northern Maine (Fig. 1), where it merges with the Merrimack Trough (Bradley 1983). The Ordovician and Silurian strata comprising this basin have been assigned various group or formational names at different locations along its length. In northwest New Brunswick all specimens

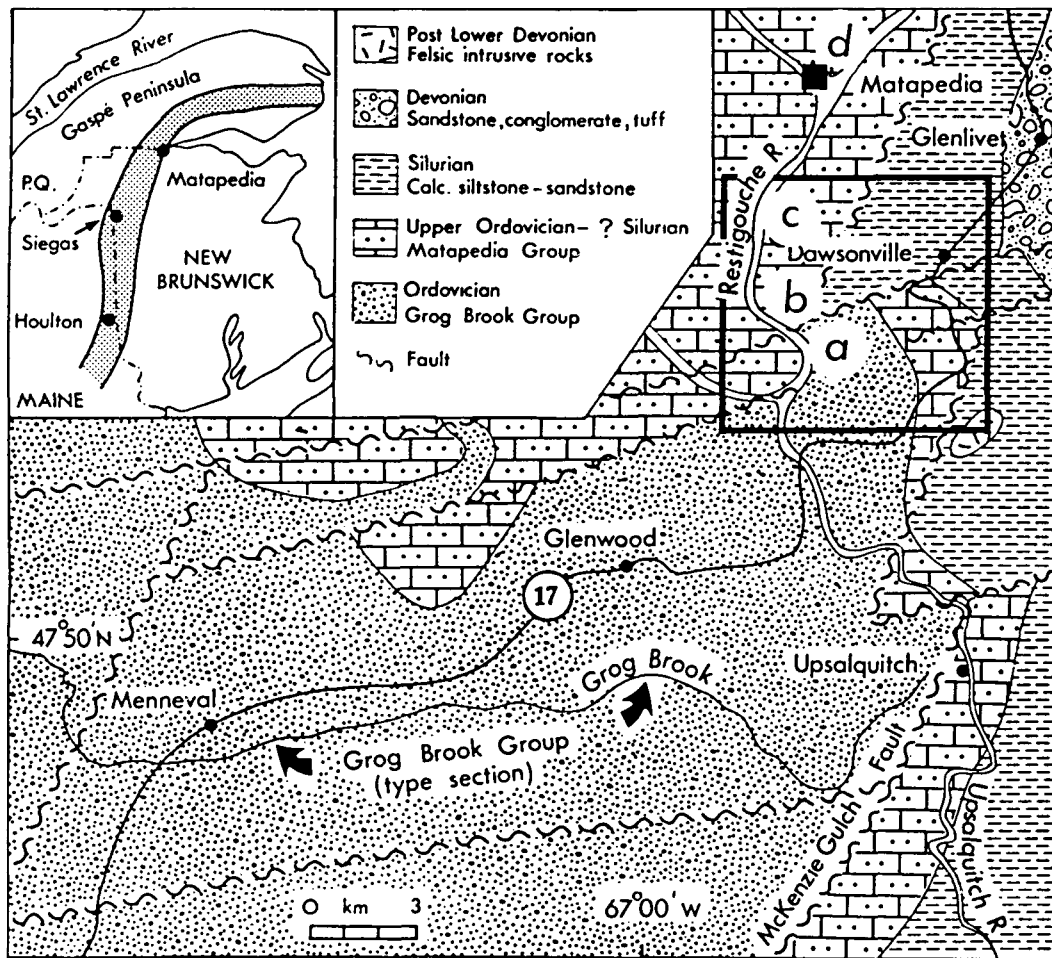


Fig. 1 - Generalized geological map of the Matapedia Basin in northwest New Brunswick (modified after St. Peter 1977; Nowlan 1983) illustrating locations a-d inclusive where *Yakutatia*, as described herein, was collected. Boxed area containing locations a-c inclusive is illustrated in Figure 2. Inset map indicates general distribution of Matapedia Basin in Gaspé, New Brunswick and Maine.

were collected from the oldest exposed strata within the basin, the Grog Brook and Matapedia groups, and which are Late Ordovician-Early Silurian in age. In southwest Gaspé specimens were collected from the coeval Matapedia Group.

Although partially complete and fragmentary specimens of *Yakutatia emersoni* have been observed at several additional locations, those described herein were more complete and were made at four locations (Figs. 1,2). These are:

1. The Grog Brook Group on the eastern (New Brunswick) bank of the Restigouche River at Runnymede, 400m south of the confluence with Rafting Ground Brook (a in Figs. 1,2; NTS 21-0/15, lat. 47°54'30" N, long. 66°56'57"W).

