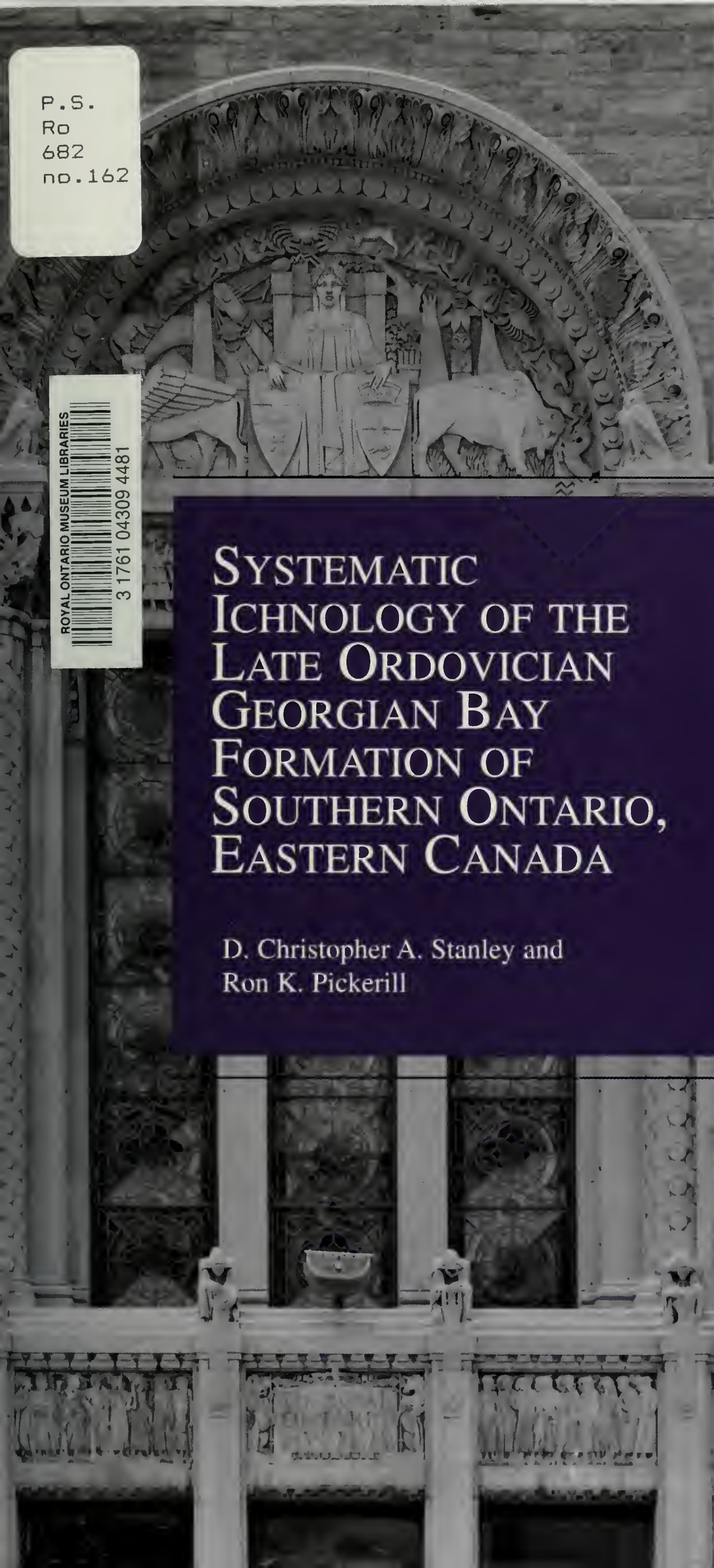

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Systematic Ichnology of the Late Ordovician Georgian Bay Formation of Southern Ontario, Eastern Canada

D. Christopher A. Stanley and
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ROM

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Cover: *Rusophycus polonicus* Orlowski, Radwański and Roniewicz, convex hyporelief, ROM 49429.

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Contents

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Abstract

The Late Ordovician Georgian Bay Formation of southern Ontario comprises between 127 and 177 m of alternating predominantly grey shales and grey calcareous sandstones, and is informally subdivided into lower shale-dominated and upper sandstone-dominated members. The succession is interpreted as a storm-dominated shelf sequence; many individual sandstone-shale couplets display all or part of a characteristic internal sequence encompassing a basal lag zone overlain by hummocky cross-stratification overlain by horizontal-laminated and cross-laminated deposits, all overlain by shale.

While the upper member, as exposed extensively on Manitoulin Island, contains few and only poorly preserved trace fossils, the lower member has revealed an abundant ichnofauna characterized by 26 ichnogenera represented by at least 47 ichnospecies, namely, *Arenicolites* isp.; *Arenituba verso* (Chamberlain, 1971a); *Arthraria antiquata* Billings, 1872; *Aulichnites parkerensis* Fenton and Fenton, 1937; *Chondrites* isp.; *Cochlichnus anguineus* Hitchcock, 1858; *Cochlichnus* n. isp.; *Cruziana* cf. *lobosa* Seilacher, 1970; *Cruziana problematica* (Schindewolf, 1921); *Cruziana quadrata* Seilacher, 1970; *Cruziana* ispp.; *Curvolithus multiplex* Fritsch, 1908; *Didymaulichnus lyelli* (Rouault, 1850); *Diplocraterion* cf. *biclavatum* (Miller, 1875); *Diplocraterion helmerseni* (Öpik, 1929); *Diplocraterion parallelum* Torell, 1870; *Fustiglyphus annulatus* Vialov, 1971; *Gordia marina* Emmons, 1844; *Gyrochorte comosa* Heer, 1865; *Helminthopsis hieroglyphica* Wetzel and Bromley, 1996; cf. *Lingulichnus verticalis* Hakes, 1976; *Lockeia siliquaria* James, 1879; cf. *Monocraterion tentaculatum* Torell, 1870; *Monomorphichnus bilinearis* Crimes, 1970; *Monomorphichnus lineatus* Crimes, Legg, Marcos and Arboleya, 1977; cf. *Palaeophycus crenulatus* Buckman, 1995; *Palaeophycus heberti* (de Saporta, 1872); *Palaeophycus striatus* Hall, 1852; *Palaeophycus tubularis* Hall, 1847; *Paleodictyon* ispp. a–b; *Phycodes flabellus* (Miller and Dyer, 1878a); *Phycodes palmatus* (Hall, 1852); *Planolites annularius* Walcott, 1890; *Planolites beverleyensis* (Billings, 1862); *Planolites constriannulatus* Stanley and Pickerill, 1994; *Protovirgularia rugosa* (Miller and Dyer, 1878a); ?*Protovirgularia* isp.; *Rusophycus carbonarius* Dawson, 1864; *Rusophycus cryptolithi* Osgood, 1970; *Rusophycus osgoodii* n. isp.; *Rusophycus polonicus* Orlowski, Radwański and Roniewicz, 1970; *Rusophycus pudicus* Hall, 1852; *Skolithos magnus* Howell, 1944; *Skolithos verticalis* (Hall, 1843); *Trichophycus lanosus* Miller and Dyer, 1878a; and *Trichophycus venosus* Miller, 1879.

This association of ichnotaxa contains elements of the *Cruziana* ichnofacies, indicative of a subtidal environment below fair-weather wave base, but above storm wave base. In overall taxonomic composition the ichnofaunal assemblage compares favourably to that from coeval and palaeoenvironmentally similar strata previously documented from carbonates of the Cincinnatian Series of Ohio.

Introduction

PURPOSE

The Late Ordovician Georgian Bay Formation of southern Ontario represents a storm-deposited sequence, 127–177 m thick, predominantly comprising interbedded grey shales and grey calcareous sandstones (Kerr and Eyles, 1991). It contains a diverse ichnofauna that can be assigned to the *Cruziana* ichnofacies of Seilacher (1964, 1967). Virtually no systematic ichnological research has been undertaken in this formation since Fritz (1925, 1926) described several "fucoids" from these strata. The principal purpose of this study, therefore, is to re-assess taxonomically all previously collected material, supplemented by new and additional collections made by us between 1990 and 1992, thereby providing an updated catalogue of the ichnology of the formation for possible future comparative purposes.

STUDY AREA

The Georgian Bay Formation of southern Ontario, eastern Canada, crops out along a northwesterly-southeasterly trending belt from the shores of Lake Ontario at Toronto and Mississauga in the southeast, through the shores of Georgian Bay at Meaford, and onto the northern shores of Manitoulin Island in the northwest (Text-Fig. 1). Surface outcrop of the formation is restricted to the Toronto/Mississauga and Meaford areas, where numerous riverbank and creek sections exist, and to various localities on Manitoulin Island, where road-cut, riverbank, and waterfall sections are present. Most of the area between Toronto and the shores of Georgian Bay is covered by extensive glacial drift, resulting in only very rare exposures along small inland creeks. Access to sections in the Toronto/Mississauga area is granted by bicycle paths along the banks of the Credit, Don, and Humber rivers, as well as along Mimico and Etobicoke creeks (Text-Fig. 2). In the Georgian Bay area, the type locality of the Georgian Bay Formation, along the banks of Workman's Creek, is accessible where it is crossed by Highway 26. Additional sections in the area are present on sideroads. Sections on Manitoulin Island are easily visited by the numerous paved and gravel roads covering the island.

PREVIOUS WORK—SEDIMENTOLOGY/STRATIGRAPHY

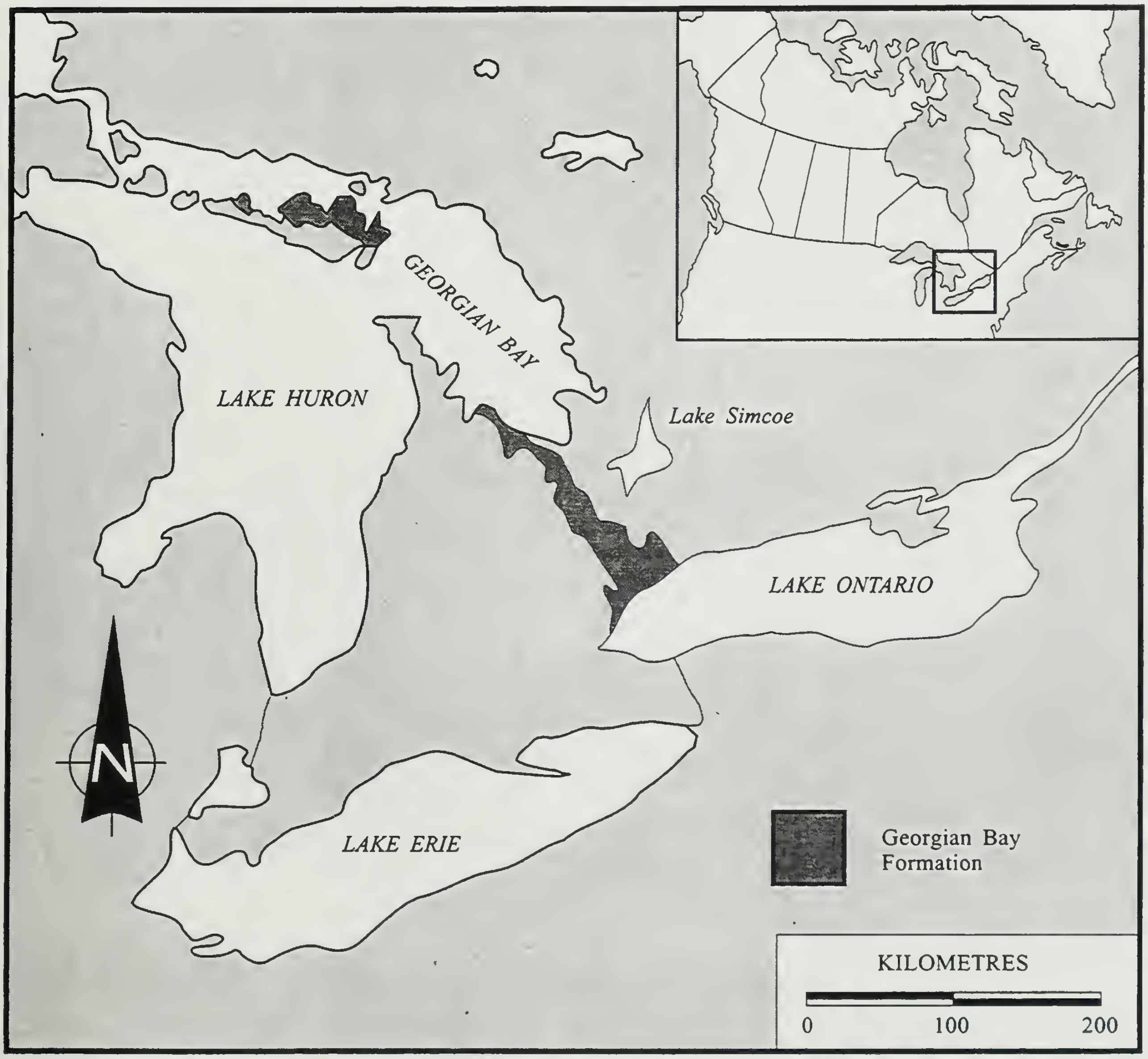
Historically, most geological research on the Georgian Bay Formation has been in the areas of sedimentology, macropalaeontology, biostratigraphy, and, more recently, lithostratigraphy (Foerste, 1912, 1916, 1924; Fritz, 1925, 1926, 1946, 1951, 1970, 1971; Parks, 1925, 1928; Caley, 1936, 1940; Okulitch, 1939; Gorrell, 1952; Liberty, 1953, 1969; Sanford, 1961; Beards, 1967; Lajtai, 1969; Liberty and Bolton, 1971; Winder and Sanford, 1972; Burke et al., 1973; Haugh, 1979; Kobluk, 1980; Russell and Telford, 1983; Eckert, 1987). In addition to these studies, Burke et al. (1973) and particularly Kerr and Eyles (1991) outlined palaeoenvironmental interpretations for the formation, and descriptions of the sedimentology are also available in several fieldtrip guidebooks (Liberty, 1954, 1964, 1968, 1978; Sanford and Mosher, 1978). The geology of the formation, as it appears on Manitoulin Island, has more recently received attention from Byerley and Coniglio (1989a, 1989b, 1991).

PREVIOUS WORK—ICHNOLOGY

To date, no comprehensive ichnological study of the Georgian Bay Formation has been undertaken. Several specimens described by Fritz (1925, 1926) as plant fossils, or "fucoids," were in fact trace fossils, while Burke et al. (1973), Byerley and Coniglio (1989a), and Kerr and Eyles (1991) offered partial, but not totally correct, ichnotaxonomic lists of traces present in the formation. The relatively diverse and generally well preserved ichnofauna of this formation is the focus of this study.

ICHNOFACIES

The ichnofacies concept was originally introduced by Seilacher (1964, 1967) in order to illustrate the association of recurrent trace-fossil assemblages with palaeoenvironmental conditions. While Seilacher's original concept of archetypal ichnofacies as a series of depth-dependent assemblages was truly visionary in the sixties and can still be applied in many situations, it is now recognized that changes in other environmental parameters associated with increasing water depth, such as salinity, temperature, oxygen, and current strength, are crucial to the makeup of a recurring ichnocoenose (Frey et al., 1990; Bromley, 1990). Trace fossils from the Georgian Bay Formation can collectively be referred to the *Cruziana* ichnofacies (cf. Rudkin, 1981; Kerr and Eyles, 1991). This ichnofacies possesses abundant crawling traces, inclined or vertical U-shaped burrows displaying mostly protrusive spreite, and scattered vertical cylindrical burrows, and is characterized by a generally high diversity and abundance (Frey and Pemberton, 1984). An environment characterized by subtidal, unconsolidated substrates associated with either moderate energy levels in shallow waters (below daily wave base but above storm wave base) or reduced energy levels in deeper, quieter waters is generally indicative of this ichnofacies (Frey and Pemberton, 1984; Frey et al., 1990).



TEXT-FIG. 1. Map of southern Ontario showing extent of Georgian Bay Formation and place names referred to in text.

TEXT-FIG. 2. Map of Mississauga and Metro Toronto areas giving key outcrop locations along the Credit, Don, and Humber rivers and Mimico and Etobicoke creeks.

Systematic Ichnology

INTRODUCTORY REMARKS

Updated synonymies have been undertaken for those ichnotaxa lacking recent systematic studies or that have numerous poorly classified examples in need of revised taxonomic assignments. These include *Arenituba* Stanley and Pickerill, 1995; *Cochlichnus* Hitchcock, 1858; and *Fustiglyphus* Vialov, 1971. The synonymies for *Fustiglyphus* and *Arenituba* have already been published by us (respectively, Stanley and Pickerill, 1993a, 1995), and are therefore not repeated, while that for *Cochlichnus* is presented herein. Ichnotaxa such as *Diplocraterion* Torell, 1870, *Palaeophycus* Hall, 1847, *Planolites* Nicholson, 1873, and *Skolithos* Haldeman, 1840, have received detailed systematic treatment by, respectively, Fürsich (1974), Pemberton and Frey (1982), and Alpert (1974). Han and Pickerill (1994a, 1995) have also recently provided detailed discussions on, respectively, *Phycodes* Richter, 1850, and *Helminthopsis* Heer, 1877. The latter has also received detailed discussion by Wetzel and Bromley (1996).

Several ichnotaxa from the Georgian Bay Formation have been figured in earlier works (Fritz, 1925; Kerr and Eyles, 1991). Fritz included *Chondrites* von Sternberg, 1833; *Diplocraterion biclavatum* (Miller, 1875); *Phycodes flabellus* (Miller and Dyer, 1878a); *Palaeophycus tubularis* (Hall, 1847); *Rusophycus pudicus* Hall, 1852; and *Trichophycus venosus* Miller, 1879. Kerr and Eyles included *Chondrites*; *Cruziana problematica* (Schindewolf, 1921); *Didymaulichnus* Young, 1972; *Diplocraterion biclavatum, Monomorphichnus lineatus* Crimes et al., 1977; *Palaeophycus striatus* Hall, 1852; *Palaeophycus tubularis, Rusophycus carbonarius* Dawson, 1864; and *Trichophycus venosus*.

In order to avoid an unnecessarily lengthy citation list, the dates of publication of ichnotaxa are given only for those that are described in this work, this action being in agreement with Article 22 of the International Code of Zoological Nomenclature (ICZN), which states that the "citation of the date of publication of a name is optional." All material figured herein is housed in the Department of Invertebrate Palaeontology, Royal Ontario Museum, Toronto, Ontario, Canada, and specimens are designated by numbers bearing the prefix ROM. Several older museum specimens may bear two numbers following this prefix. The first is the number assigned to the specimen during the production of a standardized catalogue in the 1970s. The second, found within brackets, signifies the old catalogue number by which the specimen was referred to in early works such as Fritz (1925) (see Waddington et al., 1978). A list of all ROM material, along with the respective ROM catalogue numbers, is given in Appendix 1. Additional material is housed in the Department of Geology, University of New Brunswick, Fredericton, New Brunswick, Canada.

Because of poor preservation some material is considered unworthy of detailed description. This includes examples of *Arenicolites* isp. (ROM 49767, 50049), *Lockeia siliquaria* James (ROM 50076), and *Rusophycus carbonarius* Dawson (ROM 50083), which, although not described, do contribute to the overall diversity of the trace-fossil material, and for completeness and possible future reference purposes they are also included in the ROM collections as well as in Appendix 1.

Ichnogenus *Arenituba* Stanley and Pickerill, 1995

TYPE ICHNOSPECIES

Micatuba verso Chamberlain, 1971a, by monotypy.

DIAGNOSIS

Generally irregularly arranged, sometimes branched tubes radiating from a central gallery, singly or bunched, straight, curved, winding, or sinuous, smooth to finely annulate, sand-coated or -filled (after Stanley and Pickerill, 1995).

DISCUSSION

See Stanley and Pickerill, 1995.

Arenituba verso (Chamberlain, 1971a)

Pl. 1, fig. 1

Arenituba verso Stanley and Pickerill, 1995, fig. 2.

DIAGNOSIS

As for ichnogenus.

MATERIAL

One specimen: ROM 49640.

DESCRIPTION AND REMARKS

See Stanley and Pickerill, 1995.

Ichnogenus *Arthraria* Billings, 1872

TYPE ICHNOSPECIES
Arthraria antiquata Billings, 1872, by monotypy.

DIAGNOSIS
Dumbbell-shaped trace fossil parallel to stratification, preserved in convex hyporelief, composed of a shallower stem connecting two wider and more deeply impressed terminations, both of which are commonly hemispherical, but heart, dogbone, and arrowhead shapes in various combinations occur. Terminations do not extend vertically upwards and vertical tubes and spreiten are absent (after Fillion and Pickerill, 1984a).

DISCUSSION
Detailed examination of *Arthraria* was undertaken by Fillion and Pickerill (1984a). A discussion of its distinguishing features with respect to *Bifungites* and *Diplocraterion* is presented later in the remarks on *D*. cf. *biclavatum*.

***Arthraria antiquata* Billings, 1872**
Pl. 1, fig. 2

MATERIAL
One specimen: ROM 50050.

DIAGNOSIS
Smooth *Arthraria* typically preserved in convex hyporelief (after Fillion and Pickerill, 1990a).

DESCRIPTION
Specimen preserved as a dumbbell-shaped convex hyporelief, 2.4 cm in length. Two smooth hemispherical terminations, 4–5 mm in length by 6–7 mm in width, are separated from each other by a 4 mm wide, smooth connecting rod 15 mm in length. Of the two terminations, one is more deeply impressed (3 mm) than the other, which is of similar depth to the connecting rod (2 mm).

REMARKS
To date, *Arthraria* is monoichnospecific; the material is therefore assigned to *A. antiquata*. The most effective criterion for distinguishing *A. antiquata* from specimens of the morphologically similar ichnotaxon *Diplocraterion* in the Georgian Bay Formation is connecting-rod morphology. *Arthraria* bears a connecting rod that is more or less flat, whereas that of *Diplocraterion* tends to arch as a result of the characteristic U-shaped morphology of the latter. In many cases, this results in a pinching-out of the connecting rod proximal to the dumbbell terminations. Additionally, size of *A. antiquata* is considerably smaller than *Diplocraterion,* and compares favourably to type material of the former ichnotaxon.

