New occurrence of *Phycodes templus* Han and Pickerill, 1994 with a taxonomic reassessment of *Yangziichnus yichangensis* Yang, 1984

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The ichnospecies *Phycodes templus* Han and Pickerill, 1994, previously only reported from the Lower Devonian Wapske Formation (Tobique Group) of New Brunswick, is described from the Lower Devonian Chapman Sandstone (Dockendorff Group) of northeastern Maine. This recording extends the environmental range of the ichnospecies from deep-water basinal turbiditic strata of the Wapske Formation to storm-dominated shelf deposits of the Chapman Sandstone. Morphologically, *Phycodes templus* closely resembles the ichnotaxon *Yangziichnus yichangensis* Yang, 1984. Herein we recommend abandonment of the ichnogenus *Yangziichnus* and suggest assignment to *Phycodes*, namely *Phycodes yichangensis* comb. nov.

L'ichnoespèce *Phycodes templus* de Han et Pickerill, 1994, antérieurement seulement signalée à partir de la formation du Dévonien inférieur Wapske (groupe de Tobique) au Nouveau-Brunswick, a été repérée dans le secteur du Dévonien inférieur de Chapman Sandstone (groupe de Dockendorff) dans le nord-est du Maine. Ce relevé étend le territoire environnemental des ichnoespèces des strates turbiditiques de bassins marins profonds de la formation Wapske aux dépôts de la plate-forme dominée par les tempêtes du secteur de Chapman Sandstone. D'un point de vue morphologique, le *Phycodes templus* ressemble beaucoup à l'ichnotaxon *Yangziichnus yichangensis* de Yang, 1984. Nous recommandons par les présentes l'abandon de l'ichnogenre *Yangziichnus* et nous proposons sa classification parmi les *Phycodes*, notamment à titre de nouvelle combinaison *Phycodes yichangensis*.
[Traduit par la rédaction]

INTRODUCTION

The ichnogenus *Phycodes* Richter, 1850 is characterized by essentially horizontal, bundled structures of typically flabellate or broomlike burrows that are developed from a single or a few initial (or proximal) tunnels. As reviewed in Han and Pickerill (1994a), existing ichnospecies of *Phycodes* are distinguished essentially on the nature, style, disposition and degree of burrowing from the initial structures. Han and Pickerill (1994a) formulated the new ichnospecies *Phycodes templus* for *Phycodes* possessing two or, more typically, several horizontal interconnected broomlike or flabellate bundles that collectively form an inverted pagoda-like structure. Their material was collected from the Lower Devonian Wapske Formation of the Tobique Group of northwestern New Brunswick, eastern Canada, an essentially deep-water, marine, siliciclastic turbiditic sequence interbedded with decreased proportions of volcanic strata (see also Han and Pickerill, 1994b and references therein). Herein we report a recently discovered occurrence of *P. templus* from the Lower Devonian Chapman Sandstone (Dockendorff Group) of northeastern Maine, U.S.A. This recording suggests that the behavioural activity represented by the producer(s) of *P. templus* is environmentally perhaps more widespread than previously recognized and is certainly not restricted to deep-water marine environments. Furthermore, documentation of this new occurrence of *P. templus* affords us the opportunity to assess taxonomically the morphologically similar ichnotaxon *Yangziichnus yichangensis* Yang, 1984.

LOCATION AND GEOLOGICAL BACKGROUND

The Dockendorff Group of Boucot *et al.* (1964) crops out to the west and southwest of Presque Isle, northeastern Maine (Fig. 1), and occupies a large, southward plunging elliptical trough known as the Chapman Syncline (Pavlides *et al.*, 1964). The group comprises a sequence of volcanic and sedimentary strata, estimated by Roy (1980) as 3600 m in thickness, and is subdivided into four units, in ascending stratigraphic order, the Hedgehog and Swanback formations, the Chapman Sandstone and the Edmunds Hill Andesite (Fig. 1). These strata are Lochkovian - Pragian (early Devonian) in age (Boucot *et al.*, 1964), mostly Lochkovian (Roy and White, 1987).