2. The Matapedia Group on the eastern

(New Brunswick) bank of the Restigouche River at Runnymede, 300m north of the confluence with Rafting Ground Brook (b in Figs. 1,2; NTS 21-0/15, lat. 47°54'40"N, long. 66°57'45"W).

3. The Matapedia Group on the eastern (New Brunswick) bank of the Restigouche River, 100m north of the confluence with Dawson Brook (c in Figs. 1,2; NTS 21-0/15 lat. 47°55'35"N, long 66°56'55"W).

4. The Matapedia Group on the highway section (#132) at Matapedia, Quebec (d in Fig. 1; NTS 21-0/15, lat. 47°58'40"N, long. 66°56'55"W).

Conodonts recovered by Nowlan (1983) from location a have yielded a Late Ordovician, probably Gamachian age. The graptolite *Dicellograptus* cf. *complanatus* recorded by Rickards and Riva (1981) from location b also indicates a Late Ordo-

vician age. Because of the absence of faunas, the precise age of locations c and d is unknown and could conceivably extend into the Early Silurian.

MATERIAL AND OCCURRENCE

Specimens of *Yakutatia emersoni* have not been directly observed *in situ*, instead all material was collected from the abundant debris available at each of the locations. Comparison of the debris with the actual outcrops indicates, however, that no significant transportation of the material has occurred and the specimens can be regarded as essentially autochthonous. This is not an unusual situation in ichnological studies where erosion and weathering are important prerequisites to the preservation and enhancement of colour or textural contrasts between the trace fossils and their enclosing matrix, particularly in carbonates (Kennedy 1975).

In total, twelve specimens of *Y. emersoni* have been collected, five of which are figured herein (Fig. 3), and all of which are housed in the Paleontological

Collections of the University of New Brunswick. In contrast to many of the other trace fossils present in the same strata (see below) the ichnospecies is therefore relatively uncommon, as indeed it is in the Cretaceous Kodiak Formation of Alaska (McCann and Pickerill 1986). Although because of the nature of the material very few associated trace fossils have been directly observed, the Grog Brook and Matapedia groups contain the following additional ichnogenera: *Asteriacites*, *Buthotrephis*, *Chondrites*, *Cochlichnus*, *Cosmorhapha*, *Glockerichnus*, *Gordia*, *Helminthopsis*, *Neonereites*, *Nereites*, *Palaeophycus*, *Paleodictyon*, cf. *Petalichnus*, *Phycosiphon*, *Planolites*, *Protopaleodictyon*, *Scalarituba*, *Spirodesmos*, *Spirorhapha*, *Stroliborhapha*, *Syncoprulus* and *Taenidium* (see Pickerill 1980, 1986; Pickerill and Forbes 1980). The only ichnogenera to have been observed on the same slabs as *Yakutatia* are poorly preserved examples of *Chondrites* and *Palaeophycus*.