Ichnogenus *Aulichnites* Fenton and Fenton, 1937

TYPE ICHNOSPECIES
Aulichnites parkerensis Fenton and Fenton, 1937, by original designation.

DIAGNOSIS
Preserved in convex epirelief with a bilobate upper surface. May show a unilobate, convex-downward lower surface, in which case lateral margins of both surfaces intersect. Upper surface may show transverse, concave-convex striations. Lobes separated by median furrow (after Hakes, 1977).

DISCUSSION
Aulichnites was erected by Fenton and Fenton (1937) for bilobed traces preserved as convex epireliefs. Comparisons between this ichnogenus and other bilobate traces followed. Chamberlain (1971b) placed *Aulichnites* in synonymy with *Scolicia* de Quatrefages, offering virtually no discussion supporting this action, which was later rejected by Häntzschel (1975). Hakes (1977) discussed the validity of maintaining *Aulichnites* as a separate ichnogenus from *Scolicia* and *Taphrhelminthopsis* Sacco, suggesting that a re-examination of type material of *Scolicia* was required to determine whether *Aulichnites* should remain separate. Distinction between *Aulichnites* and *Taphrhelminthopsis* can be made on the basis that while the former occurs exclusively as a convex epirelief or concave hyporelief, the latter occurs only as convex hyporeliefs. Książkiewicz (1970, 1977) suggested that rare specimens of *Taphrhelminthopsis* are preserved as convex epireliefs; however, we believe that such material should more correctly be assigned to *Aulichnites*.

Similarities were noted by Fillion and Pickerill (1990a) between *Aulichnites* and *Bolonia* Meunier; however, in the latter the median furrow is more prominent than the associated lobes. Additionally, as *Bolonia* is more concave than convex, it is more comparable to *Chevronichnus* Hakes. *Psammichnites* Torell, which may also take the form of bilobate ribbons preserved in convex epirelief, can be distinguished from *Aulichnites* through the latter's lack of "a well-developed medial groove [or] a medial ridge corresponding to the upper surface medial furrow" when preserved in concave hyporelief (Hakes, 1977:218). *Psammichnites* is generally longer and flatter, with steep margins and a central sinusoidal furrow in epirelief, as well as being wider and less winding than *Aulichnites* (Hofmann and Patel, 1989). The lobes of *Psammichnites* also may bear transverse to somewhat oblique striellae (Fillion and Pickerill, 1990a).

***Aulichnites parkerensis* Fenton and Fenton, 1937**
Pl. 1, fig. 3

MATERIAL
Two specimens: ROM 50051–50052, plus additional field occurrences.

EMENDED DIAGNOSIS
Sinuous to straight, unbranched, bilobate positive epirelief traces having a narrow median furrow. Surfaces of the lobes may bear weak transverse concave-convex striations (modified after Howard and Frey, 1984; Frey and Howard, 1990).

DESCRIPTION
Specimens are preserved as gently curved to winding, bilobate, convex epireliefs, 7–15 mm in width by 130–230 mm in length. Lobes either are smooth or display faint striations oriented 45° to the midline. Widths of individual lobes range from 3 mm to 8 mm and may vary within a specimen. The median furrow varies in width from 0.5 mm to 2 mm.

REMARKS
Several examples appear to display a tendency towards level-crossing, suggesting comparison with the ichnogenus *Gordia* Emmons. However, unlike *Gordia,* in which such level-crossing occurs within single specimens, the majority of *Aulichnites* displaying this feature are in fact specimens crossing one another, but not themselves. One specimen (ROM 50051) does, however, follow a coiled path, producing an apparent level-crossing.

Ichnogenus *Chondrites* von Sternberg, 1833

TYPE ICHNOSPECIES
Fucoides antiquus Brongniart, 1828, by subsequent designation of Miller (1889:114).

DIAGNOSIS
Dendritic, smooth-walled, regularly ramifying small burrow systems that normally do not interpenetrate or interconnect. Diameter of components within a given system remains essentially constant (after Pemberton and Frey, 1984).

DISCUSSION
Since the erection of *Chondrites* in 1833, over 170 ichnospecies have been recognized in the literature, in many cases based only on slight differences in size or form (Chamberlain, 1971b). Additionally, Häntzschel (1975) recognized 17 ichnogenera as being synonymous with *Chondrites*. Although the possibility that *Chondrites* may have been produced by something other than algae was first suggested by Nathorst in 1881 (*in* Osgood, 1970), it was one of the last fucoids to be recognized as a trace fossil, being described exclusively as of algal origin until Richter (1927) described the phenomenon of phobotaxis (fear of touching) in *C. bollensis* (Zieten), in which it was observed that branches running on a "collision course" with other branches appeared to terminate just short of contact. This was thought by Richter (1927) to be indicative of an organism attempting to gain maximum efficiency in feeding by not reworking sediment already exploited. Alternatively, Simpson (1957) suggested that *Chondrites* was produced by an organism resting on the surface, using an extendable proboscis to explore the sediment beneath it for nutrients. This was accomplished by first exploring the sediment directly to the maximum distance from the organism, and then, working backwards along this initial burrow, producing offshoots, the unworked areas being restricted to one side of previous explorations. Phobotaxis was therefore used by the animal to avoid contact with previously covered ground. The principal difference between these two explanations is that the former suggested phobotaxis was used as an aid in ensuring a systematic coverage of an area, whereas the latter suggested that it was used to eliminate repeated excavation of territory during a more or less random approach to feeding. More recent discussions on the ichnotaxon have been presented, particularly with respect to its formation (Kotake, 1991) and as an indicator of anaerobic conditions (Bromley and Ekdale, 1984). Additionally, Vossler and Pemberton (1989) have discussed its possible role as an indicator of opportunistic species.

***Chondrites* isp.**
Pl. 1, fig. 4

Buthotrephis subnodosa Fritz, 1925:26, pl. 3, fig. 7.
Chondrites Kerr and Eyles, 1991, fig. 10b.

MATERIAL
Four slabs, each containing numerous specimens: ROM 17497 and ROM 50053–50055, plus additional field occurrences.

DESCRIPTION
Specimens consist of dichotomously branched, smooth burrows preserved as concave to flat epireliefs with up to four orders of branching. Individual burrows never interpenetrate. Branches typically terminate just short of contact as if on a "collision course" with another branch. More rarely (in three instances) two branches cross over one another without interpenetrating. Burrow cross-sections are elliptical, presumably a result of compaction. Disappearance of branches beneath the surface suggests the presence of a three-dimensional structure. Burrows display a relatively uniform diameter of 2–3 mm. Angles of bifurcation range from 23° to 48°, though one small system has angles ranging from 53° to 65°. Burrow-fill is a structureless, lighter, finer-grained micrite, though some specimens display a black fill.

REMARKS
Given the state of taxonomic disarray of *Chondrites*, ichnospecific assignment of these specimens is considered unrealistic. Comparison can be made, however, to Osgood's (1970) broad group "*Chondrites* Type B," described as groupings of tunnels, 1–4 mm in diameter, with a high contrast between filling and host rock, with tunnels piercing bedding planes and up to five orders of bifurcation ranging from 20° to 40°. Given the recognition of *Buthotrephis* Hall as for the most part synonymous with *Chondrites* (Häntzschel, 1975), some specimens of *B. palmata* Hall having been regarded as more akin to *Phycodes* Richter (Fillion and Pickerill, 1990b), ROM 17497 [1258HR] should be regarded as *Chondrites* isp. It should be noted that while Fritz (1925, pl. 3, fig. 6) assigned ROM 17497 [1258HR] to *B. subnodosa* in the text, the corresponding figure caption referred the specimen to *B. gracilis* Hall.

Ichnogenus *Cochlichnus* Hitchcock, 1858

TYPE ICHNOSPECIES
Cochlichnus anguineus Hitchcock, 1858, by monotypy.

non *Cochlichnus serpens* Webby, 1970:97–99 (*partim*), figs. 16 a–b (=*Helminthopsis*).
non *Cochlichnus* isp. Crimes, Legg, Marcos, and Arboleya, 1977:118 (*partim*), pl. 8a (=*Taphrhelminthopsis circularis*); Courel, Demathieu, and Gall, 1979:384, pl. 5, fig. 4 (=*Helminthopsis*); Pickerill, 1980, fig. 3a (*partim*) (=*Helminthopsis*).
non *Cochlichnus* Eagar, Okolo, and Walters, 1983:293, pl. 24f (=*Helminthopsis*); Pieńkowski and Westwalewicz-Mogilska, 1986:62, fig. 4b (=*Helminthopsis*); Narbonne, 1984:408, fig. 7g (=*Helminthopsis*).

DIAGNOSIS
Regularly meandering, horizontal trails and burrows resembling sine curves. Sinuosity of the trail may be extremely regular or somewhat irregular (after Pemberton and Frey, 1984; Fillion and Pickerill, 1990a).

DISCUSSION
Originally monoichnospecific, several new ichnospecies of *Cochlichnus* have been established since its formulation by Hitchcock in 1858, namely, *C. antarcticus* Tasch, *C. annulatus* Orlowski, *C. duomaensis* Yang, *C. kochi* Ludwig, *C. lagartensis* Muniz, *C. serpens* Webby, *C. surpuliformis* Yang and Hu, and *C. sousensis* Muniz. With the exception of *C. annulatus*, the vast majority of specimens assigned to these more recently erected ichnospecies can easily be assigned to *C. anguineus*, as can specimens described by other authors as either *Cochlichnus* or *Cochlichnus* isp. (see synonymy). Crimes et al. (1977, pl. 6d) illustrated one specimen of *C. anguineus* as *Cochlichnus* isp. However, the list of plates illustrating this form incorrectly cites plates 6d and 8a, and the latter depicts a specimen of *Taphrhelminthopsis circularis* Crimes, Legg, Marcos and Arboleya, as is correctly indicated in the figure's caption.

Courel et al. (1979) figured a specimen from the Middle Triassic of France. Although a portion of the trace displays a sinusoidal form typical of *Cochlichnus*, the remainder is more characteristic of *Helminthopsis* Heer. When faced with such "compound specimens," we follow the suggestion of Pickerill (1994) and Pickerill and Narbonne (1995) that the assigned name reflect the dominant morphology present. As more than half of the specimens figured by Courel et al. (1979, pl. 5, fig. 4) lack a sinusoidal form, the ichnogenus is best identified as *Helminthopsis*. Eagar et al. (1983), Narbonne (1984), and Pieńkowski and Westwalewicz-Mogilska (1986) illustrated specimens as *Cochlichnus* isp. that do not display a truly sinusoidal form; these, too, are best assigned to the more irregularly meandering ichnotaxon *Helminthopsis*. Material figured by Crimes and Crossley as their newly erected *Helminthopsis regularis* was described as "string-like burrows in fairly regular sine curves, which are of greater wavelength than amplitude" (Crimes and Crossley, 1991:38, figs. 4c–d, 5m–n). However, this diagnosis provides no distinction between *H. regularis* and *Cochlichnus*, both being sinusoidal forms whose wavelength is greater than their amplitude. In their discussion, Crimes and Crossley suggested that these two forms could be distinguished on the grounds that *Cochlichnus* displays a greater amplitude-to-wavelength ratio and is much larger in burrow diameter than *H. regularis*. However, as no boundary figure for separating these two forms based on the statistical analysis of amplitude-to-wavelength ratios was proposed, and as size is generally considered a poor ichnotaxobase for the distinction of two ichnogenera (cf. Pickerill, 1994), *H. regularis* is best considered a junior synonym of *C. anguineus* (see also Han and Pickerill, 1995; Wetzel and Bromley, 1996).

Rindsberg (1994:42) erected the ichnogenus *Cymataulus* for "horizontal, branched or simple, wavy burrows of relatively short wavelength," recognizing two ichnospecies, *C. undulatus* and *C. kochi*. While this ichnogenus was erected with the intention of recognizing a distinction between sinusoidal trails (*Cochlichnus*) and burrows (*Cymataulus*), such a distinction is in practice difficult if not impossible to make, as most specimens of each of these ichnotaxa are preserved as top or bottom surface reliefs. Rindsberg's (1994) recognition of *Cymataulus kochi* based on the presence of branching is a dubious assignment because many of the specimens believed by him to display branching in fact portray intersection of two unrelated traces (e.g., Eagar et al., 1985). In view of these problems, *Cymataulus* and its two associated ichnospecies are best regarded as junior synonyms of *Cochlichnus anguineus*.

***Cochlichnus anguineus* Hitchcock, 1858**
Pl. 2, fig. 1; Pl. 11, fig. 4

Cochlichnus anguineus Hitchcock. Häntzschel, 1962; W188, fig. 116.1; Pickerill, 1981:42, fig. 2c; 1992:26, fig. 4f; Archer and Maples, 1984:449, fig. 3c; Pemberton and Frey, 1984:289, fig. 5a; McCann and Pickerill, 1988:334, fig. 3, no. 7; Dam, 1990:125–126, fig. 6a; Metz, 1989:212, fig. 1b; 1992:30, fig. 1; 1995:44, fig. 1a; 1996:121, fig. 3A; Buatois and Mángano, 1990, fig. 2; 1993:241, fig. 3d; Fillion and Pickerill, 1990a:23, pl. 3, fig. 3; Crimes and Crossley, 1991:44, figs. 8a–b; Mikuláš, 1992:391–392, pl. vi, fig. 2; McCann, 1993:42, fig. 4c; Han and Pickerill, 1994b:225, fig. 3F; Gluszek, 1995, figs. 5, 7–8, 15A; Archer, Calder, Gibling, Naylor, Reid, and Wightman, 1995:2032, fig. 5d; Buatois, Mángano, Wu, and Zhang, 1996:293, figs. 8A–B.

Cochlichnus aff. *anguineus* Hitchcock. Książkiewicz 1977:151–152, pl. 20, fig. 1; 166, figs. p–q.

Cochlichnus isp. Kemper, 1968, pl. 7, fig. 5; Tasch, 1968b:191, figs. 2a–c; Aceñolaza and Durand, 1973:50, pl. 2c; Crimes, Legg, Marcos, and Arboleya, 1977:118, pl. 6d; Roniewicz and Pieńowski, 1977, pl. 1c; Aceñolaza, 1978:24, fig. 6; Palij, Posti, and Fedonkin, 1983, pl. 54, figs. 3–4, 6–7; Liñán, 1984:59–60, pl. 2, figs. 8b, 9; Demathieu, 1985, pl. 1b; Crimes and Anderson, 1985:317, figs. 6.1–2; McCann, 1990, fig. 4c; Mikuláš, 1991, pl. 4, fig. 5; Hofmann, Cecile, and Lane, 1994:733, figs. 5i–j.

Cochlichnus Hakes, 1976:23–24, pl. 5.5; 1985, pl. 1f; Miller, 1984, pl. 5f; Eagar, Baines, Collinson, Hardy, Okolo, and Pollard, 1985:138, pls. 3c, 12e–f; Miller, 1986:199, pl. 12b; Crimes, 1987:104, fig. 2c; Bjerstedt, 1987:877, fig. 9.5; 1988, fig. 4e.

Cochlichnus antarcticus Tasch, 1968a:35–36, figs. 1–2.

Cochlichnus kochi Ludwig. Häntzschel, 1975:W52, fig. 31.1; Elliott, 1985:185, fig. 2.

Cochlichnus serpens Webby, 1970:97–99 (*partim*), figs. 16c–f.

Cochlichnus lagartensis Muniz, 1980:3101–3103.

Cochlichnus sousensis Muniz, 1985:239–240, fig. 1.

Cymataulus kochi Rindsberg, 1994:42.

Cymataulus undulatus Rindsberg, 1994:42–43, pl. 7c–d.

Helminthopsis regularis Crimes and Crossley, 1991:38, figs. 4c–d, 5m–n.

Biting midge trail Metz, 1987:312–313, fig. 1.

MATERIAL
One specimen: ROM 49427.

DIAGNOSIS
Smooth *Cochlichnus* (after Fillion and Pickerill, 1990a).

DESCRIPTION
Smooth, unbranched, sinusoidal burrow, 9 mm in length and displaying a wavelength of approximately 0.8 mm and an amplitude of approximately 0.8 mm. Diameter of burrow 0.1–0.2 mm. Specimen preserved in convex hyporelief.

REMARKS
Possible progenitors of this ichnospecies include annelids lacking well-developed parapodia (Hitchcock, 1858; Hakes, 1976), nematodes lacking circular muscles (Clarke, 1964), and, in subaerial deposits, insect larvae (Metz, 1987).

***Cochlichnus* n. isp.**
Pl. 2, fig. 2

MATERIAL
One specimen: ROM 50056.

DESCRIPTION
Specimen preserved as an unlined, sinusoidal burrow, 11 mm in diameter, in convex epirelief. Amplitude is 15 mm and wavelength 45 mm, while the overall course curves slightly. Surface of trace bears at least seven distinct, sharply defined striations varying from 0.3 mm to 1 mm in width. Individual striations do not run the entire length of the trace, though there is no systematic alternation of striate and smooth portions.

REMARKS

While this specimen clearly represents a previously undescribed ichnospecies of *Cochlichnus* through the presence of well-defined longitudinal striations, until additional material is found, it is inadvisable to erect a new ichnospecies to accommodate it at this time. The fact that the present specimen is preserved as a convex epirelief indicates that it must have been produced by an organism's burrowing rather than trail-making activities.

Ichnogenus *Cruziana* d'Orbigny, 1842

TYPE ICHNOSPECIES

Cruziana rugosa d'Orbigny, 1842, by subsequent designation (Miller, 1889:115).

DIAGNOSIS

Elongate, band-like, bilobate or, rarely, unilobate furrows or burrows covered by herringbone-shaped or transverse ridges, with or without two outer smooth or longitudinally striellate zones outside the V-markings, with or without lateral ridges and/or wisp-like markings if preserved on bedding soles (after Fillion and Pickerill, 1990a).

DISCUSSION

Cruziana was originally proposed by d'Orbigny (1842) to describe bilobate coffee-bean or buckle-like forms that fell within the current concept of *Rusophycus* Hall. He had initially intended to use the name *Bilobites* d'Orbigny, but discovered that this name was already in use, having been applied to a pelecypod by Dekay (1824). Soon afterwards, unaware of d'Orbigny's (1842) work, Hall (1852) described as *Rusophycus* material that was much the same as that described by d'Orbigny as *Cruziana*. This created a situation where, for the next hundred years or so, confusion reigned and *Bilobites*, *Cruziana*, and *Rusophycus* were used interchangeably for ichnotaxa displaying essentially the same morphological characteristics.

In 1953, Seilacher attempted to clarify the situation by restricting short buckle-like bilobate cubichnial (resting) forms to *Cruziana*, while longer ribbon-like repichnial (crawling) forms were described as *Crossochorda* Schimper (Osgood, 1970). In 1955, Seilacher referred all ribbon-like bilobate repichnial traces to *Cruziana*, while the shorter buckle-like cubichnial traces were described as *Rusophycus*, and *Crossochorda* was believed to represent an intermediate form between *Cruziana* and *Rusophycus*. In 1970, however, Seilacher changed his position once more to refer all bilobate traces to *Cruziana*, believing it unnecessary to maintain separate ichnogenera for burrows of different outline that could, in his opinion, be attributed to the same organism through "fingerprinting," a view upheld in a more recent contribution (Seilacher, 1991). This, of course, contravenes the belief held by most ichnologists, including ourselves, that the knowledge of the tracemaker has no significance in ichnological taxonomy (Sarjeant, 1979, Art. 40). We therefore refer longer ribbon-like repichnial forms to *Cruziana*, and short buckle-like bilobate cubichnial forms to *Rusophycus*.

Cruziana cf. *lobosa* Seilacher, 1970

Pl. 2, fig. 3

MATERIAL

Three slabs: ROM 35227, ROM 49425, and ROM 49427, plus additional field occurrences.

DIAGNOSIS

Deep furrow with almost transverse leg markings that are rounded with blunt ends instead of bearing distinct claw marks. Pleural lobes smooth (after Seilacher, 1970).

DESCRIPTION

Specimens preserved as straight to meandering convex hyporeliefs, between 5 mm and 9 mm in width and 0.25 mm and 3 mm in depth, each consisting of a central furrow bearing two parallel rows of rounded endopodial striellae, 1–2 mm in width, separated by median furrows 0.5–1 mm wide. Furrows are bordered by smooth pleural lobes 1–2 mm wide on either side.

REMARKS

On specimen ROM 49427, examples of both *Cruziana* cf. *lobosa* and *Rusophycus cryptolithi* Osgood, 1970, are present. In one example (ROM 49427), *R. cryptolithi* is continuous with a specimen of *C.* cf. *lobosa*, suggesting that the two traces were produced by the same individual, but represent slightly different behaviourial activity. *Cruziana lobosa*, while similar to *C. quadrata* Seilacher, 1970, differs in displaying clearly rounded, blunt endopodial striellae, whereas *C. quadrata* bears thinner oblique scratchings.

Cruziana problematica (Schindewolf, 1921)

Pl. 3, fig. 1

Kerr and Eyles, 1991, fig. 10J.

MATERIAL

One specimen: ROM 50058, plus numerous field occurrences.

DIAGNOSIS
Straight or curved *Cruziana*, up to 7 mm wide, showing faint, transverse striellae which can reach the margins of the trace in shallow specimens or terminate before reaching the margins in deeply impressed specimens (after Fillion and Pickerill, 1990a).

DESCRIPTION
Specimens are preserved as straight to slightly curved, slightly arched, bilobate convex hyporeliefs, 11–24 mm in length by 0.3–0.5 mm in width. The lobes, 5–12 mm wide, are covered by poorly to moderately developed striellae, and are separated by a median furrow 0.3–0.5 mm wide.

REMARKS
Specimens of *Phycodes flabellus* can be mistaken for *Cruziana problematica* in instances where only two parallel annulated branches are clearly displayed on the former. This configuration produces an apparently bilobed structure, the transverse annulations characteristic of *P. flabellus* resembling the striellae found on *C. problematica*. Sectioning of problematic material may reveal the presence or absence of an internal spreiten indicative of *Phycodes*. The smooth bilobed ichnogenus *Didymaulichnus*, also present in the Georgian Bay Formation, may have been produced by intense weathering of *C. problematica*. Specimens of both ichnotaxa were found to fall within the same ranges of length and width, the only distinguishing feature of the latter being the presence of striellae covering each lobe.

