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Résumé de l'article

Sur la riviere Tobique, dans l'ouest du Nouveau-Brunswick,_ au Canada, les flyschs du Groupe de Hatapedia appartenant au Bassin de Hatapedia, deposes en contexte de talus et d'age tardlordovlcien a eosilurien. ont llvre 13 Ichnogenres (15 ichnoespeces). savoir; Chondrites ichnospp., Cochlichnus anguineus, Dictyodora scotica, Dictyodora tenuis, Dimorphichnus Ichnosp.. Glockerichnus ichnosp., Gordia marina. Helminthopsis ichnosp., Muensteria Ichnosp., Heonereites uniserialis, Hereites jacksoni, Palaeophycus tubularis, Syncoprulus pharmaceus and Yakutatia emersoni. Parmi ceux-cl, Dimophichnus. Muensteria et Dictyodora n'ont Jamais ete signales dans le Bassin de Matapedia; 11 sagit. de plus, de la premier decouverte de Dictyodora en Amerique du Nord. Au total, 1'assemblage represente 1'ichnocenose la plus diverse jamais documentee dans les depots de talus de Paleozoique.

LATE ORDOVICIAN-EARLY SILURIAN TRACE FOSSILS FROM THE MATAPEDIA GROUP, TOBIQUE RIVER, WESTERN NEW BRUNSWICK, CANADA

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Late Ordovician-Early Silurian flysch slope deposits of the Matapedia Group of the Matapedia Basin on the Tobique River, western New Brunswick, Canada, contain 13 ichnogenera (15 ichnospecies), namely:- *Chondrites* ichnospp., *Cochlichnus anguineus*, *Dictyodora scotica*, *Dictyodora tenuis*, *Dimorphichnus* ichnosp., *Glockerichnus* ichnosp., *Gordia marina*, *Helminthopsis* ichnosp., *Muensteria* ichnosp., *Neonereites uniserialis*, *Nereites jacksoni*, *Palaeophycus tubularis*, *Syncoprulus pharmaceus* and *Yakutatia emersoni*. Of these, *Dimorphichnus*, *Muensteria* and *Dictyodora* have never previously been recorded in the Matapedia Basin and *Dictyodora* is recorded for the first time in North America. The total assemblage represents the most diverse ichnocoenosis yet recorded from Paleozoic slope deposits.

Sur la rivière Tobique, dans l'ouest du Nouveau-Brunswick, au Canada, les flyschs du Groupe de Matapédia appartenant au Bassin de Matapédia, déposés en contexte de talus et d'âge tardiordovicien à éosilurien, ont livré 13 ichnogenres (15 ichnoespèces), savoir; *Chondrites* ichnospp., *Cochlichnus anguineus*, *Dictyodora scotica*, *Dictyodora tenuis*, *Dimorphichnus* ichnosp., *Glockerichnus* ichnosp., *Gordia marina*, *Helminthopsis* ichnosp., *Muensteria* ichnosp., *Neonereites uniserialis*, *Nereites jacksoni*, *Palaeophycus tubularis*, *Syncoprulus pharmaceus* and *Yakutatia emersoni*. Parmi ceux-ci, *Dimophichnus*, *Muensteria* et *Dictyodora* n'ont jamais été signalés dans le Bassin de Matapédia; il sagit, de plus, de la premier decouverte de *Dictyodora* en Amérique du Nord. Au total, l'assemblage représente l'ichnocénose la plus diverse jamais documentée dans les dépôts de talus de Paléozoique.

[Traduit par le journal]

INTRODUCTION

Detailed systematic ichnological studies of deep-water flysch strata of Mesozoic age have been undertaken in several parts of the world (e.g., Macsotay, 1967; Ksiazkiewicz, 1970, 1977; Tanaka, 1971; Kern and Warme, 1974; Crimes *et al.*, 1981; etc.). In contrast, Paleozoic, particularly lower Paleozoic studies remain poorly documented, with the notable exceptions of, for example, Crimes (1970), Aceñolaza (1978), Pickerill (1981), and Benton (1982a). The importance of detailed taxonomic studies of deep-water lower Paleozoic trace fossils cannot be overemphasized. For example, the paucity of such studies, as noted by Pickerill (1980), has resulted in Phanerozoic trace fossil diversity models (Seilacher, 1974, 1977; Frey and Seilacher, 1980) which are not in accord with the observed data. Over the last decade one of us (R.K.P.) has been involved with the collection and description of trace fossils from the middle Ordovician to lower Silurian flysch succession of the Matapedia Basin (see below) of New Brunswick and Quebec. Recent work in part of this basin in the Perth-Andover area of New Brunswick (Fig. 1, Pickerill, 1986) revealed an extremely important site with respect to trace fossils contained in these strata. Unfortunately, the site is situated on the planned location of a trout and salmon aquaculture center, construction of which is imminent and will result in coverage of the exposed strata. In view of this, the purpose of this paper is therefore to document, particularly taxonomically, the trace fossils discovered at the site and to comment on their importance not only with respect to strata of the Matapedia Basin but also with respect to previous studies in coeval strata and trace fossil diversity models.

LOCATION AND GEOLOGICAL BACKGROUND

The Matapedia Basin of Fyffe *et al.* (1981), previously termed the Aroostook-Matapedia Carbonate Belt by Ayrton *et al.* (1969) and the Aroostook Anticlinorium by Pavlides (1968) and Rodgers (1970), is a narrow tectonostratigraphic zone extending from eastern Gaspe through New Brunswick and into northeastern Maine (Fig. 1) where it merges with the Merrimack Trough (Bradley, 1983). Strata in this basin are middle Ordovician-Early Silurian in age and have been assigned various group and, or, formational names at different locations along its length. In Gaspe, strata are referred to the late middle Ordovician-Early Silurian Honorat and Matapedia groups, the latter including the Late Ordovician-Early Silurian White