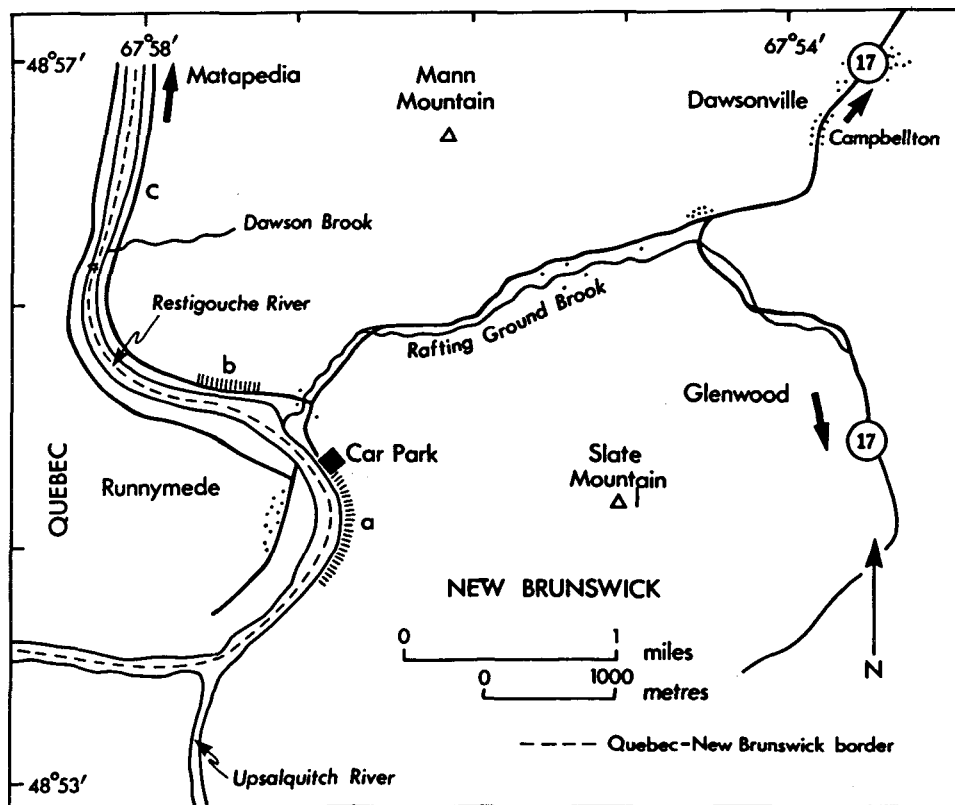


Fig. 2 - Simplified location map (modified after Pickerill 1986) of locations a-c inclusive where *Yakutatia* as described herein, was collected (see text for details).

SEDIMENTOLOGY AND DEPOSITIONAL ENVIRONMENT

The Matapedia Basin has previously been variably interpreted as the site of an ocean (Bird and Dewey 1970), as a blind embayment (McKerrow and Ziegler 1971), and as a remnant of an oceanic basin (Rast and Stringer 1980, Bradley 1983). As correctly pointed out by Nowlan (1983), since there is no conclusive evidence on the nature of the crust underlying the basin all that can really be stated is that it was a relatively deep and narrow linear marine depression. This depression was but one of several which formed in the northeast Appalachians following collisional events associated with the Taconic orogeny (Williams 1977, Rast and Stringer 1980) which occurred in late Early and early Middle Ordovician times. Within this depression the Grog Brook and Matapedia groups accumulated from late Middle Ordovician to Early Silurian times.

The Grog Brook Group, estimated by St Peter (1977) as ca. 7600m in thickness, comprises a heterogeneous assemblage of lithotypes. Most typical are interbedded argillaceous sandstones, siltstones and silty argillites, though less commonly polymictic conglomerates, pebbly sandstones and thinly bedded limestones may also be present (St Peter 1977). The majority of trace fossils in the Grog Brook Group, including *Y. emersoni*, occur in association with 2-40cm thick argillaceous sandstones and siltstones interbedded with 1-20cm thick argillites. Internally, most sandstones exhibit partial Bouma (1962) sequences with Tb-c, Tb, Ta-c and Tc, in decreasing order of abundance, being most typical and many of which are spectacularly convoluted. Lower bedding surfaces may be planar and non-erosive or may exhibit morphologically variable flute and groove markings. Many upper bedding surfaces are complexly ripple-marked.

The Matapedia Group is composed of a 1250-4000m thick succession of thinly interbedded (1-5cm) calcic and ankeritic limestones and calcareous argillites (St Peter 1977). As a result of differential

solution of the more limy beds, the rocks have a markedly ribbed appearance such that previous authors (e.g. Ayrthon et al. 1969) have referred to them as "ribbon limestones". The limy beds are generally massive though approximately 10% exhibit parallel and, or, cross-lamination. Most are planar based and rarely some are erosive. Isolated small-scale channelized lenticular beds may also be present; these are typically infilled with cross-laminated sets. Slumped horizons are locally common. Interbedded calcareous argillites are rarely finely laminated but more typically massive, or where weathering is pronounced, extremely bioturbated.

To date no detailed and systematic sedimentological studies of either of these groups have been undertaken. Nevertheless, what studies do exist all suggest deposition of both in deep water marine environments. St Peter (1977) suggested both groups to have been deposited by turbidity currents in bathyal or even abyssal environments. Stringer and Pickerill (1980) however, suggested that broadly coeval strata of the Matapedia Group in the Grand Falls area to the southwest (the Carys Mills Formation) were deposited in a deep water slope environment by hemipelagic settling and normal bottom-following contour currents with only periodic introduction of material by turbidity currents and other mass flow mechanisms. The present author does agree, however, that the Grog Brook Group represents a succession deposited essentially by turbidity and other mass flow sediment support mechanisms.