Cruziana problematica is identical in all respects to the ichnogenus *Isopodichnus* Bornemann. Criteria historically utilized to distinguish *Cruziana* and *Isopodichnus* (all unacceptable ichnotaxobases under any circumstances) have included 1) their relative sizes, 2) their stratigraphic ages, 3) their facies associations, and 4) the supposed identity of their respective producers, the *Cruziana* believed to have been produced by trilobites, and the *Isopodichnus* by notostracan branchiopods (Romano and Whyte, 1987; Pickerill, 1994). Bromley and Asgaard (1979) and Romano and Whyte (1987) concluded that *Isopodichnus* Bornemann be regarded a synonym of *Cruziana*, a suggestion supported by ourselves, as well as Bromley (1990), Pickerill and Peel (1990), Pickerill (1992, 1994), and Keighley and Pickerill (1996).

Cruziana quadrata Seilacher, 1970
Pl. 2, fig. 4

MATERIAL
One specimen: ROM 50059, plus an additional field occurrence.

DIAGNOSIS
Deep furrow with rectangular cross-section. Narrow endopodial lobe of oblique multiple scratches on either side of median line. Pleural lobe smooth with few transverse scratches (after Seilacher, 1970).

DESCRIPTION
Specimens are preserved as straight to winding convex hyporeliefs, 4–6 mm wide, up to 90 mm long. A central region, 2.0–2.5 mm wide, bearing fine, straight, endopodial striellae, oriented 45°–65° with respect to the long axis of the trace, is bound on either side by pleural lobes 1.0–1.5 mm wide displaying well-developed transverse scratches at 1-mm intervals.

REMARKS
Cruziana quadrata, while also bearing distinct pleural lobes, differs from *C. lobosa* in that endopodial striellae are not blunt or pustulose in appearance on the former; rather, distinct thin scratchings are displayed.

Cruziana ispp.
Pl. 3, fig. 2

MATERIAL
Two specimens: ROM 50060–50061; three specimens on one slab: ROM 50062; three specimens on one additional slab: ROM 50063.

DESCRIPTION
Variably but generally poorly preserved, straight to winding structures, up to 15 mm in width and 143 mm in length, preserved in convex hyporelief. Most material is bilobed with individual lobes possessing variably developed transverse scratch markings that in ROM 50063 are locally tricuspate. Specimens in ROM 50063 are essentially unilobate, though a 3-cm portion of one is clearly bilobate.

REMARKS
Though poor preservation precludes ichnospecific assignment, this material can clearly be assigned to *Cruziana*. Based on its variable morphology we suspect that more than one ichnospecies is present and include its documentation herein for possible future comparative purposes.

Ichnogenus *Curvolithus* Fritsch, 1908

TYPE ICHNOSPECIES

Curvolithus multiplex Fritsch, 1908, by subsequent designation (Häntzschel, 1962:W189).

EMENDED DIAGNOSIS

Band-like horizontal burrows with a trilobate upper surface consisting of two lateral round lobes and a median lobe separated from each other by narrow angular furrows. Width of lateral lobes may be equal to or smaller than the median lobe. A faint central furrow may occur on the median lobe. Lower surface may be bilobate, consisting of two small lateral round lobes and a large median furrow, or quadrilobate, consisting of four lobes separated by three angular furrows. May also be unilobate. Inner portion of lateral lobes may show an angular crest parallel and adjacent to the median furrow (modified after Fillion and Pickerill, 1990a; Maples and Suttner, 1990).

DISCUSSION

Curvolithus was erected by Fritsch in 1908 to encompass burrows bearing trilobate upper surfaces. Two ichnospecies were introduced, namely, *C. multiplex* and *C. gregarius,* the former exhibiting a trilobate upper surface associated with a bilobed lower surface, the latter differing in displaying a quadrilobate lower surface. In 1970 Webby erected *C.*? *davidis.* While no formal diagnosis was included, Webby's description provided offered no distinguishing features between this ichnospecies and *C. multiplex, C.*? *davidis* being comprised of "a broad axial ridge and two narrower, marginal ridges separated by relatively narrow shallow grooves" (Webby, 1970:103). In view of this, we tentatively regard *C.*? *davidis* as a junior synonym of *C. multiplex.*

Badve and Ghare (1978) introduced *Curvolithus annulatus* for forms bearing an annulated trilobate upper surface associated with a smooth, rounded lower surface. Walter, Elphinstone, and Heys (1989) described *C. aequus* to encompass trilobate traces in which the widths of the three lobes were approximately the same. Maples and Suttner (1990) formulated *C. manitouensis* with material that is indistinguishable from Fritsch's (1908) *C. gregarius.* Maples and Suttner (1990) suggested that the presence of a quadrilobate lower surface distinguished *C. manitouensis* from all other ichnospecies of *Curvolithus.* However, as both *C. gregarius* and *C. manitouensis* bear trilobate upper surfaces in association with quadrilobate lower surfaces, we regard the former as a senior synonym of the latter.

Curvolithus multiplex Fritsch, 1908

Pl. 3, fig. 3

MATERIAL

Two specimens: ROM 50064–50065.

DIAGNOSIS

Curvolithus with a bilobate lower surface and a trilobate upper surface in which the median lobe is wider than the lateral lobes.

DESCRIPTION

Specimens preserved as burrows, 9–13 mm wide by 22–36 mm long, one in full relief, the other as a convex hyporelief. On the former, one surface bears two lateral lobes 1 mm wide flanking a much broader central lobe 8 mm wide. A faint central ridge 9 mm long commences at one end of the trace. The opposing surface displays a central furrow 2 mm wide bounded on either side by lobes 4 mm in width. Not as well preserved, the latter specimen bears only one well-developed lateral lobe on the lower surface. The entire surface is covered by fine longitudinal striellae running the length of the trace. The maximum thickness displayed by both specimens is 4 mm.

REMARKS

As no formal diagnosis of this form could be located, that given above is proposed. While the present specimens are relatively poorly preserved, the characteristic features of *Curvolithus multiplex* can be discerned. Similarly preserved material has been described by Heinberg (1970, 1973) and Fillion and Pickerill (1990a).

Ichnogenus *Didymaulichnus* Young, 1972

Didymaulichnus Kerr and Eyles, 1991, fig. 10e.

TYPE ICHNOSPECIES

Fraena lyelli Rouault, 1850, by original designation (Young, 1972:10).

DIAGNOSIS

Smooth, furrow-like horizontal trails or burrows, bisected longitudinally by a narrow median groove if preserved in hyporelief (after Young, 1972).

DISCUSSION

When the ichnogenus *Didymaulichnus* was formally introduced, *D. miettensis* was erected by Young (1972). Subsequently, five additional ichnospecies have been established, namely, *D. lyelli* (Rouault), *D. rouaulti* (Lebesconte), *D. tirasensis* Palij, *D. nankervisi* Bradshaw, and *D. alternatus* Pickerill, Romano, and Meléndez. Of these, we consider *D. nankervisi* to have been inappropriately assigned to *Didymaulichnus* because one of the diagnostic properties of this ichnospecies was stated to be the presence of "transverse or pit-like depressions on either side of the median ridge" (Bradshaw, 1981:635). Examination of the accompanying plates reveals that this vague and interpretive description refers to transverse or mound-like swellings running along the crests of each lobe. The presence of such a feature is at variance with the diagnosis of the ichnogenus, which requires the lobes to be smooth (Young, 1972). Therefore, we believe that *D. nankervisi* is in fact more akin to *Pteridichnites* Clarke and Swartz (cf. Fillion and Pickerill, 1990a).

Didymaulichnus can be distinguished from the similar ichnogenus *Cruziana* through the lack of scratch marks on the lobes. The former ichnogenus is believed to be the work of gastropods (Glaessner, 1969; Hakes, 1976) or trilobites (Crimes, 1970; Bradshaw, 1981).

Didymaulichnus lyelli (Rouault, 1850)

Pl. 3, fig. 4

MATERIAL

Two specimens: ROM 49427 and ROM 50066, plus additional field occurrences.

DIAGNOSIS

Bilobate trail or burrow bisected longitudinally by a shallow groove (in convex hyporelief), without oblique scratches, lateral ridges, marginal bevels, or regularly alternating, deeply impressed sections (after Fillion and Pickerill, 1990a).

DESCRIPTION

Specimens are preserved as smooth, straight to slightly curved, bilobed convex hyporeliefs, 3.5–4.3 mm in width, 17–42 mm in length, and 1.5–2 mm in depth. A median furrow, 0.3–2 mm in depth, runs the length of each trace, dividing it into two lobes of equal width, the surfaces of which are seen to be slightly undulatory in places.

REMARKS

The present material is assigned to *Didymaulichnus lyelli* due to its lack of 1) marginal bevels seen in *D. miettensis* and *D. tirasensis,* 2) alternating burrow depths characteristic of *D. alternatus,* and 3) lateral ridges characteristic of *D. rouaulti.*

Ichnogenus *Diplocraterion* Torell, 1870

TYPE ICHNOSPECIES

Diplocraterion parallelum Torell, 1870, by subsequent designation (Matthew, 1891:163).

DIAGNOSIS

Vertical U-shaped spreiten-burrows (after Fürsich, 1974).

DISCUSSION

This ichnogenus was erected by Torell in 1870 for vertical U-shaped burrows. Subsequently, two morphologically similar ichnogenera were established, namely, *Corophioides* Smith, and *Polyupsilon* Howell. The differences between these three ichnogenera have since been a topic of considerable debate. The primary difference between *Corophioides* and *Diplocraterion* was based essentially on the presence of funnel-like openings in the latter (Abel *in* Goldring, 1962). However, this criterion is now considered an inappropriate ichnotaxobase, as this feature may easily be absent due to weathering effects, leaving two essentially identical structures (Ekdale et al., 1984). Different development of spreite was used by Knox (1973) to separate these ichnogenera, though intermediate forms have been found, suggesting a gradational variation within a single ichnogenus (Fürsich, 1974).

Polyupsilon was distinguished from *Diplocraterion* based on divergence of the U-tube arms in the former as the sediment-water interface was approached, though, as this was only an accessory feature, and as the diagnostic features of *Diplocraterion* (U-tube with spreite) were present, ichnogeneric level separation was not warranted (Fürsich, 1974). *Polyupsilon* was regarded as a junior synonym of *Corophioides* by Knox (1973), and the following year, Fürsich (1974) assigned all vertical spreiten-bearing U-tubes to *Diplocraterion.*

Diplocraterion cf. *biclavatum* (Miller, 1875)

Pl. 4, fig. 1; Pl. 5, figs. 1–2

Arthraria biclavata Fritz, 1925:26, pl. 3, fig. 7.
Bifungites Kerr and Eyles, 1991, fig. 10a.
Diplocraterion Kerr and Eyles, 1991, fig. 10d.

MATERIAL

One slab containing eight examples in ROM collection: ROM 17491 [1252HR] and ROM 50067–50069, plus additional specimens collected in the field.

DIAGNOSIS
Diplocraterion in which the arms of the U-tube are extended below the base of the deepest U to form blind pouches. The ichnospecies is most commonly preserved as concave epireliefs with a dumbbell shape (after Fürsich, 1974).

DESCRIPTION
These traces are preserved as dumbbell-shaped concave epireliefs and convex hyporeliefs. One example is preserved in vertical semirelief and displays protrusive spreiten. Specimens display total lengths varying from 26 mm to 103 mm. Thickness of the dumbbell terminations varies from 10 mm to 31 mm. Shape of the terminations is either hemispherical or dogbone. Widths of the connecting bar vary from 2 mm to 5 mm. In many cases, the connecting bar is arched, being broader and deeper at the centre, tapering and becoming shallower, sometimes pinching out, as each termination is approached. In vertical section, convex hyporeliefs display no overlying structure. Terminal depressions are generally smooth, though some unevenness may be present. In ROM 17491 [1252HR], copper-brown stains occur in association with smooth terminations, though similar stains are seen by themselves elsewhere on the slab, sometimes in pairs. The connecting bar of one example on ROM 17491 [1252HR] passes through the slab, appearing as a short segment on the underside.

REMARKS
Unequivocal assignment at the ichnogeneric rank of the present material to *Arthraria, Bifungites,* or *Diplocraterion* is problematic. Distinction between these ichnogenera is based on the presence or absence of vertical tubes above the terminations and, when present, the structure of the sediment between these tubes (Fillion and Pickerill, 1984a). The material described here is reminiscent of each of these ichnogenera and, because of the lack of any vertical components, is most comparable to *Arthraria.* However, in the field, numerous occurrences of *Diplocraterion* in vertical section were observed, whereas no traces that could be unequivocally recognized as *Bifungites* were identified, and only one example of *Arthraria* was found. Assignment of the present material to *Diplocraterion* is considered justified by the significant difference in size of the specimens studied, the majority being much larger than the single specimen of *Arthraria.* Additionally, the presence of an arched connecting rod, not seen in *Arthraria,* further suggests assignment to *Diplocraterion.* As the material is preserved as dumbbell-shaped forms, assignment to *D.* cf. *biclavatum* is proposed, the terminations most likely being a result of the presence of blind pouches at the base of the burrow characteristic of this ichnospecies (Fürsich, 1974).

***Diplocraterion helmerseni* (Öpik, 1929)**
Pl. 4, fig. 2

MATERIAL
One specimen: ROM 48896.

DIAGNOSIS
Diplocraterion having an expanded base (after Fürsich, 1974).

DESCRIPTION
Specimen is preserved in vertical semirelief as a U-shaped vertical burrow displaying an expanded base. Distance between the arms is 37 mm, this expanding to a maximum of 72 mm at the base. Protrusive spreiten are present between the arms. Depth of the trace, as preserved, is 150 mm, 37 mm of which is the expanded base. Diameter of the tubes is 6 mm.

REMARKS
In addition to *D. helmerseni,* Fürsich (1974) recognized four other ichnospecies in his study of vertical, spreiten-bearing, U-shaped trace fossils, namely, *D. parallelum* Torell, *D. biclavatum, D. habichi* (Lisson), and *D. polyupsilon* (Smith) (see also Bromley, 1990:157). ROM 48896 can be distinguished from these in that it possesses a basal expansion not seen in *D. parallelum,* lacks the blind pouches characteristic of *D. biclavatum,* does not display divergent arms characteristic of *D. habichi,* and lacks any evidence of bidirectional spreite as seen in *D. polyupsilon.*

***Diplocraterion parallelum* Torell, 1870**
Pl. 4, fig. 3

MATERIAL
One specimen: ROM 50071, plus numerous field occurrences.

DIAGNOSIS
Diplocraterion having parallel arms and a unidirectional spreite (after Fillion and Pickerill, 1990a).

DESCRIPTION
Specimens are preserved in endorelief as U-shaped tubes in vertical section, sometimes displaying dumbbell-shaped semireliefs on associated top surfaces. Dimensions vary between 19 mm and 55 mm in width by 43 mm to 63 mm in depth. Arms are for the most part parallel, though in some instances a slight flaring at the base is present, reminiscent of *D. helmerseni.* Protrusive spreiten are present, individually separated by intervals of 1–4 mm. Where present, burrow-arm fill is identical to the host rock.

REMARKS
The slight widening of the arms towards the base of one individual suggests that a gradation between *D. helmerseni* and *D. parallelum* may be present.

Ichnogenus *Fustiglyphus* Vialov, 1971

TYPE ICHNOSPECIES
Fustiglyphus annulatus Vialov, 1971:91, fig. 3, by monotypy.

DIAGNOSIS
Straight horizontal strings or narrow cylinders of varying length encircled at regular or varying intervals by ring-like "knots" or well-defined swellings that display no bifurcation or invagination; rosary-like. Preserved in convex hyporelief or concave epirelief (after Stanley and Pickerill, 1993a).

DISCUSSION
See Stanley and Pickerill, 1993a.

Fustiglyphus annulatus Vialov, 1971
Pl. 5, fig. 3

Fustiglyphus annulatus Stanley and Pickerill, 1993a, figs. 2–3.

MATERIAL
Five specimens: ROM 49465 and ROM 49467–49470.

DIAGNOSIS
Unbranched *Fustiglyphus* bearing spherical-, hemispherical-, heart-, or ring-shaped (either singly or paired) swellings. An individual specimen may be comprised entirely of one type of swelling or of combinations of two or more (after Stanley and Pickerill, 1993a).

DESCRIPTION AND REMARKS
See Stanley and Pickerill, 1993a.

Ichnogenus *Gordia* Emmons, 1844

TYPE ICHNOSPECIES
Gordia marina Emmons, 1844, by monotypy.

DIAGNOSIS
Unbranched, predominantly horizontal trails or burrows that wind or loop but do not regularly meander, with a marked tendency to level-crossing. Burrow-fill structureless (after Pickerill and Peel, 1991).

DISCUSSION
Gordia was erected by Emmons (1844) for smooth traces that resembled the freshwater worm *Gordius*. *Helminthopsis* and *Helminthoidichnites* Fitch can be distinguished from *Gordia* by their lack of consistent level-crossing. *Helminthoidichnites* can be further distinguished from *Gordia* through the latter's greater tendency to display a non-random behaviour, as revealed through computer simulation studies undertaken by Hofmann (1991). *Haplotichnus* Miller can be distinguished from *Gordia* by its sharply angled bends, and *Mermia* Smith by its more intense looping and thinner burrow diameter. Five additional ichnospecies of *Gordia* have been established since its formulation, namely, *G. molassica* (Heer), *G. arcuata* Książkiewicz, *G. hanyagensis* Yang and Hu, *G. maeandria* Jiang, and *G. nodosa* Pickerill and Peel. Of these, two have been regarded as possible junior synonyms of *G. marina*, namely, *G. molassica* and *G. hanyagensis* (Pickerill, 1981; Fillion and Pickerill, 1990a).

Gordia marina Emmons, 1844
Pl. 5, fig. 4

MATERIAL
One specimen: ROM 50072.

DIAGNOSIS
Gordia in which level-crossing is fully developed and meanders are unguided (after Fillion and Pickerill, 1990a).

DESCRIPTION
Specimen preserved in convex hyporelief as an unguided, irregularly winding, unornamented burrow, approximately 14 cm in length, and maintaining a uniform diameter of 0.5 mm throughout its largely horizontal course. The burrow either interpenetrates or passes underneath itself. Faint constrictions and nodes are seen in places. Burrow-fill is similar to the host rock.

REMARKS
The available material is assigned to *Gordia marina* based on the presence of unguided meanders and level-crossings. It differs from *G. arcuata* in that its course is fully developed rather than consisting just of apical bends, *G. maeandria* in displaying unguided meanders and level-crossings, and *G. nodosa* by lacking the regularly or irregularly spaced annulations characteristic of the latter.

Ichnogenus *Gyrochorte* Heer, 1865

TYPE ICHNOSPECIES
Gyrochorte comosa Heer, 1865, by subsequent designation (Häntzschel, 1962:W196).

EMENDED DIAGNOSIS
Horizontal burrows preserved in epirelief having biserially arranged, obliquely aligned, transverse plaits separated by a median furrow. The entire burrow complex may consist of vertically repetitive, more or less identical modular units. Traces may be associated with hypichnial, smooth, winding, bilobate grooves of similar dimensions and course to the epichnial counterpart (after Hallam, 1970; Pemberton and Frey, 1984).

DISCUSSION
As reviewed in Hallam (1970), since its formulation, the ichnotaxon *Gyrochorte* has been interpreted as having been produced by molluscs or worms moving along the sediment-water interface (Heer, 1865), the tunnelling or crawling activity of amphipods, and infaunal worm-like organisms (Heinberg, 1973). Heinberg's (1973) exceptionally well preserved material from the Cretaceous of Greenland suggested that it was best interpreted as having been produced by a deposit-feeding worm-like organism moving obliquely through the sediment, a conclusion also supported herein.

To our knowledge, eight ichnospecies have been assigned to *Gyrochorte,* namely, *G. burtoni* Książkiewicz, '*G*'. *carbonaria* Pollard, *G. comosa*, ?*G. dubia* Sacco, *G. imbricata* Książkiewicz, *G. obliterata* Książkiewicz, *G. ramosa* Heer, and *G. vermicularis* Heer. Of these, ?*G. dubia* is regarded as a *nomen dubium,* and '*G*'. *carbonaria* as a *nomen nudum*; the taxonomic status of the remaining ichnospecies requires further evaluation.

***Gyrochorte comosa* Heer, 1865**
Pl. 6, fig. 1

Gyrochorte comosa Pickerill, 1994, fig. 1.3 (*partim*).

MATERIAL
Two specimens: ROM 50073 (*partim*) and ROM 50074, plus additional field occurrences.

DIAGNOSIS
As for the ichnogenus.

DESCRIPTION
Specimens preserved as horizontal, meandering, bilobate, convex epireliefs, 2–3 mm in width. Obliquely arranged biserial transverse segmentation, with from five to seven segments per cm, runs along the length of the specimens, which range from 50 mm to 75 mm in length. The angle between this segmentation and the median groove ranges from 45° to 70°.

REMARKS
Specimens of *Gyrochorte comosa* form compound specimens (*sensu* Pickerill, 1994) with the ichnotaxa *Planolites annularius* Walcott and *P. beverleyensis* (Billings). Such specimens demonstrate the fact that one organism can display different behaviours, thereby producing more than one ichnotaxon. The example illustrated in Plate 6, fig. 1, would have been produced by an organism, possibly an annelid, moving through the sediment first in an oblique manner to produce *Gyrochorte comosa,* then changing its behaviour to burrowing horizontally to produce *P. beverleyensis,* followed by a change to movement involving peristaltic muscular contractions to produce *P. annularius.*

Gyrochorte comosa can be distinguished from other existing ichnospecies of *Gyrochorte* by its lack of 1) oblique incisions characteristic of *G. burtani* Książkiewicz, 2) imbricate asymmetrical riblets characteristic of *G. imbricata* Książkiewicz, and 3) densely spaced irregular incisions characteristic of *G. obliterata* Książkiewicz. According to Heer (1877), *G. vermicularis* is broader and possesses a deeper median furrow than *G. comosa,* and *G. ramosa* is broader and laterally branched.