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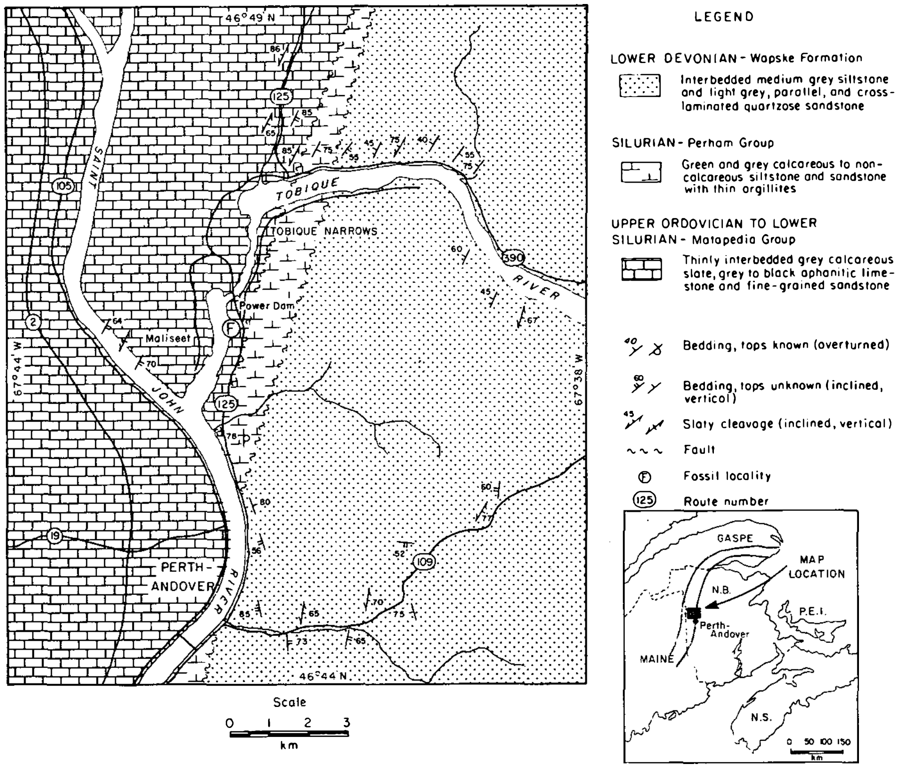

Fig. 1. Location and simplified geological map of the Perth-Andover area, western New Brunswick. Note that in the small inset map, the Matapedia Basin is outlined by a stippled ornament.

Head and Pabos formations (Nowlan, 1983). In New Brunswick the strata include the late middle Ordovician-Early Silurian Grog Brook and Matapedia groups (St. Peter, 1977; Nowlan, 1983) while in Maine they are referred to as the Madawaska Lake Formation of at least middle Ordovician age (Roy and Mencher, 1976) and an overlying Carys Mills Formation of latest Ashgillian or earliest Silurian age (Rickards and Riva, 1981). Trace fossils described in this paper were located in western New Brunswick just north of the Perth-Andover area (Fig. 1) and were collected from the Matapedia Group whose equivalent to the west in eastern Maine is the Carys Mills Formation. The location of the site is on the eastern bank of the Tobique River approximately 1.5 km upstream from its confluence with the Saint John River (Fig. 1), though as noted in the introduction, this site will be unavailable in the near future as a consequence of construction of an acquaculture center. No fossils are present in the Matapedia Group at this location and therefore the assignment of a Late Ordovician (Ashgillian) to Early Silurian age is based on correlation with equivalent graptolite-bearing strata found elsewhere in the Matapedia Basin (e.g., Rickards and Riva, 1981).

The Matapedia Group consists of delicately laminated calcareous argillites, individual laminae typically being <1 mm in thickness, laterally persistent or (very rarely) impersistent, rarely lenticular, and separated by <2 cm-thick (typically <1 cm-thick) dark, relatively calcite- and ankerite-poor argillites. Interbedded with these parallel-laminated calcareous argillites are 1-2 cm thick ankeritic limestones which are generally massive but rarely are parallel-laminated. On outcrop scale these interbeds are apparently laterally continuous though may be attenuated due to tectonism. They are sharp-based and exhibit sharp and clearly defined upper surfaces. Rare interbeds of slightly more coarser grained, less calcareous siltstones or fine-grained sandstones are also present and are parallel- or cross-laminated. The internal arrangement of laminae, parallel-laminated passing vertically into cross-laminated sets, indicates deposition of such units from decelerating flows. Some of these units are normally graded and several are composite. The units are planar based but with no obvious erosive features and exhibit sharply defined upper surfaces. The relative importance of the three lithotypes is difficult to estimate, even semi-quantitatively, because of structural, exposure and weathering problems; however, calcareous argillites and interbedded ankeritic limestones are very predominent with only rare interbeds of calcareous siltstones.

To date no systematic or detailed sedimentological studies of the Matapedia Group have been undertaken, although existing literature suggests deposition of the strata in a deep-water marine environment. St. Peter (1977) suggested deposition in a bathyal or abyssal environment whereas Stringer and Pickerill (1980) suggested deposition on a slope marginal to the northeast trending Miramichi Anticlinorium (see Fyffe *et al.*, 1981) to the southeast. The more thickly bedded calcareous siltstones exhibit evidence of deposition from decelerating flows, probably turbidite flows. The trace fossils indicate deposition in deep-water, but most have previously been reported from other sequences in both slope and basinal regimes. The interbedded calcareous argillites and ankeritic limestones are not indicative of any specific depositional environment, as they do not possess diagnostic environmental indicators. Nevertheless they do suggest deposition above the calcite compensation depth and therefore presumably of shallower origin than bathyal or abyssal conditions. Thus, the most realistic model appears to be that presented by Stringer and Pickerill (1980), who, based on studies of equivalent strata elsewhere in the Matapedia Group, suggested its deposition on a slope by hemipelagic and normal bottom-following contour currents with periodic introduction of ankeritic limestones and calcareous siltstones by turbidity currents.

THE TRACE FOSSIL ASSEMBLAGE

A total of 13 ichnogenera represented by 15 ichnospecies were collected from the site. These trace fossils, as described subsequently in more detail, are: *Chondrites* ichnospp., *Cochlichnus anguineus* Hitchock, 1858; *Dictyodora scotica* (M'Coy, 1851); *Dictyodora tenuis* (M'Coy, 1851); *Dimorphichnus* ichnosp.; *Glockerichnus* ichnosp.; *Gordia marina* Emmons, 1844; *Helminthopsis* ichnosp.; *Muensteria* ichnosp.; *Neonereites uniseralis* Seilacher, 1960; *Nereites jacksoni* Emmons, 1844; *Palaeophycus tubularis* Hall, 1847; *Syncoprulus pharmaceus* Richter and Richter, 1939; *Yakutatia emersoni* (Ulrich, 1904). The trace fossils were collected from the extensive talus material at the site and therefore were not located *in situ*, though this is not an unusual situation in ichnological research (Fillion and Pickerill, in press). Because of extensive deformation and pressure solution activity (cf. Stringer and Pickerill, 1980) the trace fossils are, on the whole, poorly-preserved and difficult to observe. They occur on upper and lower bedding plane surfaces though because of the delicate and thinly laminated nature of most of the strata it is often difficult, if not impossible, to distinguish top from bottom surfaces.