Because of the lack of sedimentological studies, it is difficult to realistically assess the precise depositional environments of both groups. Palaeontological studies (Rickards and Riva 1981, Nowlan 1983) suggest that the Matapedia and Grog Brook groups are in part coeval and therefore are merely lateral facies equivalents. Accepting that the Matapedia Group and its lithologically-equivalent correlatives such as the Carys Mill Formation are all in fact slope deposits, it may well be that the Grog Brook Group strata represent mass flow deposits

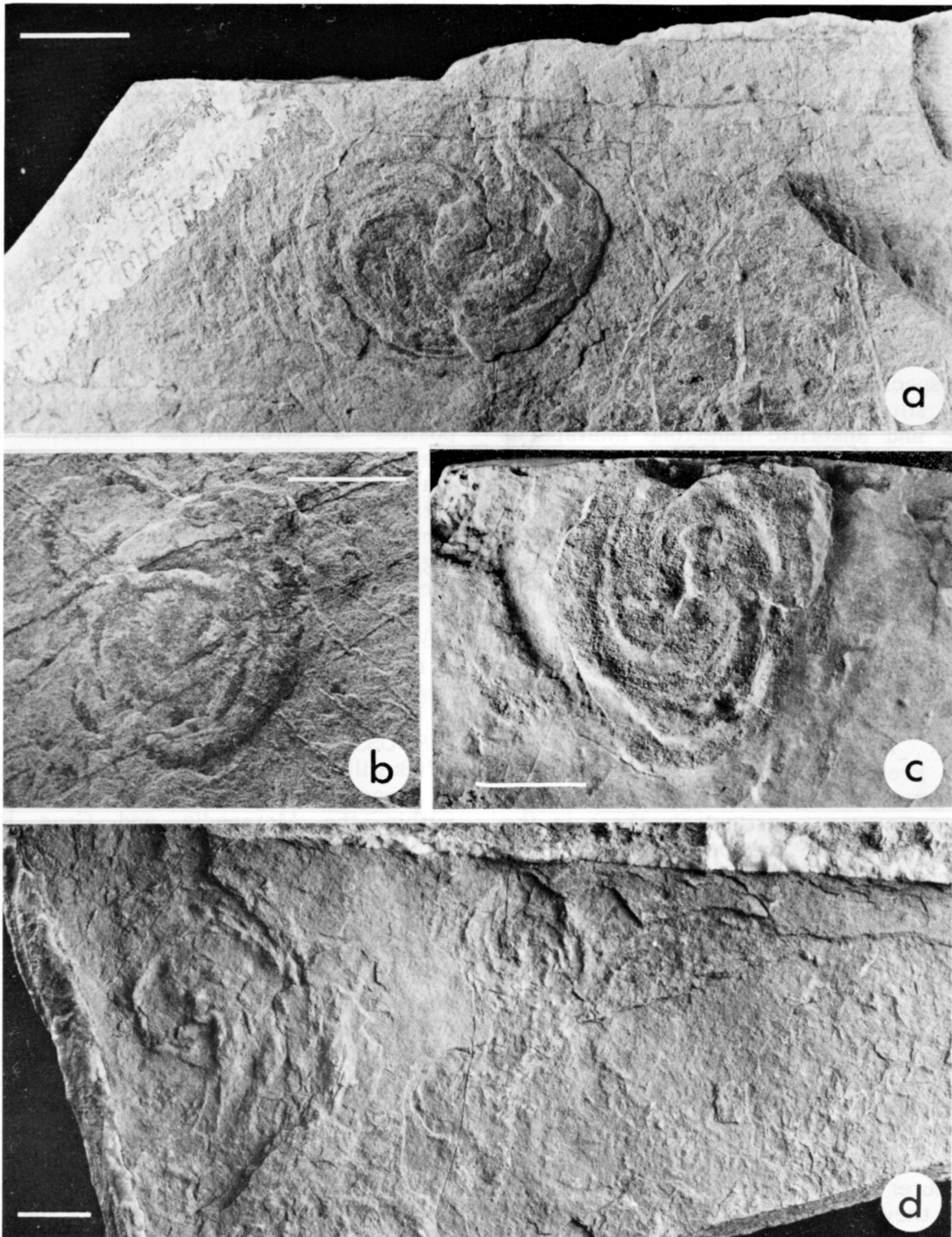


Fig. 3 - Specimens of *Yakutatia emersoni* from the Grog Brook and Matapedia groups of the Matapedia Basin in northwestern New Brunswick and southwestern Gaspé. a. Specimen preserved in positive hyporelief from the Matapedia Group at Matapedia (locality d). b. Specimen preserved in positive hyporelief from the Matapedia Group at locality c. c. Specimen preserved in positive hyporelief from the Grog Brook Group at locality a. d. Two specimens preserved in negative epirelief from the Matapedia Group at locality b. All specimens found in float material. Bar scale = 1 cm.

developed within major channels cut through these slope deposits. Although this is speculative, it is notable that Hamilton-Smith (1971, 1980) has demonstrated by detailed mapping and lithofacies analysis an analogous scenario in broadly coeval strata in the Matapedia Basin of the Siegas area (Fig. 1) of New Brunswick. It is also notable that the Grog Brook Group consists generally of coarse-grained and thickly bedded mass flow deposits consistent with deposition in channels (e.g. see Walker 1984).