Ichnogenus *Helminthopsis* Heer, 1877

TYPE ICHNOSPECIES
Helminthopsis hieroglyphica Wetzel and Bromley, 1996, by subsequent designation (Wetzel and Bromley, 1996:13).

DIAGNOSIS
Unbranched, irregularly winding or meandering, pre- or post-depositional horizontal burrows or trails that do not touch or cross themselves. Only one order of meandering may be present. Burrow-fill massive (after Han and Pickerill, 1995).

DISCUSSION
Han and Pickerill (1995) and Wetzel and Bromley (1996) have addressed the taxonomic status of the 22 historically defined ichnospecies of *Helminthopsis.* Han and Pickerill (1995) concluded that only three, namely, *H. abeli* Książkiewicz, *H. hieroglyphica* Wetzel and Bromley, and *H. granulata* Książkiewicz, are taxonomically valid and useful forms, and Wetzel and Bromley (1996) that *H. abeli, H. hieroglyphica,* and *H. tenuis* Książkiewicz are

preferable. Despite these differences in opinion, the Georgian Bay material does not conflict, at the ichnospecific rank, with these varied interpretations.

***Helminthopsis hieroglyphica* Wetzel and Bromley, 1996**
Pl. 6, fig. 3

MATERIAL
One slab: ROM 50075, plus additional field occurrences.

DIAGNOSIS
Helminthopsis in which the windings, normally wide and low, comprise straight segments interspersed with irregularly sinuous and variably developed segments. The full course is commonly, though not exclusively, alternately winding and straight (after Książkiewicz, 1977; Han and Pickerill, 1995; Wetzel and Bromley, 1996).

DESCRIPTION
Specimens are preserved as smooth concave epireliefs and convex hyporeliefs, 1–4 mm in diameter and 35–180 mm in length. Burrows can display an elliptical cross-section. Individual traces never cross. Burrows display low and broad meanders along with straight segments up to 85 mm in length.

REMARKS
The presence of straight segments in association with an irregular winding pattern distinguishes these traces from other ichnospecies of *Helminthopsis*. Though traditionally this ichnospecies had Heer *in* Maillard, 1887, as its author, Wetzel and Bromley (1996) have recently proposed a new type.

Ichnogenus *Lingulichnus* Hakes, 1976

TYPE ICHNOSPECIES
Lingulichnus verticalis Hakes, 1976, by monotypy.

DIAGNOSIS
Vertical to slightly inclined, tubular burrows with elliptical transverse cross-section displaying two planes of symmetry (after Szmuc et al., 1976).

DISCUSSION
Lingulichnus was established by Hakes (1976) for sediment-filled tubes that possessed an elliptical cross-section and occurred perpendicular or inclined to bedding. At the same time, one ichnospecies, *L. verticalis,* was erected. Later the same year, Szmuc et al. (1976) erected *Lingulichnites amygdalinus* describing essentially identical traces, a fact recognized by Osgood (*in* Szmuc et al., 1977) when this ichnogenus was placed in synonymy with *Lingulichnus,* the latter being regarded as valid by publication priority. Several possibilities regarding the nature of the tracemaking organisms were discussed by Hakes (1976), who ultimately concluded that linguloid brachiopods were responsible, the presence of two planes of symmetry in both trace and tracemaker being cited as principal evidence. Bivalves were dismissed because they possess only one plane of symmetry, as were worms because of the unlikelihood that such organisms would be able to produce vertical burrows with elliptical cross-sections.

cf. *Lingulichnus verticalis* Hakes, 1976
Pl. 6, fig. 2

MATERIAL
One specimen: ROM 17496 [1257HR] (*partim*), plus additional field occurrences.

DIAGNOSIS
Lingulichnus, commonly with concentrically packed wall-lining, parallel-sided or widest at the top, generally showing a narrower basal projection (burrow) of nearly circular cross-section (after Hakes, 1976; Szmuc et al., 1976).

DESCRIPTION
Specimens are preserved as rounded elliptical convex hyporeliefs with long axes 11–18 mm in length and short axes 5–9 mm in length. Sectioning revealed no disturbance of the overlying sediment other than the presence of a single specimen of *Skolithos verticalis* (Hall).

REMARKS
The absence of a completely preserved three-dimensional structure precludes definitive ichnogeneric assignment, yet their cross-sectional views accord with previously figured examples of *Lingulichnus*, and therefore are tentatively identified as such. Despite the lack of any vertical structure, the material can still be regarded as cf. *L. verticalis* based on cross-section morphology.

TYPE ICHNOSPECIES

Monocraterion tentaculatum Torell, 1870, by monotypy.

DIAGNOSIS

Funnels or stacked funnels oriented perpendicular to bedding and characterized by a central downward deflection of sedimentary laminae. Funnels may be perforated centrally by a tube that may continue down (after Crimes et al., 1977).

DISCUSSION

Monocraterion encompasses vertical burrows associated with funnel-shaped apertures (Torell, 1870). Comparisons have been made between this ichnogenus and several others, namely, *Cylindrichnus* Toots *in* Howard, *Laevicyclus* Quenstedt, *Rosselia* Dahmer, and *Skolithos*. *Skolithos*, which takes the form of simple vertical tubes, has commonly been regarded as a senior synonym of *Monocraterion* (see Ekdale et al., 1984). As the latter ichnogenus comprises a vertical tube capped by a funnel-like aperture that can easily be eroded away, the possibility exists that many examples of *Skolithos* may in fact represent eroded specimens of *Monocraterion* that have lost their capping funnel-shaped aperture. Crimes et al. (1977) and Fillion and Pickerill (1990b) have, however, discussed reasons for retaining both ichnotaxa; herein, we follow their recommendation.

In order to distinguish *Monocraterion* from *Cylindrichnus*, *Laevicyclus*, and *Rosselia*, specimens must be vertically sectioned (a course not always followed by several ichnologists, e.g., Badve and Ghare, 1980; Leszczyński and Seilacher, 1991), because all four ichnogenera display, in bedding-plane view, circular to slightly elliptical sets of concentric circles with, in some cases, a central mound corresponding to a vertical or oblique shaft. However, when specimens of these ichnotaxa are vertically sectioned, *Monocraterion* is found to comprise a vertical tube flaring at the aperture, taking a funnel-like form (Häntzschel, 1975). Alternatively, *Cylindrichnus* takes the form of subconical, weakly curved, circular to oval burrows, bearing concentrically layered exterior walls (Häntzschel, 1975). *Laevicyclus* comprises a central vertical tube whose aperture is surrounded by concentric circles, possibly produced by a circular sweeping action of extended tentacles (Osgood, 1970), and *Rosselia* takes the form of thin burrows, commonly oblique to bedding, that bear expanded openings filled with concentric layers of weathered matrix (Häntzschel, 1975).

To our knowledge, only four ichnospecies of *Monocraterion* have been cited in the literature, namely, *M. clintonense* (James), *M. lesleyi* Prime, *M. rajnathi* Badve and Ghare, and *M. tentaculatum*. Of these, the first two appear to be recognized only by the age of the deposits in which they are found and *M. rajnathi* by the presence of a thin wall and a less crowded occurrence (Badve and Ghare, 1978). While no other ichnospecies of *Monocraterion* has been described as displaying a wall, the possibility exists that it reflects the nested cone structure characteristic of *Monocraterion*. Therefore, this ichnospecies is best regarded as a *nomen dubium*. Howell (1946:33) suggested, with respect to *M. tentaculatum* and *M. clintonense*, that the former's "burrows are so similar to our Silurian burrows that the two should perhaps be considered to be congenetic, in spite of the fact that the one is Cambrian age, the other Silurian." Use of the same "distinguishing criterion" is implied in the case of *M. lesleyi*, "believed to be of Early Ordovician age" (Howell, 1946:33). As age is not a valid ichnotaxobase under any circumstances, and as no additional distinguishing criteria have been given for these ichnotaxa, *M. clintonense* and *M. lesleyi* should best be considered junior synomyms of *M. tentaculatum*.

cf. *Monocraterion tentaculatum* Torell, 1870

Pl. 6, fig. 4

MATERIAL

One specimen: ROM 50077, plus additional field occurrences.

DIAGNOSIS

Sub-cylindrical tube, perpendicular to bedding, typically straight, rarely slightly curved, ends upwards in a funnel. Tube unbranched, in many cases slightly tapering downwards. Funnel in transverse section circular or fairly irregular, in vertical section wide or narrow, straight-sided, cup- or trumpet-shaped; varying in width and depth. The tube continues through the funnel in several instances, and sporadically ends upwards in a second funnel (after Fillion and Pickerill, 1990a).

DESCRIPTION

Specimens comprise round to slightly elliptical markings, 11–27 mm in diameter, preserved as concave hyporeliefs, though two specimens are preserved in concave epirelief. Markings are ornamented with internal concentric rings. In two specimens, circular mounds 6 mm wide are present in the centre of the specimen. In most cases, when vertically sectioned, specimens contained no distinct associated overlying or underlying structure, although one individual was associated with an underlying funnel-shaped structure revealed by disturbed bedding.

REMARKS

Distinction from the similar ichnogenera *Laevicyclus* and *Rosselia* is based on the nature of associated vertical structure. As no such structure is associated with any of these specimens, they can be compared only with *Monocraterion*. Specimens preserved as concave hyporeliefs represent casts on the bases of sandstone beds of burrows originally situated in underlying mud deposits, this accounting for the lack of associated vertical structures. Of the two preserved as concave epireliefs, one is associated with an underlying, distinctly funnel-shaped structure revealed by disturbed bedding.

Ichnogenus *Monomorphichnus* Crimes, 1970

TYPE ICHNOSPECIES

Monomorphichnus bilinearis Crimes, 1970, by monotopy.

DIAGNOSIS

A series of straight or slightly sigmoidal, parallel or intersecting striae, isolated or grouped in sets, in places repeated laterally, and typically preserved in convex hyporelief (after Crimes, 1970).

DISCUSSION

Monomorphichnus was erected by Crimes (1970) to encompass traces produced by trilobites that raked the sediment surface while being carried by a current. Similarities between *Monomorphicnus* and *Dimorphichnus* Seilacher were noted by Crimes (1970:58), though the two ichnogenera differ in the former's lack of "blunt markings formed by the digging in of the limbs on one side." When initially erected, only one ichnospecies was recognized, namely, *M. bilinearis,* characterized by paired parallel striae, one more pronounced than the other (Fillion and Pickerill, 1990a). Subsequently, four additional ichnospecies have been described, namely, *M. multilineatus* Alpert, characterized by deeper central ridges; *M. lineatus* Crimes, Legg, Marcos and Arboleya, displaying single ridges; *M. pectenensis* Legg, characterized by the presence of striations between individual ridges; and *M. intersectus* Fillion and Pickerill, which exhibits intersecting dig marks. A fifth ichnospecies, *M. cretacea* Badve and Ghare, is better placed in *M. lineatus,* the former having been recognized as a distinct ichnospecies only on the basis of its geological age, an unacceptable ichnotaxobase.

***Monomorphichnus bilinearis* Crimes, 1970**

Pl. 7, fig. 1

MATERIAL

One specimen: ROM 50078.

DIAGNOSIS

Monomorphichnus with paired parallel striae with one stria of each pair typically more prominent than the other (after Crimes, 1970).

DESCRIPTION

Specimen consists of four pairs of straight to slightly curved parallel ridges, 10–35 mm in length, preserved as convex hyporeliefs. Within each pair, one ridge is longer and slightly wider than the other, widths varying between 0.25 mm and 0.75 mm; 2–3.5 mm separate each ridge within a pair, pairs being 9–10 mm apart. Sediment comprising ridges is coarser grained than the host rock, producing a condition in which several of the ridges are recognized solely by a difference in lithology, no vertical relief being present.

REMARKS

Monomorphichnus bilinearis is distinguished from other ichnospecies of *Monomorphichnus* through its possession of paired ridges, not seen in *M. lineatus*; its lack of striations between ridges characteristic of *M. pectenensis*; and its lack of deeper central ridges seen in *M. multilineatus.*

***Monomorphicnus lineatus* Crimes, Legg, Marcos and Arboleya, 1977**

Pl. 5, fig. 4; Pl. 7, fig. 2

Monomorphichnus Kerr and Eyles, 1991, fig. 10a.

MATERIAL

One specimen: ROM 50079, plus additional field occurrences.

DIAGNOSIS

Monomorphichnus composed of parallel, isolated, straight to slightly sigmoidal striae, which may be repeated laterally (after Crimes et al., 1977).

DESCRIPTION

The material consists of groups of four to sixteen unpaired ridges preserved as convex hyporeliefs that are 4–79 mm in length and 0.2–1 mm in width. Distance between individual ridges is 1–9 mm, complete sets being 24–30 mm in length by 4–86 mm in width. Most ridges are straight, though some may be slightly sinuous.

REMARKS

Monomorphichnus lineatus can be distinguished from *M. bilinearis* through the former's lack of paired ridges, and from *M. multilineatus* in that the latter possesses central ridges that are deeper than the outer ridges.

Ichnogenus *Paleodictyon* Meneghini *in* Murchison, 1850

TYPE ICHNOSPECIES
Paleodictyon strozzii Meneghini, 1850, by monotypy.

DIAGNOSIS
Honeycomb-like network of four-to-eight-sided, commonly hexagonal, horizontal meshes, preserved typically in convex hyporelief, more rarely in concave epirelief. Meshes with or without vertical outlets, of variable size and shape. Outline of entire systems rounded, or more typically hexagonal (after Pickerill, 1990).

DISCUSSION
See Stanley and Pickerill, 1993b, and Crimes and McCall, 1995.

Paleodictyon isp. a
Pl. 8, fig. 1

Paleodictyon isp. a Stanley and Pickerill, 1993b, figs. 2a–b.

MATERIAL
Two specimens: ROM 49424 and ROM 49624.

DESCRIPTION AND REMARKS
See Stanley and Pickerill, 1993b.

?_Paleodictyon_ isp. b
Pl. 9, fig. 3

?*Paleodictyon* isp. b Stanley and Pickerill, 1993b, fig. 2c.

MATERIAL
One specimen: ROM 49625.

DESCRIPTION AND REMARKS
See Stanley and Pickerill, 1993b.

Ichnogenus *Palaeophycus* Hall, 1847

TYPE ICHNOSPECIES
Palaeophycus tubularis Hall, 1847, by subsequent designation (Miller, 1889:130).

DIAGNOSIS
Straight to slightly curved to slightly undulose or flexuous, smooth or ornamented, typically lined, essentially cylindrical, predominantly horizontal structures interpreted as originally open burrows; burrow-fill typically massive, similar to host rock; where present, bifurcation is not systematic, nor does it result in swelling at the sites of branching (after Fillion and Pickerill, 1990a).

DISCUSSION
Palaeophycus was originally erected by Hall (1847) to include plants with terete, simple or branched, cylindrical or sub-cylindrical stems whose surfaces were nearly smooth, without transverse ridges, and apparently hollow (Hall, 1847). The original designation of the nomenclatural type of *Palaeophycus* has been a topic of debate. Pemberton and Frey (1982) shared Häntzschel's (1975) belief that Bassler (1915) designated *P. tubularis* as the type ichnospecies. However, Miller (1889:130) was in fact the first to make this designation (Fillion and Pickerill, 1990a). The diagnosis of *Palaeophycus* was twice emended by Fillion and Pickerill (1984b, 1990a), first to exclude systematic and non-systematic winding and/or meandering burrows and then to exclude systematically branching burrows as well as burrows in which there is swelling at the points of branching due to bifurcation. A detailed discussion of the distinction between *Palaeophycus* and the morphologically similar ichnogenus *Planolites* can be found in Pemberton and Frey (1982), Stanley and Pickerill (1994), and Keighley and Pickerill (1995).

cf. _Palaeophycus crenulatus_ Buckman, 1995
Pl. 7, fig. 3

MATERIAL
One specimen: ROM 50058, plus additional field occurrences.

DIAGNOSIS
Annulate *Palaeophycus* with annulations on a millimetre scale (after Buckman, 1995).

DESCRIPTION
Specimens preserved as straight to slightly curved, unbranched convex epireliefs and hyporeliefs, 5–6 mm wide and 69–156 mm long with an elliptical to circular cross-section. Surfaces are covered by annulations 0.9–2 mm wide and 1–2 mm apart, displaying densities of two to ten annulations per cm. Burrow-fill is similar to the host rock.

REMARKS
P. crenulatus was recently formulated and described by Buckman (1995), who thereby alleviated the impractical

nomenclatural problems involved with the ichnotaxa *P. annulatus* and *P. serratus,* described respectively by Badve (1987) and McCann (1993). Although no linings are visible on the Georgian Bay material, we believe this may be a function of weathering (cf. Frey and Howard, 1985). Additionally, Buckman (1995) failed to resolve the overall nomenclatural difficulties with respect to annulate ichnotaxa and offered a precise limit, based solely on his Irish material, on the annulation density, an ichnotaxobase that in our experience can be varied. We therefore only tentatively assign the material to *P. crenulatus.*

***Palaeophycus heberti* (de Saporta, 1872)**
Pl. 8, fig. 2

MATERIAL
One specimen: ROM 50080.

DIAGNOSIS
Unornamented, thickly lined *Palaeophycus* (after Pemberton and Frey, 1982).

DESCRIPTION
Specimen is preserved as a slightly curved, unbranched, thickly lined, smooth, concave/convex epirelief maintaining a uniform total width of 2.8 mm. The central tube, where preserved, is oval in cross-section and 1.3 mm in width by 1 mm in height. Complete specimen, as preserved, is 65 mm long. Both the fill and the lining are massive and identical to the host sediment.

REMARKS
Palaeophycus heberti can be distinguished from *P. tubularis* by the presence of a thick lining on the former. It is set apart from all remaining ichnospecies of *Palaeophycus* by its lack of any external ornamentation.

***Palaeophycus striatus* Hall, 1852**
Pl. 9, fig. 1

Kerr and Eyles, 1991, fig. 10h (*partim*).

MATERIAL
One specimen: ROM 50081, plus additional field occurrences.

DIAGNOSIS
Thinly lined *Palaeophycus*, sculpted by continuous, parallel, longitudinal striae (after Pemberton and Frey, 1982).

DESCRIPTION
Specimens are preserved as either concave or convex epireliefs. All are straight to slightly curved. Dimensions vary from 3 mm to 9 mm in width and 32 mm to 45 mm in length. Parallel striae with 0.5–1.5 mm between crests run the entire length of each of the specimens, with reliefs varying from fine (≈0.1 mm) to very coarse (≈0.75 mm). Where burrow-fill is present, it is identical to the host rock.

REMARKS
The presence of striations uninterrupted along their length distinguishes these specimens from *P. alternatus* (Pemberton and Frey, 1982).

***Palaeophycus tubularis* Hall, 1847**
Pl. 8, fig. 3

Palaeophycus sp. indet. Fritz, 1925:28–29, pl. 3, fig. 2.
Palaeophycus virgatus Fritz, 1925:32, pl. 3, fig. 3.
Unnamed burrow—Kerr and Eyles, 1991, fig. 10h (*partim*).

MATERIAL
Two suites in ROM collections: ROM 17494 [1255HR] (*partim*) (containing two specimens) and ROM 17495 [1256HR], plus numerous field occurrences.

DIAGNOSIS
Smooth, unornamented burrows of variable diameter, thinly but distinctly lined (after Pemberton and Frey, 1982).

DESCRIPTION
Specimens are preserved in convex hyporelief or full relief, with both displaying elliptical cross-sections. Traces range in diameter from 1 cm to 3 cm. Surfaces are generally smooth, though faint longitudinal and transverse striations are present in areas of some specimens. No evidence of lining is present on any specimen. Burrow collapse is present in one example, revealed by changes in burrow cross-section eccentricity, and by the presence of a wrinkled appearance in places. Traces are straight to slightly sinuous. Apparent branching produced by burrow interpenetration is present in two specimens. Burrow-fill is of similar lithology to the host rock in all cases.

REMARKS
The thin lining, one of the diagnostic characteristics of *Palaeophycus tubularis,* was not observed in any of the specimens, probably because such a thin lining is easily eroded (Howard and Frey, 1984; Frey and Howard, 1985). However, the presence of burrow collapse, the lack of surface ornament, and the similar grain size of the fill and host rock all support assignment of the present material to this ichnospecies. Of the three samples originally catalogued as ROM 17494 [1255HR] to represent *Palaeophycus virgatus,* only two are considered by us as belonging to *P. tubularis.* The third, a trace preserved as a concavo-convex full

relief bearing striations on the convex surface, is believed to be *Trichophycus venosus* Miller and Dyer. One additional specimen (ROM 17495 [1256HR]), originally described by Fritz (1925) as *Palaeophycus* sp. indet., is in fact assignable to *P. tubularis*.

Palaeophycus virgatus, to which the ROM material was originally assigned by Fritz (1925), was described by Alpert (1975) as *Planolites virgatus* (Hall, 1847). Subsequently, Pemberton and Frey (1982) placed this ichnospecies in synonymy with *Palaeophycus tubularis*.

Ichnogenus *Phycodes* Richter, 1850

TYPE ICHNOSPECIES
Phycodes circinatus Richter, 1853:30, by subsequent monotypy.

DIAGNOSIS
Horizontal bundled burrows preserved outwardly as convex hyporeliefs. Overall pattern may be reniform, fasciculate, flabellate, broom-like, ungulate, linear, falcate, or circular. Some forms consist of a few main branches showing a spreite-like structure that gives rise distally to numerous free branches. In other forms the spreiten are lacking and branching tends to be secund or more random. Individual branches are terete and finely annulate or smooth (after Osgood, 1970).

DISCUSSION
Several ichnogenera have been placed in synonymy with *Phycodes*, though some of these assignations have been questioned. Seilacher (1955) suggested that *Arthrophycus* Hall, discussed in some detail by Sarle (1906), was a junior synonym of *Phycodes*, but this was refuted by Osgood (1970) on the grounds that the former was larger, displayed bilobate branching up to 1 cm in diameter, and was transversely articulated. Indeed, most ichnologists still regard *Phycodes* and *Arthrophycus* as separate and distinctive. Hall's (1852) *Buthotrephis palmata* was also considered synonymous with *Phycodes* by Seilacher (1955), but this was also not supported by Osgood (1970) because although *B. palmata* was unlike others in that ichnogenus, the branches were smoother, larger, and displayed a different branching pattern to that seen in *Phycodes*. However, Osgood (1970) did not take into consideration that *B. palmata* was based on discordant types, some specimens displaying branching from a single point, as seen in *Phycodes*, while others displayed branching at different distances from the base, as seen in *Chondrites* (Fillion and Pickerill, 1990b). The assignment of *Licrophycus* Billings as a junior synonym of *Phycodes* by Osgood (1970) has stood unchallenged. A detailed discussion on the ichnospecies of *Phycodes* is given in Han and Pickerill (1994a).