Most specimens were discovered as isolated individual traces but some slabs (Fig. 2) exhibited numerous burrows. The most common traces, in decreasing order of abundance, were *Palaeophycus tubularis*, *Helminthopsis* ichnosp., *Chondrites* ichnospp. and *Dictyodora* ichnospp. The remainder were represented by only a few individual specimens and in the case of *Glockerichnus* ichnosp., *Neonereites uniserialis* and *Yakutatia emersoni* by only a single example of each. It must be emphasized that many hours of collecting were spent at this location and therefore we believe that the

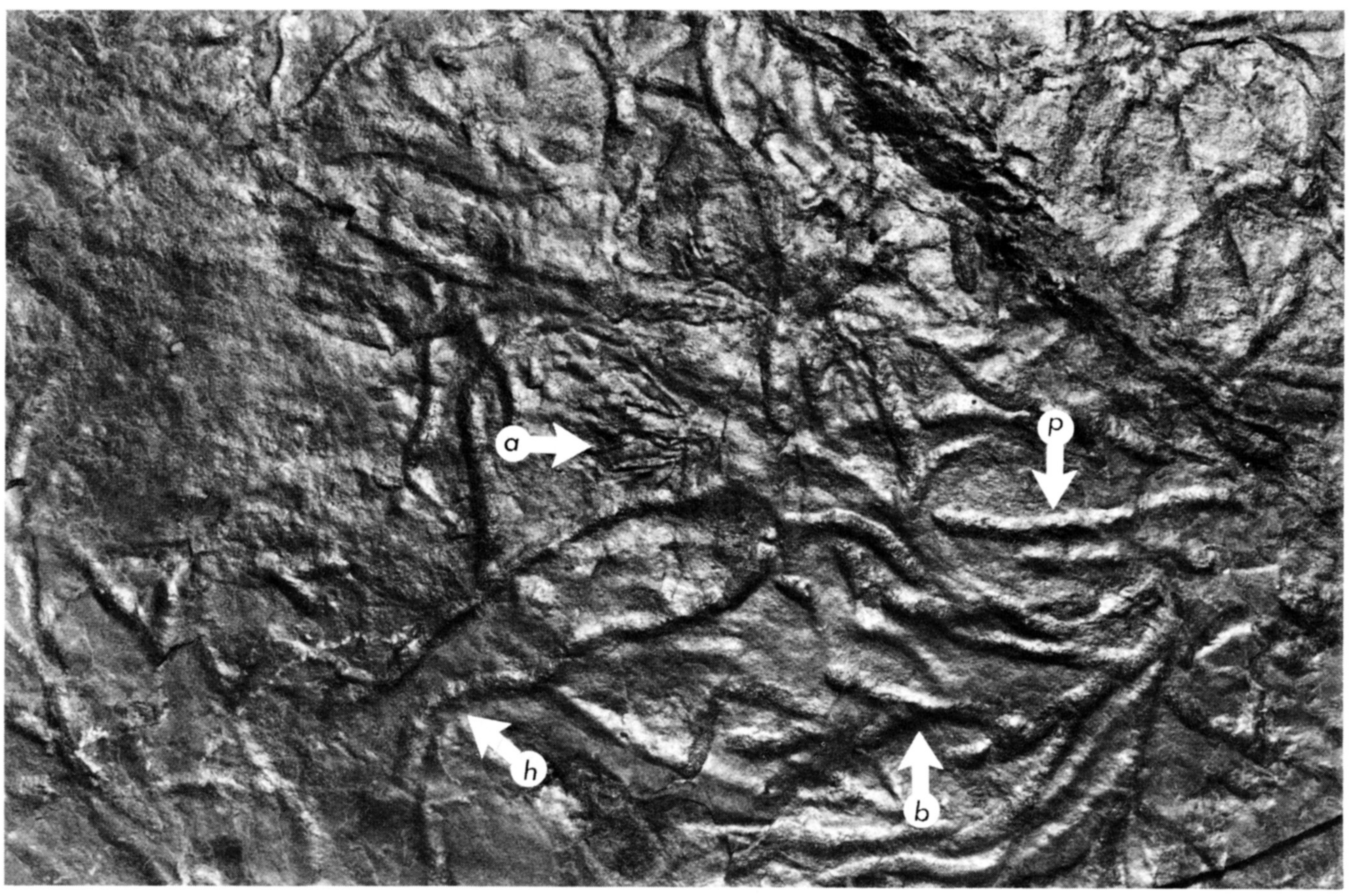

Fig. 2. Bottom surface of a siltstone slab from the Matapedia Group exhibiting numerous burrows. a - *Chondrites* ichnosp. type B, p - *Palaeophycus tubularis*, h - *Helminthopsis* ichnosp., b - *Chondrites* ichnosp. type A., x1.

trace fossils described herein are truly representative of the original assemblage.

DISCUSSION

With respect to the Matapedia Group elsewhere within the Matapedia Basin of Maine, New Brunswick and Quebec the trace fossils at the Tobique River site are important in the following aspects:-

1. Personal observation of many additional sites in the Matapedia Group has indicated that trace fossils are generally rare in these strata and are restricted to poorly-preserved simple burrow systems, particularly *Chondrites*. The site is therefore a unique locality within the Matapedia Group.
2. As a corollary, the site has therefore preserved the most diverse and abundant collection of trace fossils within the Matapedia Group. Previous records of trace fossils in the Group (Pickerill, 1980, 1985, in press) have only listed *Chondrites*, *Helminthopsis*, *Planolites*, *Scalarituba*, *Syncoprulus* and *Yakutatia*. Thus, *Cochlichnus*, *Dictyodora*, *Dimorphichnus*, *Glockerichnus*, *Gordia*, *Muensteria*, *Neonereites* and *Palaeophycus* represent new recordings.
3. Of this latter list of new recordings only *Dimorphichus*, *Muensteria* and *Dictyodora* represent ichnogenera never previously documented from the Matapedia Basin, the remainder having been described from additional groups or formations elsewhere in the Basin (Pickerill, 1980, 1981, 1985, in press). The detailed taxonomy of *Muensteria* and other simple meniscate burrows such as *Scalarituba*, *Laminites*, *Ancorichnus* etc., has still to be resolved (Frey *et al*., 1984) and therefore further comment on its presence is perhaps not warranted at this time. Similarly *Dimorphichnus* is a simple arthropod-produced trace morphologically similar to *Diplichnites*, an ichnogenus previously recorded from coeval strata of the Matapedia Basin (Pickerill, 1980, 1981). However, the presence of *Dictyodora* cannot be overemphasized. Not only has this ichnogenus never previously been recorded from the Matapedia Basin but also it is the first recorded occurrence in North America despite being common in Paleozoic flysch sequences in Europe (see Benton and Trewin, 1980; Benton, 1982a, 1982b).
4. Until now, the trace fossil *Y. emersoni* has only previously been recorded from the Matapedia Basin in the Matapedia area of northern New Brunswick and southern Gaspe (Pickerill, 1985). This distinctive and unusual graphoglyptid trace fossil is therefore more widely distributed geographically within the Basin than previous data would suggest. *Y. emersoni* has only previously been recorded from Kodiak Island, Alaska, and the Matapedia Basin (Pickerill, 1985; McCann and Pickerill, 1986).