DESCRIPTION

All specimens are preserved on 1-3cm thick siltstone (Grog Brook Group) or calcic and ankeritic limestone (Matapedia Group) bedding surfaces as positive or negative features on soles (respectively, convex hyporelief and concave hyporelief) or negative features on tops (negative epirelief). As all material was collected in float, because of the lack of way up indicators, it proved impossible to determine the exact preservation of all specimens; nevertheless, it is suspected that most are preserved in convex hyporelief, as indeed are examples of *Yakutatia* from Kodiak Island (McCann and Pickerill 1986). Preservation is generally poor and the specimens have undergone considerable compaction, particularly those in the limestones of the Matapedia Group.

Traces are typically isolate but may occur in close proximity (Fig. 3d). No examples of intersecting specimens were observed. Each specimen consists of a dextrally (Fig. 3a) or sinistrally (Fig. 3c) coiled trace which, as noted by Seilacher (1977) resembles that of the graptolite *Cyrtograptus*. The coiling is initiated from a single, poorly-preserved curved burrow which then ramifies up to a maximum of four times but more typically three. These secondary ramifications occur on the outer convex side of the initial burrow; they are unbranched and curve in the same direction as the initial burrow thus producing the coiled or spiralled appearance. It is notable that ramification of the burrows on the inner concave side has not been observed, though this is the more common design in the Kodiak

specimens (McCann and Pickerill 1986). The entire spiralled trace forms, at most, a single involution around the acuminate central portion.

Dimensions of the traces are as follows. Diameter of burrows ranges from 1-2mm and, bearing in mind the poor preservation, is apparently constant within single specimens apart from where the individual burrows merge with the bedding surfaces at their distal extremities. Total maximum diameter of individual specimens varies from 0.9-3.4cm, the majority being ca. 2cm. Minimum diameter varies from 0.5-3cm; individual specimens are typically ca. 3mm shorter than wider.

Burrows are smooth, unornamented and possess a structureless siltstone infill identical in grain size to the enclosing matrix, being differentiated by a colour rather than textural change. The three-dimensional form is unknown as sectioning revealed no internal details. Nevertheless, the presence in some specimens of evidence of vertical tiering (e.g. Fig. 3c) suggests that *Yakutatia* was indeed a truly three-dimensional spiralled burrow system.

DISCUSSION AND CONCLUSIONS

Pickerill (1980), in his general review of trace fossils and their significance within the Matapedia and Grog Brook groups of the Matapedia Basin, briefly noted a questionable occurrence of *Yakutatia* within the sequence. At that time only poorly preserved fragmentary material was available, the presently described specimens having been collected since 1980 and their identification as *Yakutatia* also confirmed by C.K. Chamberlain (personal communication 1981). As discussed more fully by McCann and Pickerill (1986), the ichnogenus is currently nonspecific and is represented by *Y. emersoni*. It is clear from the emended diagnosis of *Y. emersoni* by McCann and Pickerill (1986) that the material described herein, although poorly preserved, conforms in all general features and can therefore be regarded as conspecific.

The recording of *Y. emersoni* from the Matapedia and Grog Brook groups of the

Matapedia Basin has three important consequences:

1. It represents the first recording of the trace fossil outside of its type location of Kodiak Island, Alaska.
2. It extends the stratigraphic range of the ichnospecies from the Cretaceous (on Kodiak Island) back to the Late Ordovician.
3. It confirms the preferred environment in which the producing organism(s) inhabited as deep water marine. On Kodiak Island, *Y. emersoni* occurs in thin-bedded turbidites interpreted by McCann and Pickerill (1986) to have been deposited in a lobe fringe environment of a deep water submarine fan. In the Matapedia Basin, it occurs in strata believed to have been deposited in deep water slope (Matapedia Group) and channel (Grog Brook Group) environments.

As noted by McCann and Pickerill (1986) several factors remain enigmatic with respect to *Y. emersoni*. First, the three-dimensional structure and the nature of the vertical spiral component is unknown. Second, the nature and affinities of the producing organism are unknown, though as in many other ichnological studies, this is not unusual. Third, the behavioural program producing such a structure is most intriguing. Unfortunately the material described herein adds little to these questions, the answers to which will hopefully be provided once additional recordings of *Yakutatia* are made from other locations.

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