Phycodes flabellus **(Miller and Dyer, 1878a)**
Pl. 11, fig. 2

Licrophycus flabellum Fritz, 1925:27–28, pl. 3, fig. 1.

MATERIAL
One specimen in ROM collections: ROM 17496 [1257HR] (*partim*), plus numerous field specimens.

DIAGNOSIS
Bundled burrows generally arranged in a flabellate pattern. Individual branches cylindrical and annulate. Sectioning reveals no evidence of spreite-like structure or faecal material (after Osgood, 1970).

DESCRIPTION
Flabellate, horizontally bundled burrow systems preserved in convex hyporelief. Comprised of one smooth central burrow, approximately 3 mm wide and up to 44 mm in length, from which branch narrower burrows (approximately 1 mm wide) that are, for the most part, distinctly annulated, with annulations at intervals of approximately 0.5 mm, though some portions are smooth. In several instances, truncation of earlier sets of these narrower burrows by later sets can be observed, suggesting the presence of two or three individuals. Annulations found on each bundle of burrows are concurrent. Extent of relief attains a maximum of 3 mm, though there is little evidence of vertical extent on the sides of the specimen, only one or two poorly preserved burrow cross-sections being observable.

REMARKS
In Fritz's (1925) original examination of the Georgian Bay Formation ichnofauna, ROM 17496 [1257HR] was described as *Licrophycus flabellum*, an assignment with which, given the state of ichnology in 1925, the present authors agree. However, given that *Licrophycus* has since been placed in synonymy with *Phycodes* (Osgood, 1970), we regard the ROM material as *Phycodes flabellus*.

The limited material available did not permit sectioning to determine the three-dimensional structure. Sectioning of Cincinnatian representatives of this ichnospecies by Osgood (1970), however, revealed that spreite-like structures were generally absent. Instead, the presence of an area of disturbed bedding grading into the host rock seemed to Osgood (1970) to have been produced by an organism that mined the sediment by displacing rather than removing it. This displacement did not produce a burrow upon whose floor sediment could be compacted due to upward movement to produce a spreite.

***Phycodes palmatus* (Hall, 1852)**
Pl. 10, fig. 3

MATERIAL
One specimen: ROM 50082, plus an additional field occurrence.

DIAGNOSIS
Phycodes exhibiting a few thick and rounded branches, branching horizontally in a palmate or digitate form from nearly the same point (after Hall, 1852).

DESCRIPTION
Specimens preserved as convex hypichnial, striate, straight to slightly curving horizontal burrows, 6–14 mm in diameter, 15–49 mm in length, and displaying up to two levels of branching. Angles between the outer first-order branches vary from 80° to 100°, while second-order branches display angles from 35° to 45°. The presence of a spreite can be inferred from the fact that second-order branches can be seen to originate at different levels from their associated first-order burrow (cf. Pickerill and Peel, 1990). Maximum widths of individual specimens vary from 44 mm to 50 mm.

REMARKS
Phycodes palmatus was originally erected as an ichnospecies of *Buthotrephis,* an ichnogenus that is for the most part a junior synonym of *Chondrites.* Fillion and Pickerill (1990b) noted that, upon examination of Hall's (1852) original figures, *B. palmata* was based on discordant material in that three different types of morphologies were present, one comparable to *Phycodes,* another to *Chondrites,* and the third was of doubtful affinity. They suggested (Fillion and Pickerill, 1990b) that material comparable to *Phycodes* be regarded as *P. palmatus.* However, Seilacher (1955) had previously described several specimens as *P. palmatus* from the Lower Cambrian of Pakistan that displayed a different "Bauplan." To resolve this conflict, Fillion and Pickerill (1990a) erected *P. wabanensis* to include Seilacher's (1955) material in addition to similar examples from the Lower Ordovician of Bell Island, eastern Newfoundland. The present material is placed within *P. palmatus* through its possession of thick and rounded digitate branches characteristic of this ichnospecies. The presence of longitudinal striations, however, is an unusual morphological variant.

Ichnogenus *Planolites* Nicholson, 1873

TYPE ICHNOSPECIES
Planolites vulgaris Nicholson and Hinde, 1874, by subsequent designation (Miller, 1889:520).

DIAGNOSIS
Unlined, rarely branched, straight to tortuous, smooth to irregularly walled or ornamented, horizontal to slightly inclined burrows, circular to elliptical in cross-section, of variable dimensions and configurations. Burrow-fill biogenic, essentially massive, differing from host rock (after Pemberton and Frey, 1982).

DISCUSSION
See Stanley and Pickerill, 1994; Keighley and Pickerill, 1995.

***Planolites annularius* Walcott, 1890**
Pl. 6, fig. 1

Planolites annularius Pickerill, 1994, fig. 1.3 (*partim*).

MATERIAL
One specimen: ROM 50073 (*partim*), plus numerous field occurrences.

DIAGNOSIS
Distinctly annulate *Planolites* (after Pemberton and Frey, 1982).

DESCRIPTION
Specimens preserved as horizontal, straight to curved, unbranched, unlined, cylindrical burrows, 2–4 mm wide by 18–35 mm long, preserved in convex epirelief. Surfaces are covered by annulations 1 mm thick by 2.2–4.2 mm wide with up to 1 mm spacing. Burrows are circular to elliptical in cross-section. Lithology of burrow-fill is slightly more coarsely grained than the host rock. Some examples grade into *Planolites beverleyensis*; in such cases, annulations are seen to gradually change from encircling the entire burrow to appearing as lateral swellings on the sides of an otherwise smooth burrow.

REMARKS
Planolites annularius can be distinguished from other ichnospecies of *Planolites* through its possession of well-developed annulations, but with no accompanying external ornamentation. The majority of the examples of *P. annularius* occur as compound specimens in association with the ichnotaxa *P. beverleyensis* and *Gyrochorte comosa.* Such compound specimens offer insight into the variations in behaviour exhibited by single individual organisms over short periods of time, and, in the examples herein, clearly show that a single individual can be engaged in three distinct behaviourial activities along a single course, involving the production of annulate, smooth, and plaited burrows respectively.

Planolites beverleyensis (Billings, 1862)
Pl. 6, fig. 1

Planolites beverleyensis Pickerill, 1994, fig. 1.3 (*partim*).

MATERIAL
One specimen: ROM 50073 (*partim*), plus numerous field occurrences.

DIAGNOSIS
Relatively large, smooth, straight to gently curved or undulose *Planolites* (after Pemberton and Frey, 1982).

DESCRIPTION
Material preserved in convex epirelief as smooth, horizontal, straight to curved, unbranched cylindrical burrows, 2–5 mm in width by up to 40 cm in length. Lithology of burrow-fill is slightly more coarsely grained than the host rock. Transverse cross-sections are circular to elliptical. In several cases, examples grade laterally into specimens of both *P. annularius* and *Gyrochorte comosa*.

REMARKS
Planolites beverleyensis can be distinguished from *P. montanus* through the latter's more contorted course. The remaining ichnospecies of *Planolites* bear external ornamentation, thereby separating them from *P. beverleyensis*.

Planolites constriannulatus **Stanley and Pickerill, 1994**
Pl. 9, fig. 2

Planolites constriannulatus Stanley and Pickerill, 1994, figs. 2, 3a–e.

MATERIAL
Twelve specimens on four slabs: ROM 49764 (holotype), ROM 49765, ROM 49766a–d, and ROM 49767a–f (paratypes).

DIAGNOSIS
Planolites characterized by both longitudinal striations and transverse annulations superimposed in the same specimen (after Stanley and Pickerill, 1994).

DESCRIPTION AND REMARKS
See Stanley and Pickerill, 1994.

Ichnogenus *Protovirgularia* McCoy, 1850

TYPE ICHNOSPECIES
Protovirgularia dichotoma McCoy, 1850, by monotypy.

DIAGNOSIS
Plaited, unbranched, keel-like trail, mostly straight or slightly curved, more rarely sinuous, consisting of a median line (ridge or furrow) with lateral chevron markings opening in the direction of movement of the producing organism (modified after Han and Pickerill, 1994b; Seilacher and Seilacher, 1994).

DISCUSSION
The nomenclatural history and detailed taxonomic considerations of *Protovirgularia* have recently been discussed by Han and Pickerill (1994c) and Seilacher and Seilacher (1994), and there is little need of additional discussion. Seilacher and Seilacher (1994) convincingly demonstrated that the ichnotaxon is produced by bivalves burrowing in, or crawling on, soft substrates.

Protovirgularia rugosa **(Miller and Dyer, 1878a)**
Pl. 10, fig. 1

MATERIAL
Two specimens: ROM 49767 and ROM 50091 (*partim*).

DIAGNOSIS
Cubichnial version of *Protovirgularia*, recognized by a chevroned escape burrow leading away from a smooth *Lockeia*-like resting burrow. Chevron marks very strong (after Seilacher and Seilacher, 1994).

DESCRIPTION
Specimens preserved as convex epireliefs 18–33 mm long by 2–8 mm wide and bearing five to fourteen pairs of obliquely directed, parallel lateral ridges, 0.5 mm thick, emanating from a central ridge 1 mm wide running the length of the trace. These lateral ridges originate from several different levels and may or may not bifurcate at their distal extremities. Two specimens bear a characteristic featureless, *Lockeia*-like ovoid mass, 6–9 mm long by 2–6 mm wide, at one end. A marked tapering is present at the opposing end of the trace, where preserved. Relief varies from 0.5 mm to 2 mm.

REMARKS
Seilacher and Seilacher (1994) considered *Walcottia rugosa* Miller and Dyer a junior synonym of *Protovirgularia* McCoy, designating the type of their newly formulated *P. rugosa* Seilacher and Seilacher, 1994, as the holotype of *W. rugosa*, as documented by Miller and Dyer (1878a). Regrettably, Seilacher and Seilacher (1994) did not con-

sider *W. cookana* Miller and Dyer, *W. sulcata* James, *W. devilsdingli* Benton and Gray, and *W. imbricata* (Hakes), and the taxonomic status of these forms remains equivocal (see also Rindsberg, 1994). Nevertheless, we are in general agreement with the taxonomic decisions made by Seilacher and Seilacher (1994), and of the four ichnospecies of *Protovirgularia* recognized by them we regard the Georgian Bay material as best identified as *P. rugosa*. Interestingly, Seilacher and Seilacher (1994) noted that *P. rugosa* is always found at the bases of sandy tempestites, an observation that accords well with the material described herein.

?*Protovirgularia* isp.
Pl. 10, fig. 2

MATERIAL
One specimen: ROM 50091 (*partim*), plus numerous field occurrences.

DESCRIPTION
Specimens are preserved as convex epireliefs 6–24 mm long by 8–24 mm wide. Though poorly preserved, a central ridge 0.3–1.0 mm wide and bearing five to seven oblique lateral ridges of comparable width is discernible. Each lateral ridge may have up to four first-order branches, or none, along its length. The larger example bears a featureless circular mass similar to those present on examples of *P. rugosa* described above.

REMARKS
The material is only tentatively included within *Protovirgularia* because of its poor preservation. Notably, of the four ichnospecies recognized by Seilacher and Seilacher (1994), *Protovirgularia longespicata* (de Stefani) is the only ichnospecies to develop palmate systems, a result of repeated probings by the producing bivalve.

Ichnogenus *Rusophycus* Hall, 1852

TYPE ICHNOSPECIES
Rusophycus clavatus Hall, 1852, by subsequent designation of Miller (1889:138).

DIAGNOSIS
Shallow to deep, short, horizontal, bilobate burrows preserved in convex hyporelief. Lobes are parallel or merge posteriorly and may be smooth or exhibit transverse to oblique scratch marks in various arrangements, typically directed anteriorly. Coxal, exopodal, spinal, cephalic, and pygidial markings may be present (after Fillion and Pickerill, 1990a).

DISCUSSION
Erected by Hall in 1852 as a genus of plants "consisting of simple or branched stems, which are transversely rugose or wrinkled" (Hall, 1852:23), *Rusophycus* has been the subject of nomenclatural confusion. Included in d'Orbigny's (1842) original description of the ichnogenus *Cruziana* was *C. rugosa,* whose dimensions and diagnosis fall within the current concept of *Rusophycus*. This prompted several authors to place all rusophyciform traces within the ichnogenus *Cruziana* (James, 1885; Seilacher, 1970, 1991), as "the valid name of a taxon is the oldest available name applied to it" (ICZN, 1985:47, Art. 23a). Such a scheme, however, does not permit distinction between cubichnial and repichnial forms at the ichnogeneric level, and as a result most authors now prefer to retain both *Rusophycus* and *Cruziana* as separate forms.

***Rusophycus cryptolithi* Osgood, 1970**
Pl. 11, fig. 4

MATERIAL
One specimen: ROM 49427.

DIAGNOSIS
Small, ovoid, button-like *Rusophycus*. The striated lobes are subdivided into a coarser outer zone and a cordate, more finely striated, inner zone. Imprints of genal spines are commonly present. This ichnospecies differs from others within the ichnogenus by possessing a width which is equal to or slightly greater than the length (after Osgood, 1970).

DESCRIPTION
Specimen is preserved as a convex hyporelief measuring 7 mm in length by 8 mm in width. Two smooth lobes, separated by a median furrow running the full length of the trace, are framed on either side by 1-mm wide impressions of the genal spines. These impressions bear step-like interruptions suggestive of interrupted forward motion.

REMARKS
Rusophycus cryptolithi can be distinguished from other forms of *Rusophycus* by its button-like shape whose width is generally equal to or greater than its length. The characteristic ovoid shape and the presence of genal spine imprints suggest that the trilobite *Cryptolithus* might be a possible producer of the trace (cf. Osgood, 1970).

Rusophycus osgoodii **n. isp.**
Pl. 12, figs. 1–4

TYPE MATERIAL
Six specimens on four slabs: ROM 49882 (holotype) and ROM 49883–49885 (paratypes).

ETYMOLOGY
Named after the late Richard G. Osgood, Jr., in recognition of his contributions to Cincinnatian ichnology.

DIAGNOSIS
Oval *Rusophycus* bearing endopodal scratch marks running the complete width. Scratchings are coarser and more deeply impressed towards the outer margins, forming lobes. These lobes are more pronounced in shallower specimens, flaring anteriorly. Fewer and finer scratchings are present in the flat region between lobes.

DESCRIPTION
Specimens preserved as convex hyporeliefs on the soles of grey, fine-grained calcareous sandstone beds. Individuals take the form of oval resting traces, 20–38 mm in length by 16–29 mm in width, bearing endopodal scratch marks 0.25–2 mm thick and running the complete width of specimens. Length-to-width ratios are between 1:2 and 1:5. Scratchings, numbering between six and twelve per lobe, are coarser and more deeply impressed towards the outer margins of the traces. In less deeply impressed specimens, this results in the traces taking the form of paired, transversely striated lobes, 5 mm wide, which flare anteriorly. Fewer and finer scratchings are displayed in the flat region between these lobes.

REMARKS
The presence of lobes bearing deeply impressed transverse endopodal scratchings associated with less deeply impressed endopodal scratchings in a central region between these lobes is unlike any morphology exhibited by previously described ichnospecies of *Rusophycus*. Previously recognized ichnospecies of *Rusophycus* that display bordering lobes, unlike *R. osgoodii*, typically bear longitudinal exopodal scratchings with clear endopodal scratchings in the central region between these lobes (e.g., *R. carleyi* (James), *R. dilatata* Seilacher, and *R. morgati* Baldwin).

Rusophycus polonicus **Orlowski, Radwański and Roniewicz, 1970**
Pl. 11, fig. 3

MATERIAL
Two specimens: ROM 49428 (plaster cast) and ROM 49429.

DIAGNOSIS
Oval resting traces with about 12 pairs of coxal impressions between deeply impressed endopodal lobes on which the transverse or slightly retroverse markings are often indistinct. Pleural and genal spine impressions may occur (after Seilacher, 1970).

DESCRIPTION
Specimens are preserved as oval convex hyporeliefs, 87–200 mm long by 70–115 mm wide. The traces are comprised of a pair of featureless endopodal lobes, each 14–24 mm wide, which frame a central area covered by 10 pairs of coxal impressions, each pair taking the form of a matching S and Z shape. On ROM 49428, the endopodal lobes extend towards the posterior, 24 mm beyond the central zone of coxal impressions.

REMARKS
Rusophycus polonicus was first described independently by Orlowski, Radwański, and Roniewicz (1970:356) and Seilacher (1970:473) in two separate contributions in Crimes and Harper, eds. (1970). As a result, the question of who should be considered as the original author(s) of the ichnospecies arises. Two possible approaches ultimately yield the same result. If one considers Orlowski, Radwański, and Roniewicz as having priority in accordance with the Code (ICZN, 1985, Art. 24a) in that their use of the ichnotaxon appears 117 pages earlier in the volume than that of Seilacher, then clearly they should be considered the authors. Additionally, however, Seilacher (1970) listed material figured by Radwański and Roniewicz (1963) both as the type specimens and the only forms in his synonymy of this ichnospecies, which further suggests that Orlowski, Radwański, and Roniewicz be regarded as the authors of the ichnospecies (see also Orlowski, 1992).

Rusophycus polonicus can be distinguished from other morphologically similar forms of *Rusophycus* through the absence of transverse or slightly retroverse markings on the endopodal lobes characteristic of *Rusophycus carleyi* and the lack of longitudinal markings on the same structure that are characteristic of *Rusophycus dilatata*. Seilacher (1970) used the informal term "Carleyi Group" to encompass all ichnospecies of *Rusophycus* bearing distinct coxal markings between deep endopodal lobes, thereby grouping *R. carleyi*, *R. dilitata*, and *R. polonicus*. Both Osgood (1970) and Seilacher (1970) have suggested that *R. carleyi* was produced by the burrowing activities of the trilobite *Isotelus*.

***Rusophycus pudicus* Hall, 1852**
Pl. 11, fig. 1

MATERIAL
Four specimens: ROM 17493 [1254HR] and ROM 50084–50086, plus additional field occurrences.

DIAGNOSIS
Shallow *Rusophycus* with a poorly to moderately developed median furrow extending the entire length of the trace, dividing it into two lobes which bear imbricate or unevenly concentrated, weakly developed, evenly spaced scratchings forming a very obtuse V-angle. Length-to-width ratios vary between 1:5 and 1:8, width gradually tapering posteriorly. Impressions of cephalic and thoracic doublures and thoracic pleurae may be seen (after Osgood, 1970; Osgood and Drennen, 1975).

DESCRIPTION
Trilobite cubichnia preserved as bilobed elliptical convex hyporeliefs, the median furrow extending the entire length of the trace, width tapering posteriorly. Each lobe bears striae varying in width from 0.25 mm to 1 mm, no markings being seen on the nearly vertical sides of the trace. Lengths range from 13 mm to 23 mm while width varies from 10 mm to 14 mm. Depth of the traces gradually decreases towards each end from a maximum near midlength.

REMARKS
Fritz (1925) made no attempt at ichnospecific assignment of rusophyciform burrows despite the availability of a well-preserved specimen (ROM 17493 [1254HR]). Reexamination of this specimen has led to its assignment to *R. pudicus*. One organism believed to have produced at least some examples of this ichnospecies is the trilobite *Flexicalymene meeki*, as its size and shape correspond to that of *R. pudicus*, and impressions of the cephalic doublure and thoracic pleurae are occasionally observed (Osgood, 1970). The occurrence of three specimens of *F. meeki* in direct association with this trace supports this belief (Osgood, 1970), though the possibility of these being chance occurrences should be borne in mind, and all examples of *R. pudicus* should not necessarily be equated with this particular trilobite species.

Ichnogenus *Skolithos* Haldeman, 1840

TYPE ICHNOSPECIES
Fucoides? *linearis* Haldeman, 1840, by monotypy.

DIAGNOSIS
Unbranched, vertical or steeply inclined, cylindrical or sub-cylindrical, lined or unlined burrows. Walls distinct or indistinct, smooth or rough, possibly annulate; burrow-fill massive; burrow diameter may vary slightly along its length (after Alpert, 1974).

DISCUSSION
Skolithos received an in-depth systematic review by Alpert (1974), resulting in the placement of several ichnogenera such as *Sabellarifex* Richter, *Tigillites* Rouault, and *Stipsellus* Howell within this ichnogenus. Alpert (1974) recognized five ichnospecies, namely, *Skolithos annulatus* (Howell), *S. ingens* Howell, *S. linearis* Haldeman, *S. magnus* Howell, and *S. verticalis* (Hall). This scheme is regarded by most ichnologists as adequate but in need of further attention, particularly with respect to examination of type specimens (Fillion and Pickerill, 1990a). One of the principal areas of weakness involves the three ichnospecies *S. linearis, S. verticalis,* and *S. magnus,* because their respective diagnoses reveal that they are essentially identical, ambiguous diameter ranges being the only distinguishing criterion. That for *S. linearis,* stated as 3–7 mm, commonly up to 12 mm, overlaps at the lower end with *S. verticalis,* with a diameter range of 1–4 mm, and at the upper end with *S. magnus,* with a stated range of 6–12 mm. This produces a problematic situation whereby a cylindrical, straight, vertical, indistinctly walled burrow, 10 mm in diameter, could be regarded as either *S. linearis* or *S. magnus*. In the same way, a cylindrical, straight, vertical burrow, 3.5 mm in diameter, could be regarded as either *S. linearis* or *S. verticalis*. Differing lengths were given for each of these latter ichnospecies by Alpert (1974), up to a metre and 2–15 cm respectively, though this criterion also does not adequately distinguish the two. Indeed, the usefulness of length as a diagnostic feature is questionable given that this characteristic is so dependent on preservation, the observed length in many cases bearing little relation to the original length at the time the trace was produced.