The fact that 15 ichnospecies are recorded from the Tobique River site together with *Planolites* and *Scalarituba* noted elsewhere within the Matapedia Group (Pickerill, in press) deserves additional comment. As previously noted, the Matapedia Group is interpreted to have been deposited in a slope setting (Stringer and Pickerill, 1980). Paleozoic, particularly lower Paleozoic, slope environments (and herein we employ the descriptor slope to exclude associated channelized features such as canyons, channels, chutes and gulleys with their associated fans and also continental rise environments (cf. Chamberlain, 1977) and utilize the term in the sense of Buck and Bottjer (1985) as essentially 'interchannel' slope environments) remain poorly documented with respect to their ichnocoenoses (Pickerill and Harland, in press). Indeed, only two studies have to date been published on ichnocoenoses of lower Paleozoic slope sequences, those of Narbonne (1984) from upper Silurian slope carbonates of Arctic Canada and Pickerill and Harland (in press) from middle Silurian slope clastics of North Greenland. Narbonne (1984) records the ichnogenera *Chondrites*, *?Neonereites*, *Margaratichnus?*, *Palaeophycus*, *Phycodes*, *Skolithos* and *Teichnichnus*, and Pickerill and Harland (in press) record the ichnogenera cf. *Chondrites*, *Gordia*, *Helminthopsis*, *Megagrapton*, *Muensteria*, *Neonereites*, *Nereites* and *Paleodictyon*. The total of 15 ichnospecies recorded from the Matapedia Group therefore represents the most diverse trace fossil assemblage yet recorded from lower Paleozoic slope deposits.

In a series of papers published in the 1970's, Seilacher (summarized in Frey and Seilacher, 1980) suggested a progressive increase in flysch (deep-water) trace fossil diversity during the Paleozoic. The three examples noted herein are broadly coeval and contain 7-13 distinctive trace fossils (ichnogenera) which do not numerically equate with the 4-8 ichnospecies documented by Seilacher. This is perhaps further reinforced when considering that *in toto* the three slope sequences noted above contain a combined total of at least 20 distinctive ichnogenera and, if the unpublished studies of Narbonne and Packard (1983) and Narbonne and James (1984) are included, at least 28 separate ichnogenera have to date been recorded from lower Paleozoic slope sequences. Future trace fossil analyses of Paleozoic flysch sequences should therefore be directed to a more extensive and taxonomic evaluation of the full range of trace fossils because it is only with careful and detailed analysis of such sequences that more realistic and meaningful diversity models will eventually be realised.

SYSTEMATIC ICHNOLOGY

In accordance with common ichnological procedure the trace fossils described below are considered in alphabetical order rather than any formal morphological or behavioural groupings (e.g., Osgood, 1970). Preservational terminology, where applicable, follows Webby (1969) and Häntzschel (1975). For brevity, descriptions and discussion of most ichnospecies have been minimized and only relevant literature is included. All figured specimens are housed in the Geology Department, University of New Brunswick.

Ichnogenus *Chondrites* von Sternberg, 1833
Chondrites ichnosp. type A
(Fig. 3a)

Description:

Small, acutely branched (typically less than 30^{o}) burrow systems which initiate from a horizontal mastershaft and then ramify to form a dendritic network. Individual systems cover a maximum