One possible solution is to eliminate the overlapping nature of the diameter ranges for these ichnospecies. However, one could still argue that the three simply represent a gradational change within a single ichnospecies.

Skolithos is generally believed to represent the feeding burrows of annelids or phoronids.

***Skolithos magnus* Howell, 1944**
Pl. 13, fig. 1

MATERIAL
One specimen: ROM 50087, plus additional field occurrences.

DIAGNOSIS

Skolithos that may curve slightly. Diameter 6–12 mm. Burrow-wall indistinct, somewhat irregular (after Alpert, 1974).

DESCRIPTION

Specimens preserved in convex hyporelief, epirelief, or endorelief, with a circular to subcircular cross-section and following a straight to undulatory course. Diameters range from 8 mm to 11 mm. One convex epirelief is surrounded by concentric rings. Burrow-fill is massive, with a grain size similar to the host rock. Previously existing laminae are cut with little evidence of downward deflection. Wall lining is absent in all specimens.

REMARKS

The specimens are assigned to this ichnospecies primarily on the basis that their diameter falls within the 6–12 mm range of *S. magnus,* other ichnospecies being smaller. The diameter of ROM 50087 must be regarded as a minimum. Since this specimen was discovered accidentally during vertical sectioning, no surface expression being present, it was impossible to determine whether the observed section represents the maximum diameter. Another specimen was found closely associated with specimens of *Trichophycus lanosus,* the producer of this trace conceivably having used the pre-existing *Skolithos* traces to access deeper sediments.

***Skolithos verticalis* (Hall, 1843)**

Pl. 13, fig. 2

MATERIAL

One specimen: ROM 50088, plus numerous field occurrences.

DIAGNOSIS

Cylindrical to prismatic (where in contact), straight to curved, vertical to inclined *Skolithos.* Diameter 1–4 mm, length 2–15 cm. Burrow-wall smooth, rarely corrugated (after Alpert, 1974).

DESCRIPTION

Specimens preserved as unbranched, cylindrical, slightly curved, vertical burrows, 3.5–4 mm in diameter and 2.5–3 cm in length. Some downward deflection of lamination seen. Fill is of same grain size and lithology as host rock, no evidence of internal structure being present. Surficial expression of tube opening very faint.

REMARKS

Both specimens are assigned to *S. verticalis* primarily on the basis of diameter and curved habit, *S. linearis* typically being straight. Given that the burrows are difficult to detect in horizontal section, both specimens having been found fortuitously during vertical slabbing, the possibility that the traces are one of a pair of vertical tubes belonging to *Arenicolites* must be considered.

Ichnogenus *Trichophycus* Miller and Dyer, 1878a

TYPE ICHNOSPECIES

Trichophycus lanosus Miller and Dyer, 1878a, by monotypy.

DIAGNOSIS

Cylindrical, straight to gently curved, horizontal burrows whose concave ventral surface is covered by fine striae which may radiate posterolaterally from the midline. Preserved in endorelief, convex hyporelief, or, more rarely, concave epirelief. May be seen to branch vertically. Irregularly spaced transverse constrictions may also be present. Groups of parallel, discontinuous, longitudinal ridges may be seen on the concave or flat, rarely convex, straight to gently arcuate dorsal surface. Lateral surfaces may possess up to seven finely striated continuous parallel ridges. Retrusive spreite are typically seen in burrow-fill. In lined specimens, passive, laminated fill is seen, though lining is rare. Burrows terminate abruptly in an arcuate fashion (after Fillion and Pickerill, 1990a).

DISCUSSION

Trichophycus was established by Miller and Dyer (1878a) as a genus of plants consisting of "simple branches or stems having diagonal or longitudinal markings, as if made by the folding down of hair-like filaments" (Miller and Dyer, 1878a:24–25). At the time, only one species was proposed, *Trichophycus lanosus,* described as a "plant consisting of [a] round, flexuous stem, having an enlargement or spheroidal swelling at one end, and being covered with diagonal and longitudinal lines" (Miller and Dyer, 1878a:25). Subsequently, Miller and Dyer (1878b) formulated *T. sulcatus* and the following year Miller (1879) proposed *T. venosus.*

James (1884) suggested that *T. sulcatus* and *T. venosus* were the products of water drainage, as they bore a strong resemblance to "rill marks" described by Dawson (*in* James, 1884). *T. lanosus* was later acknowledged by James (1885) to be a burrow rather than a plant, the diagonal and longitudinal lines resembling folded-down, hair-like filaments referred to in the original description, probably resulting from the action of burrow formation (James, 1885). Additionally, *T. lanosus* was viewed as synonymous with *Blastophycus,* a genus of "plant" proposed by Miller and Dyer (1878a) and probably representing an early stage in the formation of *T. lanosus* (James, 1885). In 1891, James placed *Saccophycus intortus* James in synonymy with *Blastophycus diadematus* Miller along with *T. lanosus*, thereby making *S. intortus* synonymous with *T. lanosus* (James, 1891). *Cyathophycus siluriana*, a new species of sponge discussed in the same paper, was later seen as synonymous with *T. venosus* by Osgood (1970).

The nature of the organism that produced trichophyciform burrows was addressed by Bergström (1976). He suggested that the characteristic striae were produced by an organism with long legs whose bases were close together, such as a decapod crustacean, and that the tracemaker was possibly an annelid. A trilobite origin was deemed unlikely by Osgood (1970) because there was no bilobation.

***Trichophycus lanosus* Miller and Dyer, 1878a**
Pl. 13, fig. 4

MATERIAL
Two specimens: ROM 50089 and ROM 50090, plus additional field occurrences.

DIAGNOSIS
Usually sinuous *Trichophycus* with profusely striated ventral surface radiating from a button-like depression (after Osgood, 1970).

DESCRIPTION
These traces are preserved as convex hyporeliefs, the convex surface being completely covered by striae, 0.1–0.3 mm in diameter, giving the trace a shaggy appearance. Length is variable, the three examples collected having lengths between 1 cm and 3 cm. Striae commence abruptly at a featureless breakage surface roughly circular in outline, the diameter of which is equal to that of the body of the trace. When seen in the vertical plane, this structure takes the form of tubes that follow a sinuous course towards what would presumably have been the sediment-water interface at the time of burrow formation. The walls of these tubes are featureless. Terminations of the traces are arcuate, no evidence of a reduction in the density of striae in these areas being seen.

REMARKS
The conditions that lead to the formation of *Trichophycus lanosus* are not wholly understood, though it has been suggested that the striae are produced by "a circlet of appendages or extensions surrounding [a] mouth," the sinuosity of the trace suggesting that the organism possessed a flexible vermiform body (Osgood, 1970:350). The presence of a sinuous vertical burrow at one end of each of the examples herein is believed to represent either a pre-existing vertical burrow (*Skolithos*) or a vertical burrow produced by the tracemaker while descending in search of nutrient-rich layers of sediment. When such a layer was encountered, the organism burrowed horizontally, thereby producing *T. lanosus*.

***Trichophycus venosus* Miller, 1879**
Pl. 13, fig. 3

Trichophycus venosum Fritz, 1925:30–31, pl. 3, fig. 4.
Teichichnus Kerr and Eyles, 1991, fig. 10c.

MATERIAL
Two suites in ROM collections: ROM 17492 [1253HR] consisting of three specimens, and ROM 17494 [1255HR] (*partim*), plus numerous field specimens.

DIAGNOSIS
Straight to gently curved, sometimes vertically branched *Trichophycus* displaying ventral striae that radiate posterolaterally from the midline (after Osgood, 1970).

DESCRIPTION
Specimens are preserved as concavo-convex full reliefs, convex hyporeliefs, or concave epireliefs, 9–27 mm in width by 28–110 mm in length. Convex surfaces display a characteristic pattern of striae, 0.3–1.0 mm in diameter, preserved in positive relief, of which three sets are distinguishable. One set comprises parallel striae running along burrow length, a second consists of striae radiating posteriorly 180° from a point along the midline, and a third consists of striae radiating posterolaterally from the central axis at an angle of 5°–10°. When specimens are viewed laterally, the third set of striae form an angle of approximately 40° with the horizontal. All three sets of striae are not always present on the material, some displaying only the posterolaterally radiating variety. In some specimens, overprinting of several successive burrowing events due to vertical branching can be seen, retrusive spreite being seen in association with each. *T. venosus* is also preserved as concave epireliefs, though these forms are generally poorly preserved, displaying few or no striae. One specimen (ROM 50086) contains a specimen of *Rusophycus pudicus* on its bottom surface.

REMARKS
The presence of posterolaterally radiating striae on a convex ventral surface together with the presence of vertical branching distinguish these traces from the similar ichnogenera *Teichichnus* Seilacher and *Pennatulites* de Stefani (Osgood, 1970). We concur with Fritz's (1925) assignment of the ROM specimens to *Trichophycus venosus*. Several modes of formation have been suggested by various authors, including impression by plant material (Miller, 1879) and casting of small streams and rills (Fritz, 1925), though the most likely origin seems to be the production of feeding or dwelling burrows by small crustacean-like animals or setate annelids. The specimen of *Rusophycus pudicus* found in association with a specimen of *Trichophycus venosus* was possibly produced by a *Rusophycus* animal taking refuge in an abandoned *Trichophycus* burrow.

Concluding Remarks

The comparison of infaunal and epifaunal ichnotaxa can be useful when considering the relationships of tracemaking organisms to depositional events. In the Georgian Bay Formation, ichnotaxa are preserved essentially in four styles, namely, 1) full reliefs or endoreliefs in shale deposits (these include *Diplocraterion, Palaeophycus, Planolites,* and *Trichophycus*); 2) as convex epireliefs, hyporeliefs, full reliefs, or endoreliefs in calcareous sandstone deposits (these include *Arenituba, Aulichnites, Cochlichnus, Diplocraterion, Gyrochorte, Palaeophycus, Phycodes, Planolites, Protovirgularia, Skolithos,* and *Trichophycus*; 3) as convex or concave hyporeliefs on the soles of calcareous sandstone beds, the result of traces originally produced in underlying mudstone deposits being cast by overlying sandstone (these include *Cruziana, Curvolithus, Didymaulichnus, Diplocraterion, Fustiglyphus, Gordia, Lingulichnus, Lockeia, Monomorphichnus, Rusophycus,* and *Trichophycus*); and finally 4) as sandstone concave epireliefs produced by infaunal organisms originally living within overlying mud, gathering food along the mud-sand interface, *Chondrites* falling into this group.

Collectively, ichnotaxa in the Georgian Bay Formation are indicative of the *Cruziana* ichnofacies of Seilacher (1964, 1967). However, given the variable preservation of traces, it is tempting to equate certain ichnotaxa (e.g., *Arenituba, Diplocraterion, Monocraterion, Skolithos*) as reflecting opportunistic colonization of storm-deposited sand layers, producing trace fossils more typically associated with the *Skolithos* ichnofacies (cf. Vossler and Pemberton, 1989). Subsequently, calm or "fair-weather" periods following storm events would witness the deposition of muds, upon or within which deposit-feeding organisms produced traces such as *Cruziana, Gordia, Lockeia,* and *Rusophycus,* to name but several. Each series of storm events followed by periods of calm would witness a repetition of this situation.

Identity of the organism(s) that produced any given ichnotaxon is rarely known. Exceptions include *Rusophuycus pudicus,* several examples of which are believed to have been produced by the trilobite *Flexicalymene meeki* (Osgood, 1970), and *Rusophycus cryptolithi,* believed to have been produced by the trilobite *Cryptolithus,* based on the nature of genal spine impressions as well as the overall geometry, both the trace and body fossils being button-shaped (D. Rudkin, pers. comm.). *Rusophycus polonicus* is believed to have been produced by the trilobite *Isotelus* (Osgood, 1970; Seilacher, 1970), *Lingulichnus verticalis* by linguloid brachiopods (Hakes, 1976), and *Lockeia* and *Protovirgularia* by pelecypods (Osgood, 1970; Seilacher and Seilacher, 1994). The progenitors of most other ichnotaxa are unknown, and in many cases any given ichnotaxon may be produced by many different organisms, each displaying common behaviourial practices as illustrated, for example, by the compound examples of *Planolites* and *Gyrochorte.* Undoubtedly, however, many of the additional ichnotaxa described herein were produced by arthropods or worm-like organisms, most likely annelids.

Finally, we feel it useful to compare the ichnofaunal assemblage documented herein with that of the Cincinnatian of Ohio as monographed by Osgood (1970). Both sequences are of the same age, depositional environment, and biogeographic province, but the Georgian Bay Formation is dominated by siliciclastics and the Cincinnatian Series by carbonates. Comparison of these ichnofaunal suites is made in Appendix 3 which, incidentally, excludes Osgood's (1970) *incertae sedis* or invalid ichnospecies (see Häntzschel, 1975). Given the fact that several of Osgood's (1970) ichnotaxa have subsequently been re-assessed taxonomically (e.g., his *Corophioides* would now be regarded as *Diplocraterion* (Fürsich, 1974), his *Walcottia* as *Protovirgularia* (Seilacher and Seilacher, 1994), and his *Fucusopsis* as *Palaeophycus* (Pemberton and Frey, 1982)), the two suites compare favourably in terms of overall taxonomic content, suggesting that substrate composition (siliciclastic versus carbonate) was unimportant in their primary production.

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Appendix 1: Ichnotaxa from the Late Ordovician Georgian Bay Formation, Southern Ontario, with Corresponding ROM Repository Numbers

Ichnospecies	ROM No.
Arenituba verso	49640
Arenicolites isp.	49767, 50049
Arthraria antiquata	50050
Aulichnites parkerensis	50051–50052
Chondrites isp.	17497, 50053–50055
Cochlichnus anguineus	49427
Cochlichnus n. isp.	50056
Cruziana cf. *lobosa*	49425
Cruziana problematica	50058
Cruziana quadrata	50059
Cruziana ispp.	50060–50063
Curvolithus multiplex	50064–50065
Didymaulichnus lyelli	49427, 50066
Diplocraterion cf. *biclavatum*	17491, 50067–50069
Diplocraterion helmerseni	48896
Diplocraterion parallelum	50071
Fustiglyphus annulatus	815T, 49465, 49467–49470
Gordia marina	50072
Gyrochorte comosa	50073–50074
Helminthopsis hieroglyphica	50075
cf. *Lingulichnus verticalis*	17496
Lockeia siliquaria	50076
cf. *Monocraterion tentaculatum*	50077
Monomorphichnus bilinearis	50078
Monomorphichnus lineatus	50079
cf. *Palaeophycus crenulatus*	50058
Palaeophycus heberti	50080
Palaeophycus striatus	50081
Palaeophycus tubularis	17494–17495
Paleodictyon isp. a	49424, 49624
?*Paleodictyon* isp. b	49625
Phycodes flabellus	17496
Phycodes palmatus	50082
Planolites annularius	50073
Planolites beverleyensis	50073
Planolites constriannulatus	49764–49770
Rusophycus carbonarius	50083
Protovirgularia dichotoma	50091
?*Protovirgularia* isp.	50091
Rusophycus cryptolithi	49427
Rusophycus osgoodii	49882–49885
Rusophycus polonicus	49428–49429
Rusophycus pudicus	17493, 50084–50086
Skolithos magnus	50087
Skolithos verticalis	50088
Trichophycus lanosus	50089–50090
Trichophycus venosus	17492, 17494, 50086

Appendix 2: Locality Details—Toronto Region

Locality numbers are those used during field studies. Localities 1–29 are on Manitoulin Island and did not contain particularly photogenic trace-fossil specimens.

Locality No.	U.T.M. Co-ordinates	Description
30	620000 m E x 4837600 m N	Humber River at Eglinton Ave.
31	619500 m E x 4839100 m N	Humber River at Lawrence Ave.
32	620000 m E x 4835200 m N	Humber River north of Dundas St.
33	621750 m E x 4833800 m N	Humber River south of Dundas St.
34	619750 m E x 4833080 m N	Mimico Creek near intersection of Islington Ave. and Bloor St.
35	619750 m E x 4832900 m N	Mimico Creek at Springbrook Parkette
36	615700 m E x 4829150 m N	Etobicoke Creek south of The Queensway
37	615500 m E x 4829300 m N	Etobicoke Creek north of The Queensway
38	614400 m E x 4822200 m N	Credit River at Port Credit (J. C. Saddington Park)
39	608400 m E x 4821800 m N	Credit River south of Dundas St.
40	608250 m E x 4821900 m N	Credit River north of Dundas St.
41	608500 m E x 4822500 m N	Credit River north of Dundas St.
42	608400 m E x 4822600 m N	Credit River north of Dundas St.
43	607500 m E x 4823100 m N	Credit River north of Dundas St.
44	619000 m E x 4839500 m N	Humber River north of Lawrence Ave.
45	604450 m E x 4825750 m N	Credit River at Streetsville
46	608100 m E x 4832100 m N	Hwy. 410 extension south of Hwy. 401
47	605450 m E x 4824850 m N	Credit River north of Eglinton Ave.
48	605500 m E x 4824750 m N	Credit River south of Eglinton Ave.
49	631600 m E x 4838200 m N	Don Valley Brick Yard (now filled)

Appendix 3: Comparison of Ichnotaxa Occurring within the Cincinnatian of Ohio, as Described by Osgood (1970), with Those Described Here from Coeval Strata of the Georgian Bay Formation, Southern Ontario

Osgood, 1970	**Present Study**
Allocotichnus dyeri	—
—	*Arenicolites* isp.
—	*Arenituba verso*
—	*Arthraria antiquata*
Asaphoidichnus trifidum	—
Asteriacites stelliforme	—
—	*Aulichnites parkerensis*
Chondrites type A	—
Chondrites type B	*Chondrites* isp.
Chondrites type C	—
—	*Cochlichnus anguineus*
—	*Cochlichnus* n. isp.
—	*Cruziana* cf. *lobosa*
—	*Cruziana problematica*
—	*Cruziana quadrata*
—	*Cruziana* ispp.
—	*Curvolithus multiplex*
—	*Didymaulichnus lyelli*
Corophiodes biclavata	*Diplocraterion* cf. *biclavatum*
Corophiodes cincinnatiensis	*Diplocraterion helmerseni*
Corophiodes cf. *luniformis*	*Diplocraterion parallelum*
Dactylophycus quadripartitum	—
Fascifodina floweri	—
Fucusopsis sulcatum	—
—	*Gordia marina*
—	*Gyrochorte comosa*
—	*Helminthopsis hieroglyphica*
—	cf. *Lingulichnus verticalis*
Lockeia siliquaria	*Lockeia siliquaria*
—	cf. *Monocraterion tentaculatum*
—	*Monomorphichnus bilinearis*
—	*Monomorphichnus lineatus*

Osgood, 1970	**Present Study**
Ormathichnus moniliformis	—
Palaeophycus type A	cf. *Palaeophycus crenulatus*
Palaeophycus type B	—
—	*Palaeophycus heberti*
—	*Palaeophycus striatus*
Palaeophycus type C	*Palaeophycus tubularis*
?*Paleodictyon* sp.	*Paleodictyon* ispp. a–b
Petalichnus multipartitum	—
Phycodes flabellum	*Phycodes flabellus*
—	*Phycodes palmatus*
—	*Planolites annularius*
—	*Planolites beverleyensis*
—	*Planolites constriannulatus*
Rhabdoglyphus sp. (*partim*)	*Fustiglyphus annulatus*
Rhabdoglyphus sp.	—
—	*Rusophycus carbonarius*
Rusophycus carleyi	—
Rusophycus cryptolithi	*Rusophycus cryptolithi*
—	*Rusophycus osgoodii*
—	*Rusophycus polonicus*
Rusophycus pudicum	*Rusophycus pudicus*
—	*Skolithos magnus*
?*Skolithos delicatulus*	*Skolithos verticalis*
Teratichnus confertum	—
Trachomatichnus numerosum	—
Trichophycus lanosum	*Trichophycus lanosus*
Trichophycus venosum	*Trichophycus venosus*
Tylichnus asperum	—
Walcottia cookana	—
Walcottia rugosa	*Protovirgularia rugosa*
—	?*Protovirgularia* isp.

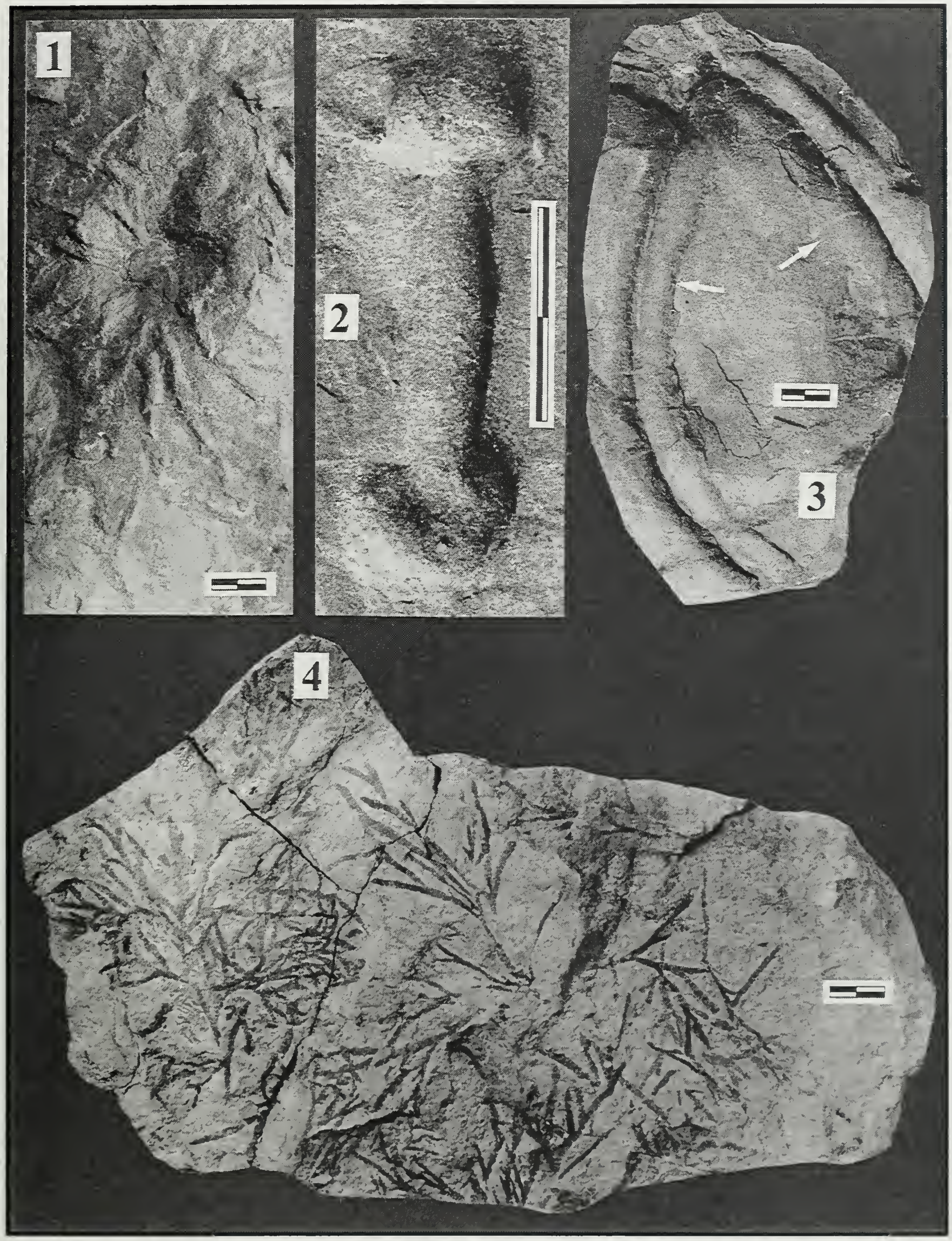

PLATE 1, FIGS. 1–4 (complete scale bars = 1 cm).
1. *Arenituba verso* (Chamberlain), convex epirelief, ROM 49640.
2. *Arthraria antiquata* Billings, convex hyporelief, ROM 50050.
3. *Aulichnites parkerensis* Fenton and Fenton, convex epirelief, ROM 50052 (examples arrowed).
4. *Chondrites* isp., concave epirelief, ROM 50053.