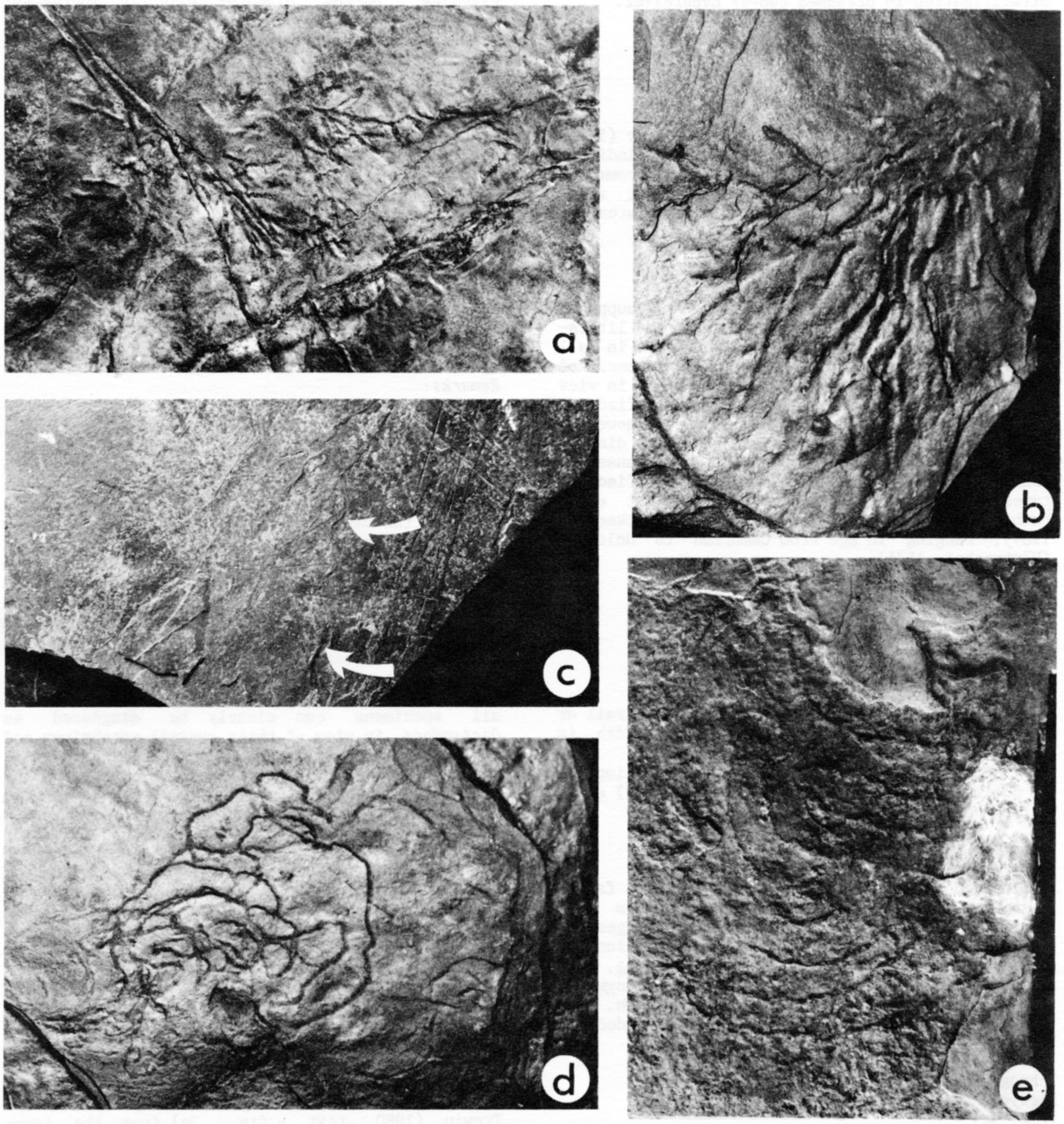

Fig. 3. Trace fossils from the Matapedia Group, Tobique River. a - *Chondrites* ichnosp. type A, x1. b - *Chondrites* ichnosp. type B, x1.4. c - *Cochlichnus anguineus* (arrowed), x1. d - *Dictyodora tenuis*, x0.8. e - *Dictyodora scotica*, x0.8.

observed area of 6 cm^2 but are typically smaller (2-3 cm^2). Individual burrows are straight and 1 mm or less in width; burrow fill is identical to host material. At least 3 orders of branching are commonly present. Preservation is parallel to stratification in presumed convex hyporelief.

Chondrites ichnosp. type B
(Fig. 3b)

Description:

As above except burrow diameter is larger (1-2.5 mm), branching is more irregular (20-90°), individual burrows may be straight or sinuous, commonly only 2 orders of branching are observed but individual systems cover a much larger surface area, up to a maximum observed of 30 cm^2.

Remarks:

Since first described in 1833, over 170 supposed ichnospecies of *Chondrites* now exist in the literature (Chamberlain, 1977) most of which are in all probability synonyms. Taxonomic re-assessment of these ichnospecies is clearly warranted and in view of this the present material is only identified at the ichnogeneric level. Equally as clear, however, is that 2 forms of *Chondrites* can be easily distinguished in the present material, and because of this taxonomic problem are herein identified as types A and B. *Chondrites* is a marine but eurybathic trace fossil (see Fillion and Pickerill, 1984), ranging in age from Cambrian to Holocene (Häntzschel, 1975).

Ichnogenus *Cochlichnus* Hitchcock, 1858
Cochlichnus anguineus Hitchcock, 1858
(Fig. 3c)

Description:

Regularly meandering, smooth, horizontal trail or burrow resembling a sine curve. Trace width is approximately 1 mm and wavelength is 5-6 mm. Fill is identical to host material and preservation is in positive convex (?epirelief or hyporelief) semirelief parallel to stratification.

Remarks:

Although locally used as a distinctive facies indicator (e.g., Hakes, 1976) *Cochlichnus* is more typically a eurybathic trace fossil and ranges in age from Late Proterozoic to Holocene. Fillion and Pickerill (in press) regard *C. kochi* Ludwig, 1869 and *C. serpens* Webby, 1970 as junior synonyms of *C. anguineus*, a view which is held herein, and therefore the ichnogenus can best be regarded as monospecific.

Ichnogenus *Dictyodora* Weiss, 1884
Dictyodora scotica (M'Coy, 1851)
(Fig. 3e)

Description:

Burrow system essentially preserved parallel to stratification and consisting of 5-10 parallel meanders each approximately 60 mm long and separated by 8-10 mm of undisturbed sediment. Individual segments of parallel meanders are gently curved. Burrow diameter varies from 2-3 mm. Rare examples, preserved at different stratification levels, demonstrate their 3-dimensionality; in such examples, burrow diameter slightly increases/decreases depending on whether such surfaces are below or above (respectively) the dominant stratification level.

Dictyodora tenuis (M'Coy, 1851)
(Fig. 3d)

Description:

Burrow system preserved parallel to stratification and consisting of irregularly meandering, typically cross-cutting but continuous trace. Primary meanders are typically broad and frequently develop secondary sinuosity. Burrow diameter varies from 0.5-1.0 mm, but as with *D. scotica*, preservation within a single specimen can be on different stratification levels and therefore vary accordingly.

Remarks:

Dictyodora is an extremely complex trace fossil consisting of a basal burrow, typically lenticular in cross-section and varying in width from 1.5-6 mm, from which extends a vertical or inclined upward tapering longitudinal wall from the dorsal line of the basal burrow which may be up to 25 mm in height (Benton and Trewin, 1980; Benton, 1982a). As such, individual specimens exhibit various preservational aspects depending on the level at which they are sectioned. We regard the specimens described herein as probably being preserved from near to the base of the wall (cf. Benton and Trewin, 1980, text - fig. 1c(b)), though there is no positive evidence to justify this as the basal burrows are conspicuously absent. Nevertheless, all specimens can clearly be diagnosed as *Dictyodora* in view of their overall morphology and the fact that slabs broken along different stratification levels illustrate their 3-dimensionality and slight morphological change with respect to this dimension.

D. scotica is differentiated from *D. tenuis* by the presence in the former of regular meanders and in the latter by irregular meanders and secondary sinuosity of the individual burrows. Additionally, although not apparent in the present material, the basal burrow in *D. scotica* is wider and the burrow height is greater (13 mm in *D. scotica*, 10 mm in *D. tenuis*). *D. zimmermanni* Hundt, 1913 possesses a less regular meandering pattern than *D. scotica* and lacks the regular secondary sinuosity characteristic of *D. tenuis* and *D. liebeana* (Geinitz, 1867) is a complex spiralled form of *Dictyodora* (Benton, 1982a). *D. scotica* as figured herein very closely resembles that figured by Benton (1982b, fig. 2d) and, particularly, Benton and Trewin (1980, text - fig. 3c) from the lower Silurian of Scotland and *D. tenuis* broadly resembles that figured by Benton and Trewin (1980, text - fig. 5), though the specimen figured herein exhibits more cross-cutting relationships.

Dictyodora has been widely reported from several European flysch sequences, as reviewed in Benton and Trewin (1980) and Benton (1982a, 1982b). To our knowledge, however, it has never previously been documented in North America though some of Emmons' (1844) material from the Silurian of Maine may prove to be congeneric, particularly some of his '*Nereites*' ichnospecies. This particular aspect is currently under investigation by two of us (R.K.P and W.H.F.). The ichnogenus ranges in age from Cambrian to Carboniferous and is an important member of the deep-water *Nereites* ichnofacies of Seilacher (1967).

Ichnogenus *Dimorphichnus* Seilacher, 1955
Dimorphichnus ichnosp.
(Fig. 4a)

Description:

Simple straight to gently curved trackways, parallel to stratification, up to 11 cm in length and composed of two types of impressions; thin straight to gently curved impressions, each 5 mm in length and 4-5 mm apart and oriented at an angle of 60° to the track axis, and short blunt impressions, each approximately 1 mm in length and located opposite to the main impressions, being separated from them by 1 cm of undisturbed sediment.

Remarks:

Seilacher (1955) erected *Dimorphichnus* for trackways produced by arthropods, particularly trilobites, in which the body was oriented nearly at right angles to the direction of movement. The resulting trace is a series of long raking imprints made by the appendages on the lee side of the body; the legs of the other side provided body support, thus these imprints resemble a series of small pits (Osgood and Drennen, 1975). It has previously been interpreted as both a feeding trail (Seilacher, 1955) or having been produced as a result of current activity (Osgood, 1975). Its reported age is from Cambrian to Silurian, though is probably present in strata of at least Paleozoic age.

Ichnogenus *Glockerichnus* Pickerill, 1982
Glockerichnus ichnosp.
(Fig. 4b)

Description:

Incomplete stellate trace preserved in negative ?epirelief, parallel to stratification. The trace consists of numerous straight to gently curved burrows which radiate out from a diffuse and poorly-preserved center. Individual burrows are unbranched, 3-4 mm in diameter and of unequal length. Maximum width of the trace is 17 cm.

Remarks:

Ichnospecies of *Glockerichnus* are based on the shape, dimensions and density of ribbing (Ksiazkiewicz, 1977). In all these respects the specimen described herein closely resembles the type ichnospecies *G. glockeri* but is only identified at the ichnogeneric level because of its generally poor and incomplete preservation. A more complete discussion of the trace fossil is given in Ksiazkiewicz (1977). It ranges in age from Ordovician to Holocene and has only previously been recorded from deep-water flysch environments.

Ichnogenus *Gordia* Emmons, 1844
Gordia marina Emmons, 1844
(Fig. 4c)

Description:

Smooth, unbranched trails or burrows of uniform diameter (1-2 mm) which exhibit a tendency to wind, but not meander, and frequently cross-cut within a single burrow system. Preservation is in positive hyporelief.

Remarks:

More complete discussions and descriptions of *Gordia* and its ichnospecies are given in Ksiazkiewicz (1977) and Fillion and Pickerill (in press). The ichnogenus is distinguished from the morphologically similar ichnogenus *Helminthopsis* by the absence in the latter of true level-crossing. *Gordia* is a facies crossing form ranging in age from upper Proterozoic to Holocene.

Ichnogenus *Helminthopsis* Heer, 1877
Helminthopsis ichnosp.
(Fig. 4g)

Description:

Simple, irregularly meandering horizontal and unbranched smooth burrows preserved in convex hyporelief. Diameter varies from 2-4 mm but is constant in individual specimens. Length variable, up to a maximum observed of 15 cm. Burrow fill is identical to surrounding host material. Burrows never cross or touch themselves.

Remarks:

Many authors, too numerous to mention here, have reported the ichnogenus in strata of Late Precambrian to Holocene age (Fillion and Pickerill, in press). It is a eurybathic form, though more frequently reported from deep-water flysch successions (Pickerill, 1981). As with *Chondrites*, many ichnospecies of *Helminthopsis* exist in the literature, most of which are difficult to differentiate and some of which may be synonymous (Ksiazkiewicz, 1977). Detailed systematic study of the ichnogenus still, therefore, has to be undertaken and in view of this the present material is identified only at the ichnogeneric level.

Ichnogenus *Muensteria* Sternberg, 1833
Muensteria ichnosp.
(Fig. 4d)

Description:

Straight to gently curved unbranched horizontal burrows preserved in convex hyporelief and concave epirelief. Individual burrows are 7-10 mm in width, up to 11 cm in length and possess internal meniscate structures, typically 10-12 per centimetre. Burrow fill is identical to surrounding host material. Individual burrows retain a constant diameter and possess thinly lined (<1 mm) but extremely sharp walls.