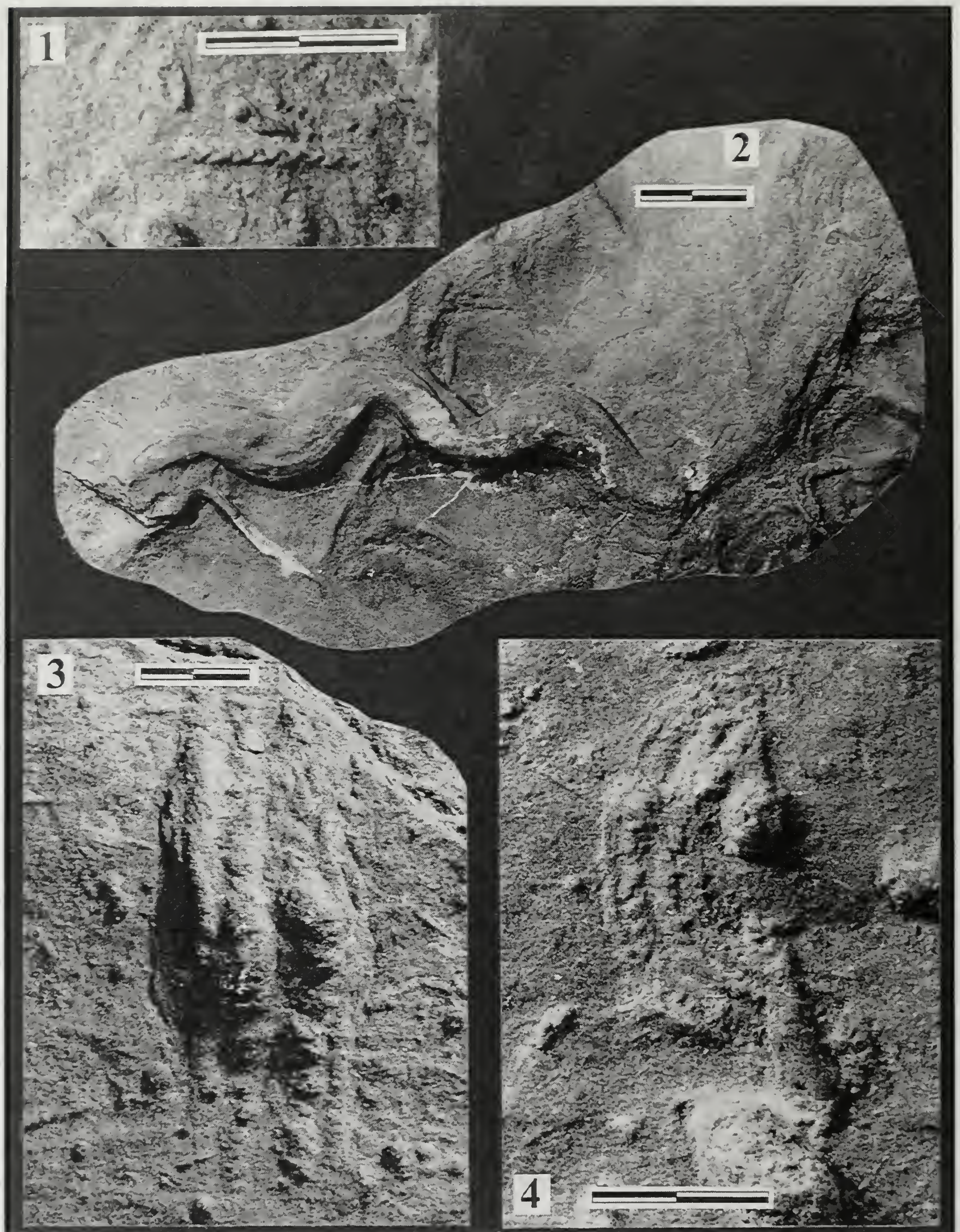

PLATE 2, FIGS. 1–4 (complete scale bars = 1 cm).
1. *Cochlichnus anguineus* Hitchcock, convex hyporelief, ROM 49427.
2. *Cochlichnus* n. isp., convex epirelief, ROM 50056.
3. *Cruziana* cf. *lobosa* Seilacher, convex hyporelief, ROM 49425.
4. *Cruziana quadrata* Seilacher, convex hyporelief, ROM 50059.

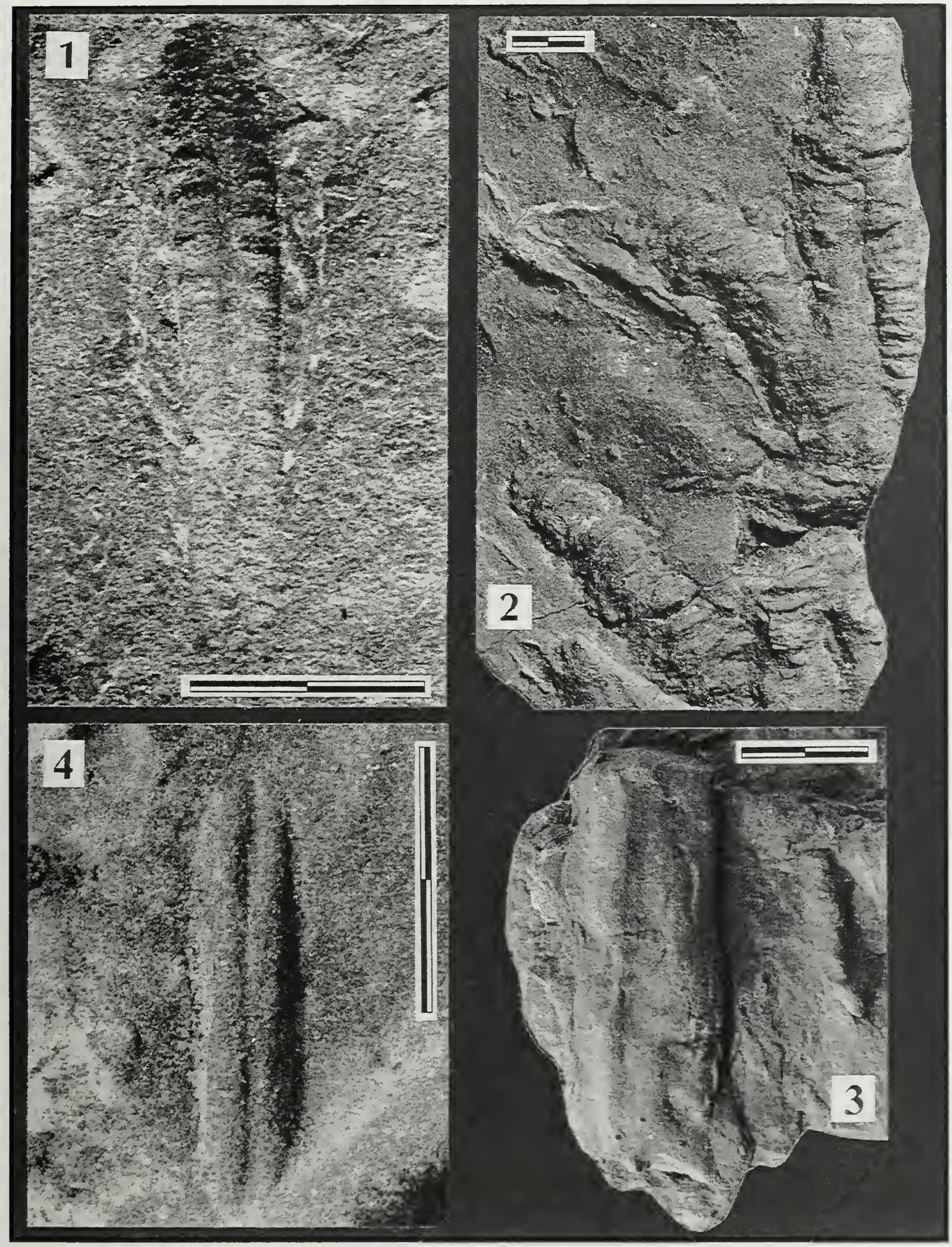

PLATE 3, FIGS. 1–4 (complete scale bars = 1 cm).

1. *Cruziana problematica* (Schindewolf), convex hyporelief, ROM 50058.
2. *Cruziana* isp., convex hyporelief, ROM 50062.
3. *Curvolithus multiplex* Fritsch, convex hyporelief, ROM 50064.
4. *Didymaulichnus lyelli* (Rouault), convex hyporelief, ROM 50066.

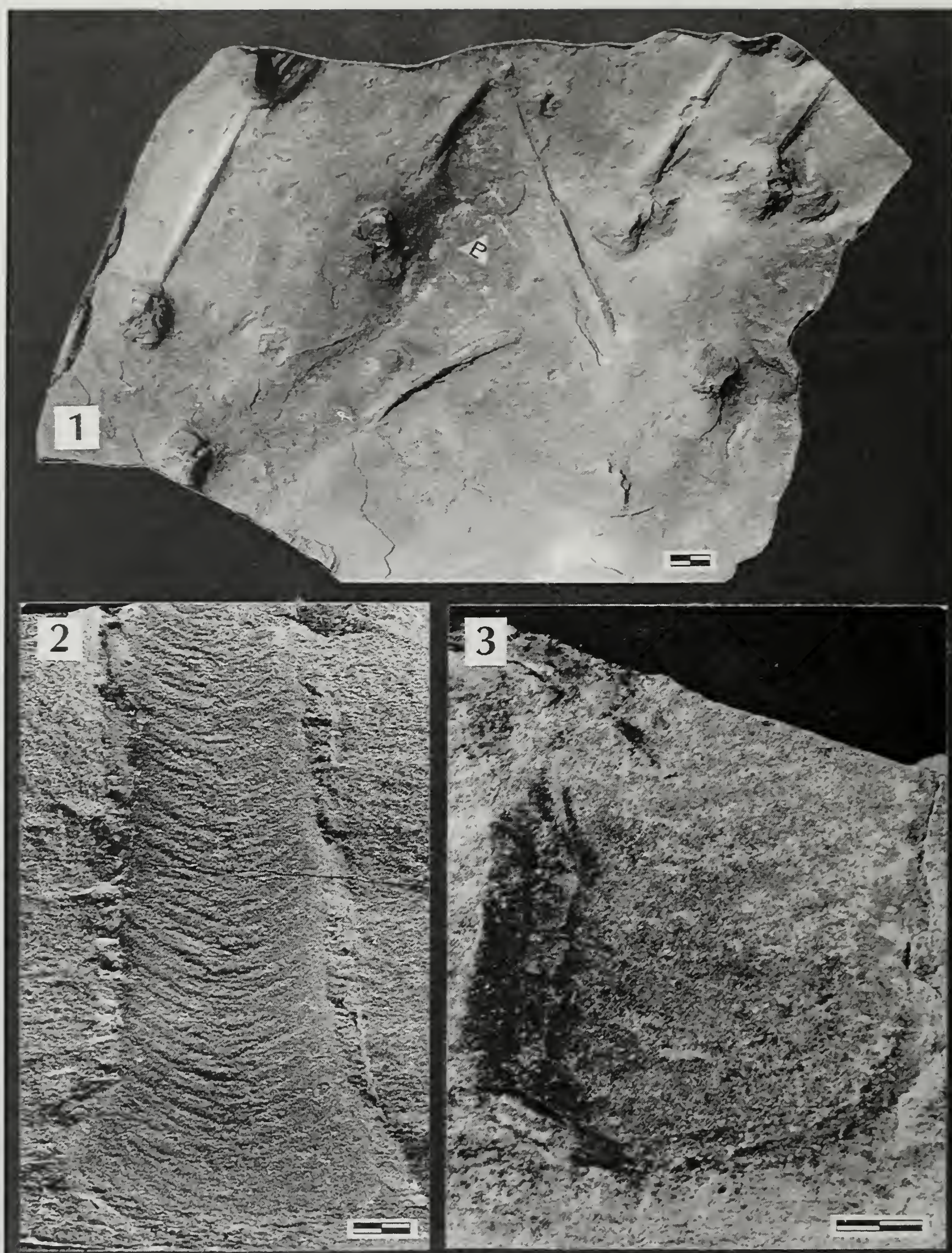

PLATE 4, FIGS. 1–3 (complete scale bars = 1 cm).
1. *Diplocraterion* cf. *biclavatum* (Miller), concave epirelief, ROM 17491.
2. *Diplocraterion helmerseni* (Öpik), convex endorelief, ROM 48896.
3. *Diplocraterion parallelum* Torell, convex endorelief, ROM 50071.

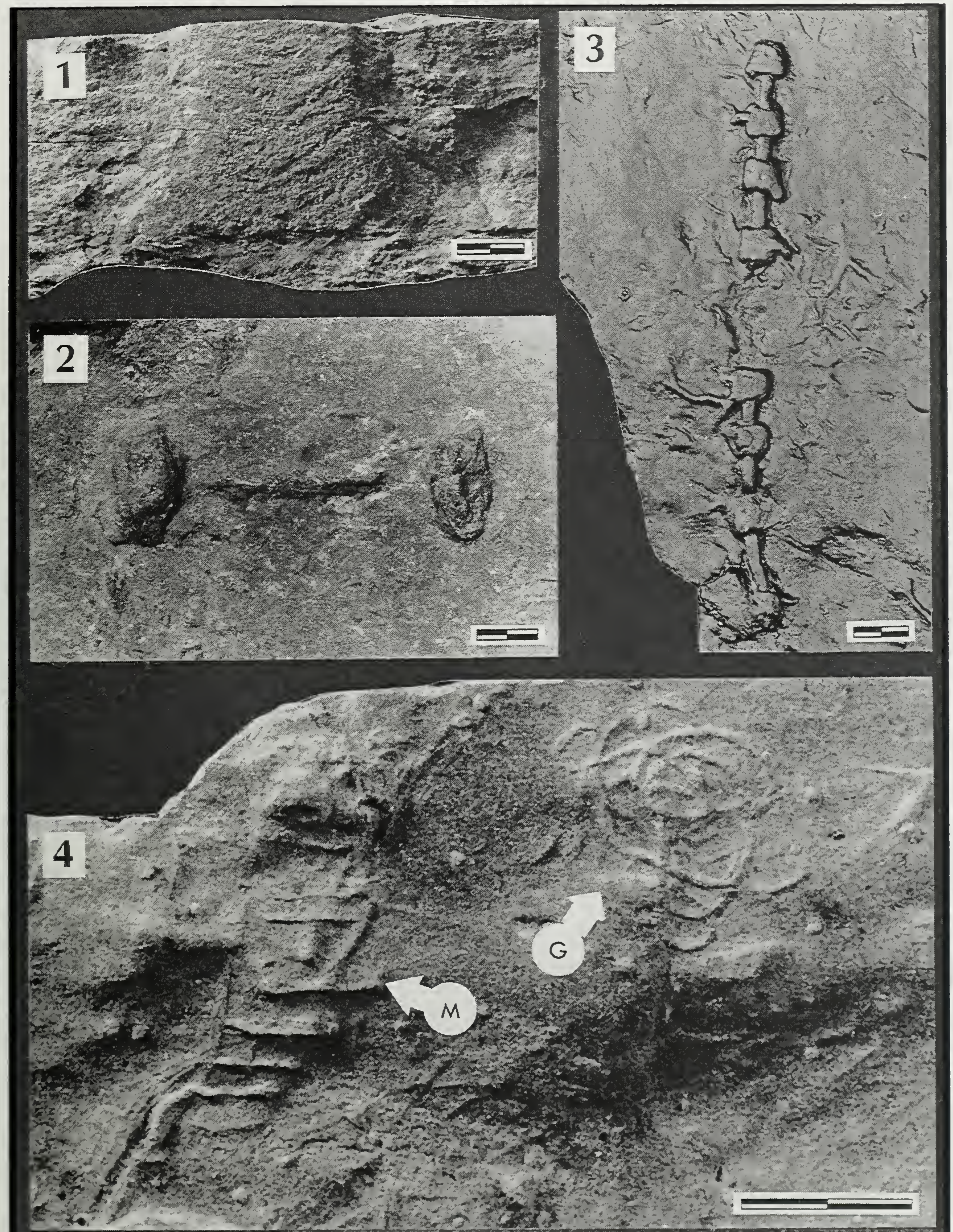

PLATE 5, FIGS. 1–4 (complete scale bars = 1 cm).

1. *Diplocraterion biclavatum* (Miller), convex endorelief, ROM 50069.
2. *Diplocraterion* cf. *biclavatum* (Miller), concave epirelief, ROM 50067.
3. *Fustiglyphus annulatus* Vialov, convex hyporelief, ROM 49465.
4. *Gordia marina Emmons* (G) and *Monomorphichnus lineatus Crimes*, Legg, Marcos and Arboleya (M), convex hyporelief, ROM 50072.

PLATE 6, FIGS. 1–4 (complete scale bars = 1 cm).

1. Compound specimens of *Gyrochorte comosa* Heer (Gc), *Planolites beverleyensis* (Billings) (Pb), and *Planolites annularius* Walcott (Pa), convex hyporelief, ROM 50073.
2. cf. *Lingulichnus verticalis* Hakes, convex hyporelief, ROM 17496.
3. *Helminthopsis hieroglyphica* Wetzel and Bromley, concave epirelief, ROM 50075.
4. cf. *Monocraterion tentaculatum* Torell, concave epirelief, ROM 50077.

PLATE 7, FIGS. 1–3 (complete scale bars = 1 cm).
1. *Monomorphichnus bilinearis* Crimes, convex hyporelief, ROM 50078.
2. *Monomorphichnus lineatus* Crimes, Legg, Marcos and Arboleya, convex hyporelief, ROM 50079.
3. cf. *Palaeophycus crenulatus* Buckman, convex hyporelief, ROM 50058.

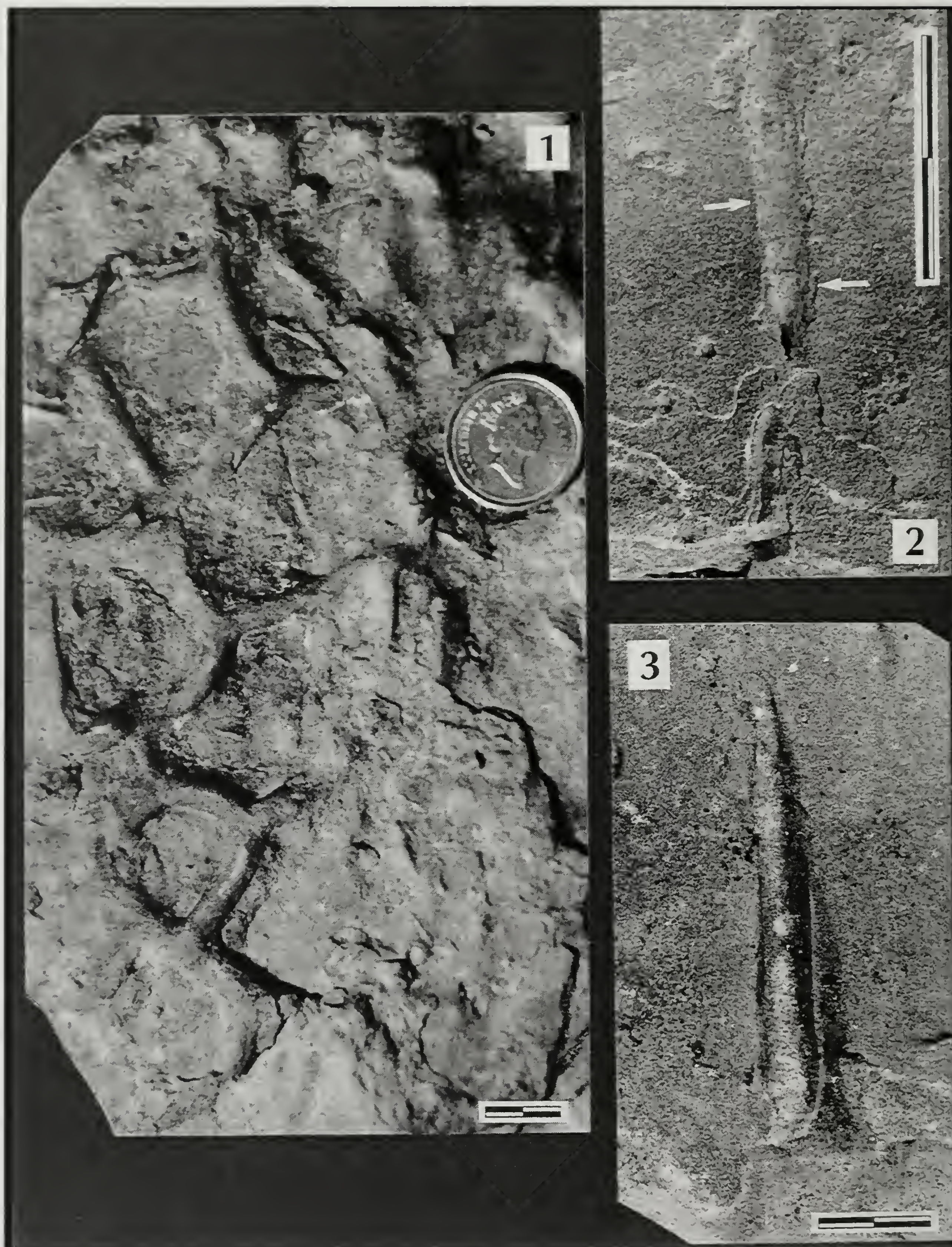

PLATE 8, FIGS. 1–3 (complete scale bars = 1 cm).
1. *Paleodictyon* isp. a, convex hyporelief, ROM 49424.
2. *Palaeophycus heberti* (de Saporta), convex hyporelief, ROM 50080. Note pronounced linings (arrowed).
3. *Palaeophycus tubularis* Hall, convex hyporelief, ROM 17494.