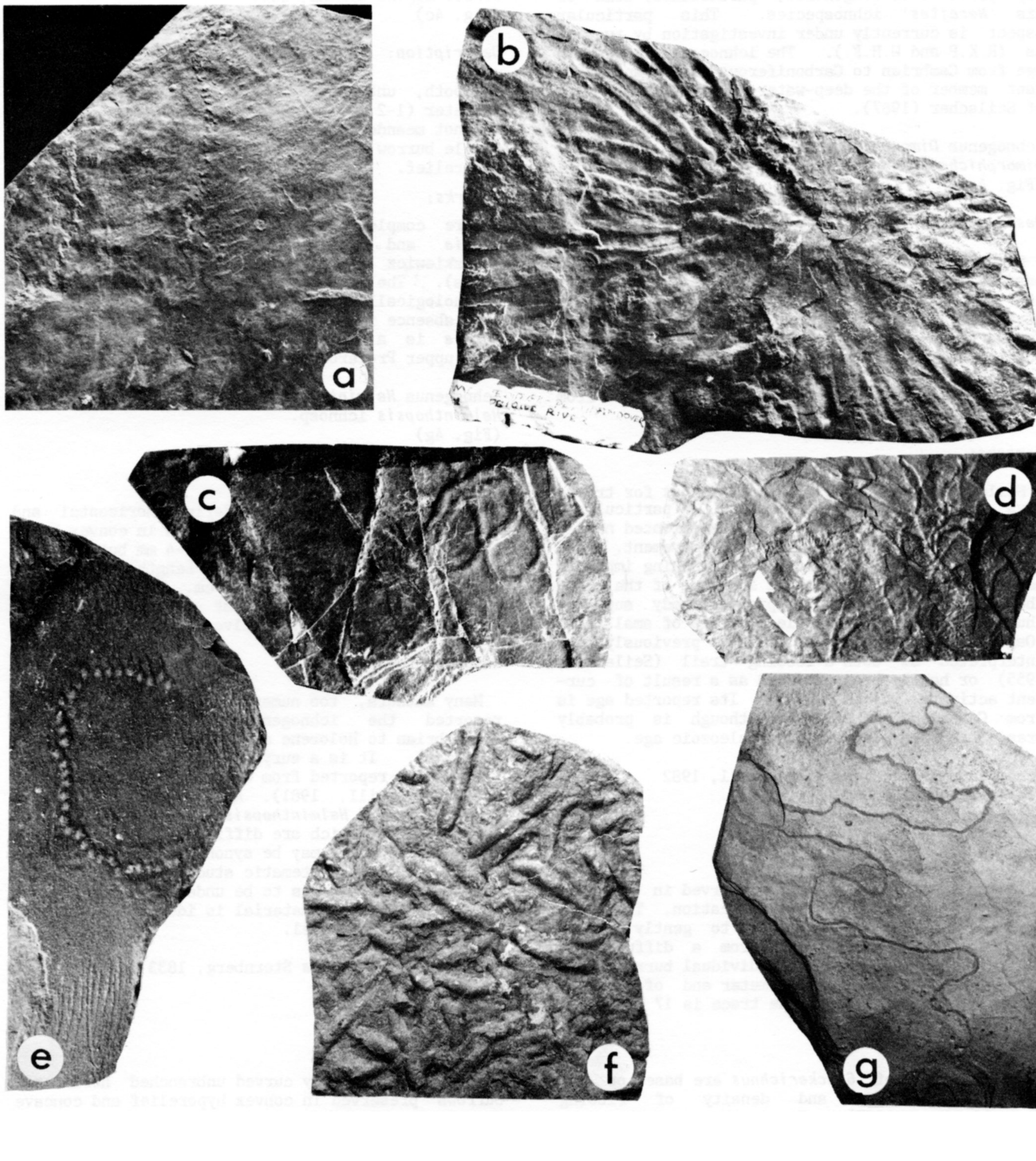

Fig. 4. Trace fossils from the Matapedia Group, Tobique River. a - *Diplichnites* ichnosp., x0.7. b - *Glockerichnus* ichnosp., x0.6. c - *Gordia marina*, x1. d - *Muensteria* ichnosp. x0.5. e - *Neonereites uniserialis*, x1.3. f - *Palaeophycus tubularis*, x1. g - *Helminthopsis* ichnosp., x0.5.

Remarks:

As noted by Frey *et al*. (1984), there is still considerable taxonomic confusion in the naming of both lined (e.g., *Ancorichnus*) and unlined (e.g., *Scalarituba*, *Beaconites*, *Taenidium*) meniscate burrows. Fürsich (1974) alluded to this difficulty and placed *Planolites montanus*, *Taenidium* and *Keckia* into synonymy with *Muensteria*. Although *Keckia* has not subsequently been utilized, both *P. montanus* and *Taenidium* are still commonly cited forms (see Pemberton and Frey, 1982; Hakes, 1985). Thus, *Muensteria* and its possible synonyms have been plagued by considerable taxonomic confusion and until re-evaluation is undertaken, as is supposedly underway by Squires and Advocate (1984), must be regarded, by rule of priority, as the available form for simple meniscate burrows. The material described herein most closely resembles, particularly with respect to width, length, non-branched nature and density of striations, the type ichnospecies, as denoted by Ksiazkiewicz (1977), *M. geniculata* Sternberg, but in view of the taxonomic confusion is only identified at ichnogeneric level. Though reportedly ranging in age from Jurassic to Cretaceous (Häntzschel, 1975), the ichnogenus has since been reported from the Holocene (Wetzel, 1983) and probably extends back to at least, as documented herein, the lower Paleozoic.

Ichnogenus *Neonereites* Seilacher, 1960
Neonereites uniserialis Seilacher, 1960
(Fig. 4e)

Description:

Curved, horseshoe-shaped chain of closely spaced uniserial subcircular pods preserved in convex hyporelief. The single specimen is 38 mm in total length, comprising 35 individual knobs, each of which is approximately 1 mm in diameter.

Remarks:

Ichnospecies of *Neonereites*, namely *N. unserialis* Seilacher, 1960, *N. biserialis* Seilacher, 1960 and *N. multiserialis* Pickerill and Harland, in press, are easily distinguished by the uniserial, biserial or multiserial arrangement of pods within an individual specimen even though transitional forms have previously been reported (e.g., Pickerill, 1981). The ichnogenus is a eurybathic but marine form and has been recorded from strata of Late Precambrian to Tertiary age (Häntzschel, 1975; Fedonkin, 1977).

Ichnogenus *Nereites* Macleay, 1839
Nereites jacksoni Emmons, 1844
(Fig. 5a)

Description:

Irregularly sinuous to meandering burrows of total and consistent width of 1 cm and variable length up to an observed maximum of 28 cm. Individual specimens consist of a smooth central portion, 2-3 mm in width, on each side of which are arranged poorly-preserved, dense (4-6 per cm), rounded and smooth lobes each up to 2.5-3 mm in

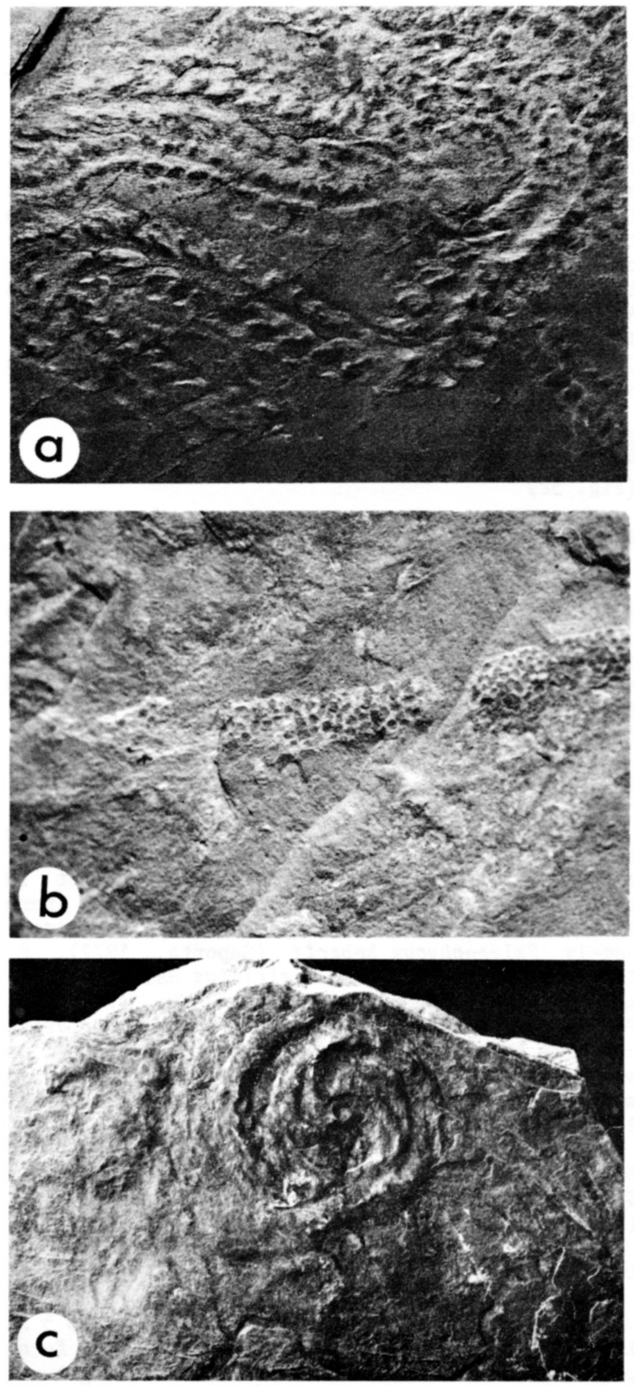

Fig. 5. Trace fossils from the Matapedia Group, Tobique River, a - *Nereites jacksoni*, x1. b - *Syncoprulus pharmaceus*, x1. c - *Yakutatia emersoni*, x1.2.

width. Preservation style is unknown but is probably in convex hyporelief.

Remarks:

A fairly comprehensive taxonomic re-assessment of the ichnogenus *Nereites* was recently undertaken by Benton (1982b). Of the four ichnospecies he recognized, namely *N. macleayi* (Murchison, 1839), *N. cambrensis* Murchison, 1939, *N. jacksoni* Emmons, 1844 and *N. pugnus* Emmons, 1844, the present material is remarkably similar to *N. jacksoni* with respect to shape and density of the lateral lobes and is diagnosed as such. Examination by one of us (R.K.P.) of topotype material of *N. jacksoni* from the Early Silurian Waterville Formation of Maine confirmed this identification. Although forming the type ichnogenus of the deep-water flysch *Nereites* ichnofacies of Seilacher (1967), the ichnogenus should be regarded as eurybathic (Hakes, 1976). It ranges in age from Late Precambrian to Holocene.

Ichnogenus *Palaeophycus* Hall, 1847
Palaeophycus tubularis Hall, 1847
(Fig. 5f)

Description:

Straight to slightly sinuous, but not meandering, smooth thinly lined horizontal burrows preserved in convex hyporelief. Diameter varies from 2-6 mm but is constant in individual specimens; length is variable, up to a maximum observed of 8 cm. Burrow fill is structureless and is identical to surrounding host material. No branching has been observed.

Remarks:

The detailed taxonomy of *Palaeophycus* was recently completed by Pemberton and Frey (1982) after several decades of confusion with respect to the ichnogenus and the closely related form *Planolites*. Of the ichnospecies they recognized, namely *Palaeophycus heberti* (Saporta, 1872), *P. tubularis* Hall, 1847, *P. striatus* Hall, 1852, *P. sulcatus* (Miller and Dyer, 1878) and *P. alternatus* Pemberton and Frey, 1982, the present material conforms best to *P. tubularis* and is diagnosed as such. *Palaeophycus* is a eurybathic form ranging in age from Proterozoic to Holocene (Häntzschel, 1975).

Ichnogenus *Syncoprulus* Richter and Richter, 1939
Syncoprulus pharmaceus Richter and Richter, 1939
(Fig. 5b)

Description:

Simple unbranched horizontal burrows, up to 5 mm in diameter and 15 cm in length filled with fecal pellets. Individual burrows may be straight or sinuous. Fecal pellets are subspherical to elliptical in shape, each approximately 1 mm in length and slightly less than 1 mm in width.

Remarks:

The oldest known pellet-filled burrows have been referred to as *Alcyonidiopsis* Massalongo, 1856, but since this name was not utilized during 63 years preceding 1955 it should best be considered a *nomen oblitum* (International Code of Zoological Nomenclature, Article 23b). *Alcyonidiopsis* burrows from the Matapedia Basin previously noted by Pickerill (1980) should therefore now be regarded as *Syncoprulus*. Häntzschel (1975) placed *Syncoprulus* in synonymy with *Tomaculum* Groom, 1902, but as noted by Hofmann (1972) this name should only be applied to individual fecal pellets rather than pellet-filled burrows. Because of the sparse recordings of *Syncoprulus* its stratigraphic range is unknown. Nevertheless it does range from at least the lower Paleozoic (this study) to the Cretaceous (as *Alcyonidiopsis* - see Chamberlain, 1977) and is probably a eurybathic form.

Ichnogenus *Yakutatia* Häntzschel, 1962
Yakutatia emersoni (Ulrich, 1904)
(Fig. 5c)

Description:

Poorly-preserved specimen in positive hyporelief parallel to stratification. The specimen is a dextrally coiled burrow system of approximately circular outline and 2.4 cm in total diameter. A centrally positioned initial burrow branches at least twice, possibly three times, and these successive branches coil in the same manner and on the outside of the initial burrow. Individual burrows are 2-3 mm wide, smooth, and burrow fill is identical to surrounding host material.

Remarks:

The monospecific and enigmatic trace fossil *Y. emersoni* was recently reviewed and redescribed by McCann and Pickerill (1986) from its type location on Kodiak Island, Alaska. The only other presently known location of the trace is, in fact, from the Matapedia Basin (Pickerill, 1985). The trace fossil is restricted to deep-water flysch environments and ranges in age from Ordovician to Cretaceous.

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