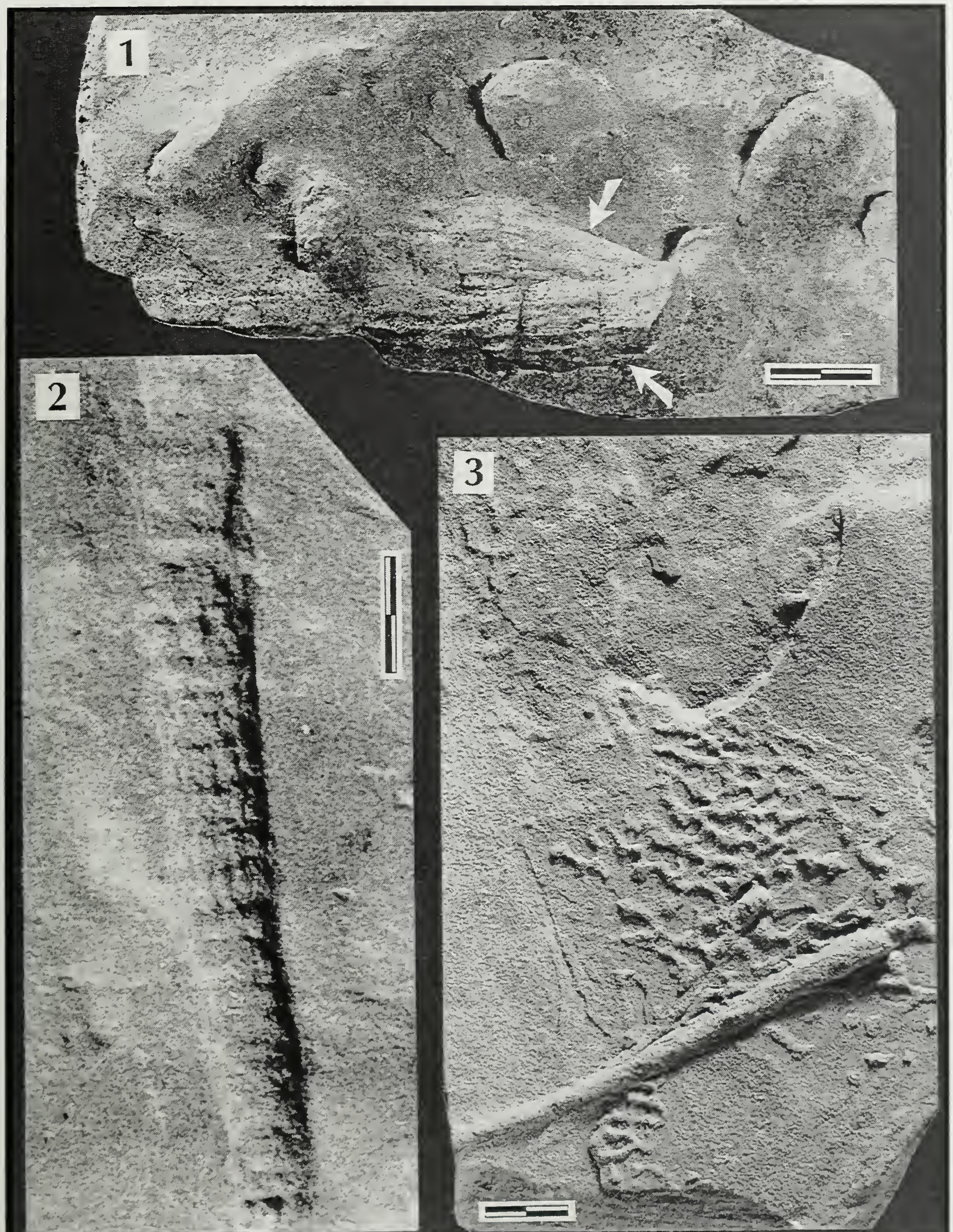

PLATE 9, FIGS. 1–3 (complete scale bars = 1 cm).
1. Two intersecting (arrowed) *Palaeophycus striatus* Hall, convex hyporelief, ROM 50081.
2. *Planolites constriannulatus* Stanley and Pickerill, convex hyporelief, ROM 49764.
3. ?*Paleodictyon* isp. b, convex hyporelief, ROM 49625.

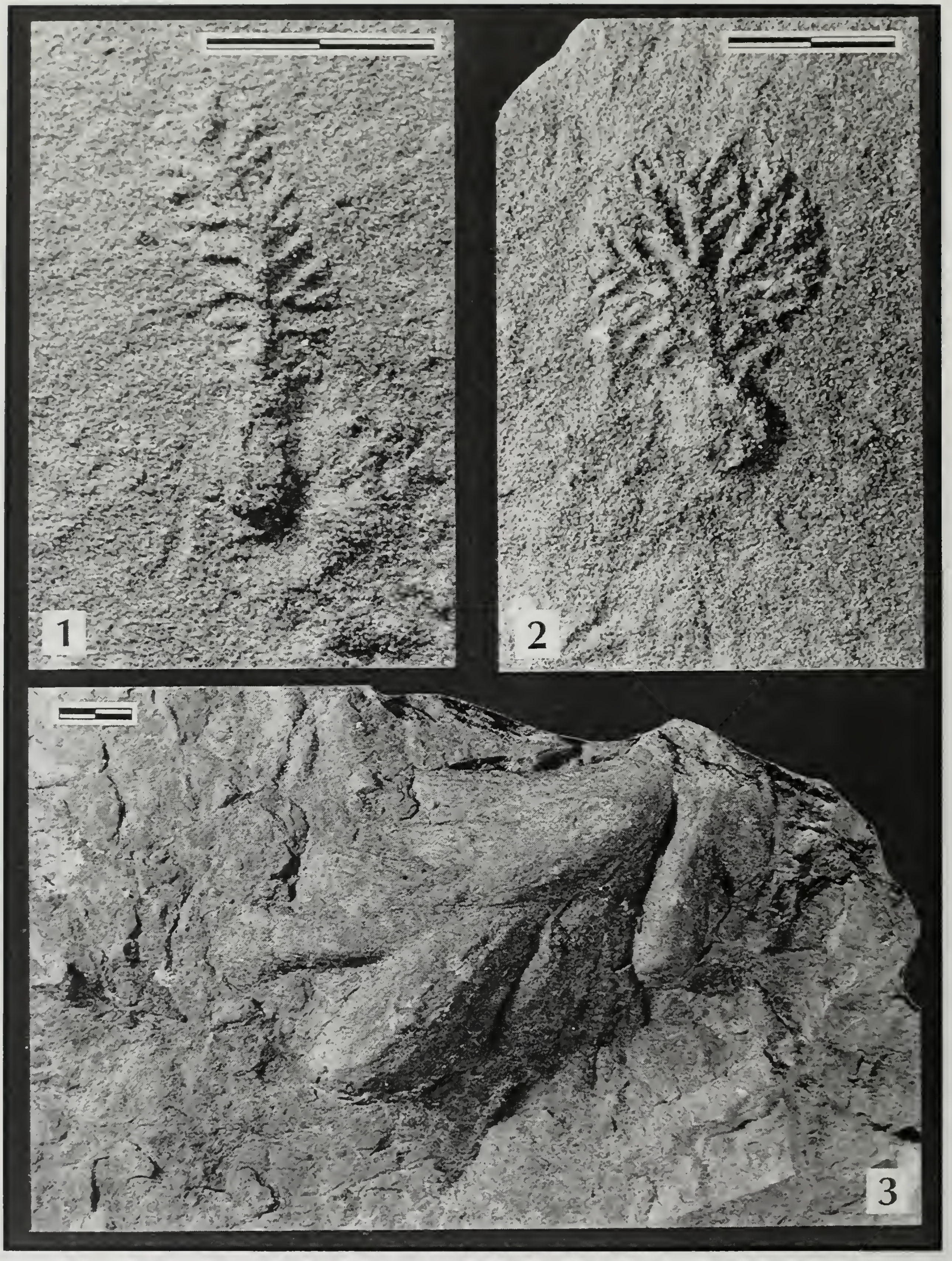

PLATE 10, FIGS. 1–3 (complete scale bars = 1 cm).
1. *Protovirgularia rugosa* Miller and Dyer, convex hyporelief, ROM 50091.
2. ?*Protovirgularia* isp., convex hyporelief, ROM 50091.
3. *Phycodes palmatus* (Hall), convex hyporelief, ROM 50082.

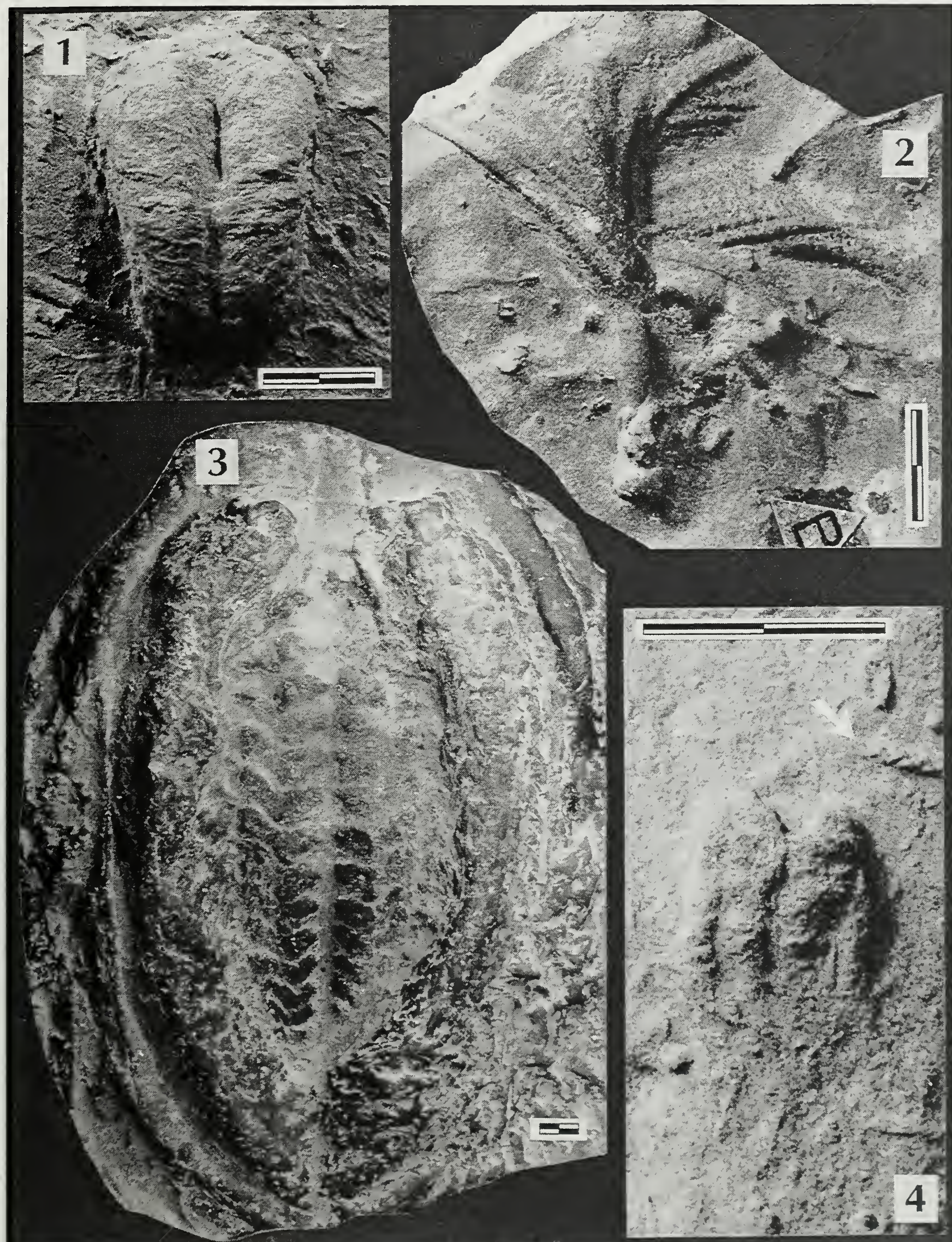

PLATE 11, FIGS. 1–4 (complete scale bars = 1 cm).

1. *Rusophycus pudicus* Hall, convex hyporelief, ROM 50085.
2. *Phycodes flabellus* (Miller and Dyer), convex hyporelief, ROM 17496.
3. *Rusophycus polonicus* Orlowski, Radwański and Roniewicz, convex hyporelief, ROM 49429.
4. *Rusophycus cryptolithi* Osgood, convex hyporelief, ROM 49427. Arrow indicates *Cochlichnus anguineus* Hitchcock as illustrated in Pl. 2, fig. 1.

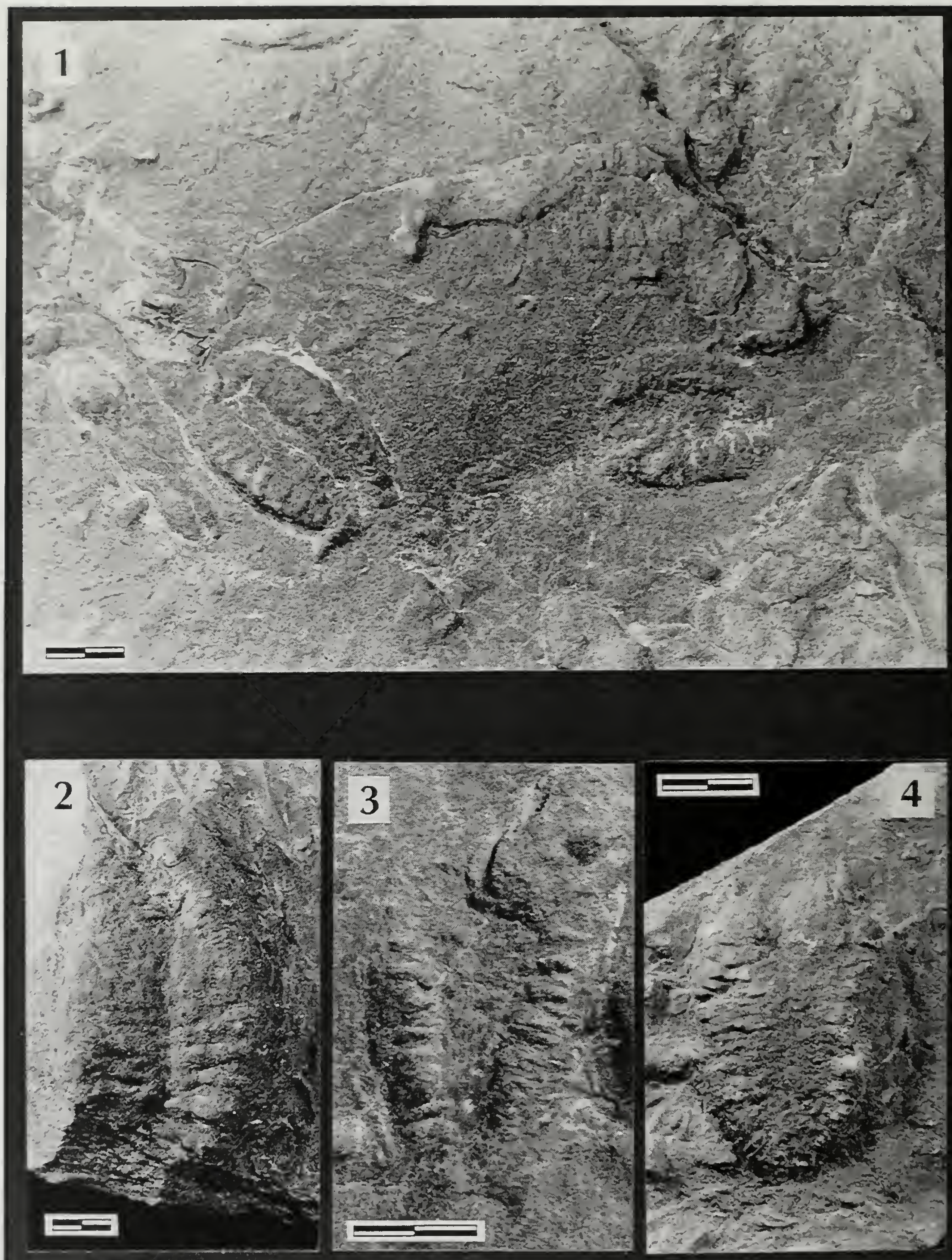

PLATE 12, FIGS. 1–4 (complete scale bars = 1 cm).
Rusophycus osgoodii n. isp.
1. Paratypes, convex hyporelief, ROM 49883.
2. Paratype, convex hyporelief, ROM 49885.
3. Holotype, convex hyporelief, ROM 49882.
4. Paratype, convex hyporelief, ROM 49884.

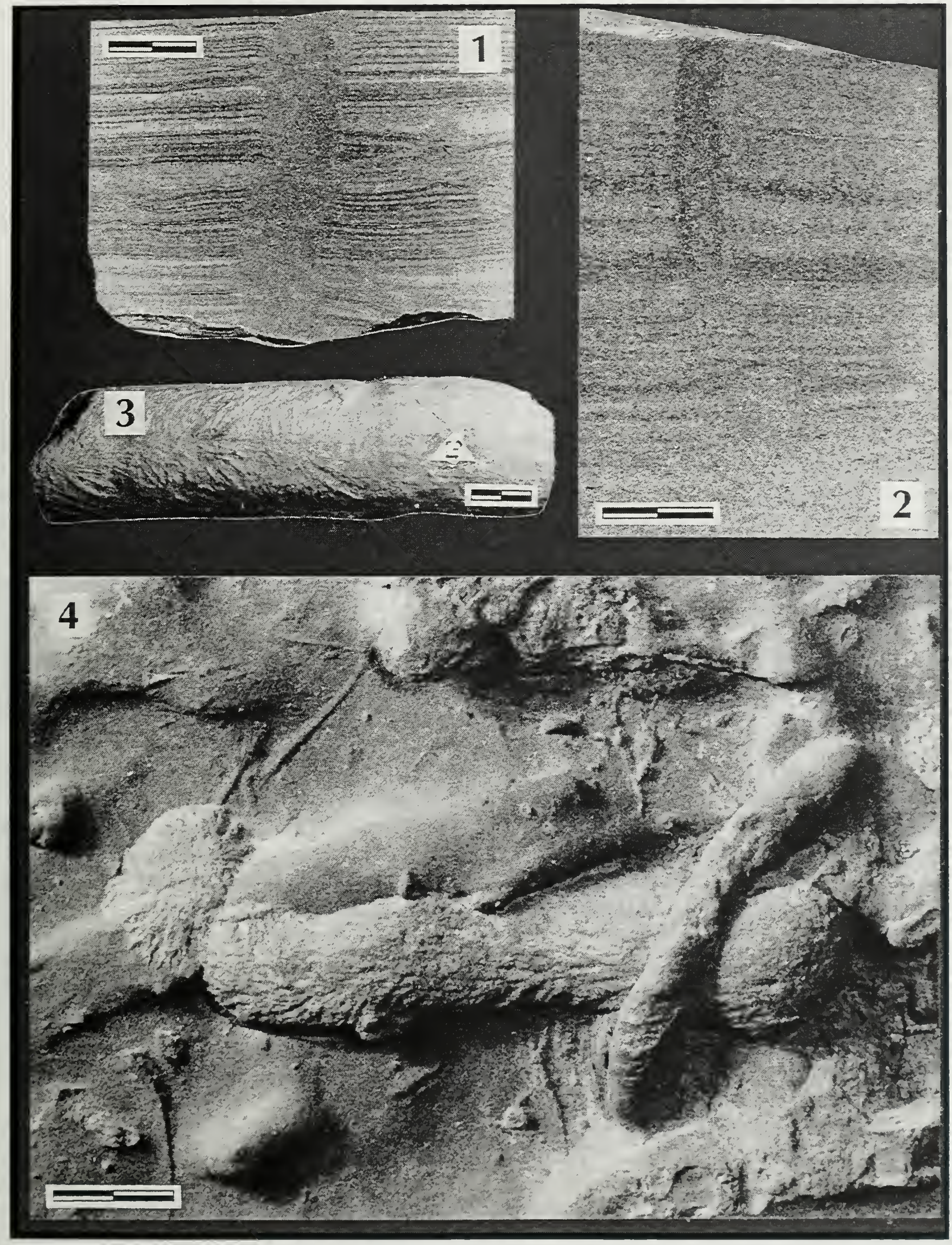

PLATE 13, FIGS. 1–4 (complete scale bars = 1 cm).
1. *Skolithos magnus* Howell, endorelief, ROM 50087.
2. *Skolithos verticalis* (Hall), endorelief, ROM 50088.
3. *Trichophycus venosus* Miller, full relief, ROM 17492.
4. *Trichophycus lanosus* Miller and Dyer, convex hyporelief, ROM 50089.

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