Phycodes templus, as described herein, was collected from a small and progressively overgrowing quarry site located in the Chapman Sandstone approximately 5 km south-southwest of Presque Isle (Fig. 1). The Chapman Sandstone comprises a sequence of fine- to medium-grained, argillaceous sandstones, up to over 1 m in thickness, but commonly less, and micaceous mudstone interbeds that are intensely bioturbated and typically very fossiliferous (Boucot *et al.*, 1964). Though to date no detailed sedimentological studies on the Chapman Sandstone have been undertaken, based on three considerations, we interpret the sequence to have been deposited in a shallow-water marine environment. First, many of the sandstone layers exhibit internal bedforms indicative of deposition as event beds and exhibit wave rippled upper surfaces. The nature and sequence of internal struc-

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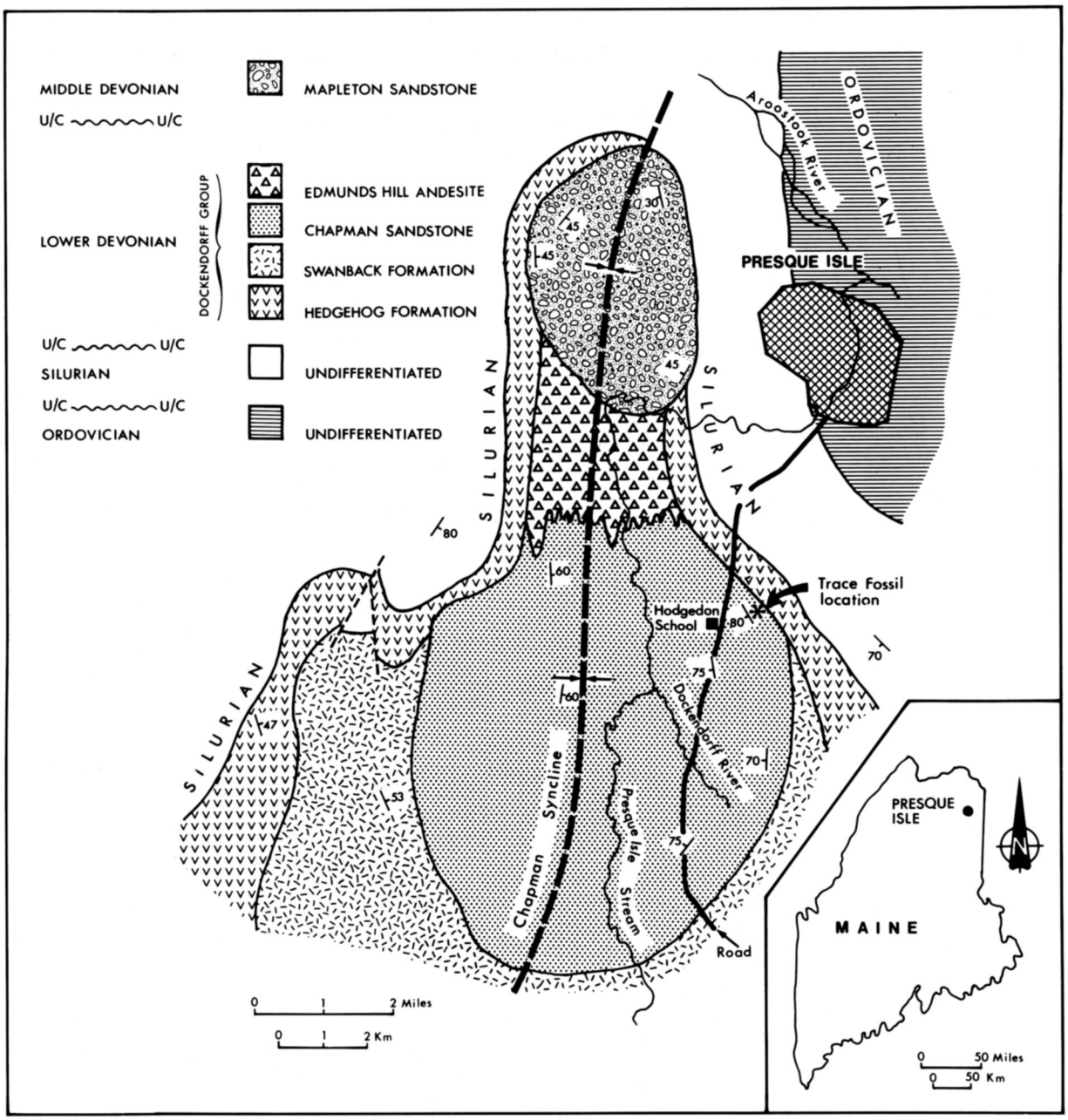

Fig. 1. Simplified geological map of the area to the west and southwest of Presque Isle, northeastern Maine (after Boucot *et al.*, 1964). For simplicity most faults are omitted.

tures in many of these sandstones compare favourably to previously described examples in which storm influence is regarded as an important, or an even dominant, factor in their formation (e.g., see review in Brenchley, 1985). Second, the abundant and essentially parautochthonous faunal assemblages, dominated by brachiopods and bivalves (Williams and Breger, 1916; Boucot *et al.*, 1964), are equivalent to benthic assemblages 2 and 3 of Boucot (1975), for which recent estimates would suggest water depths of 15 to 40 m (Brett *et al.*, 1993). Third, the Chapman Sandstone contains abundant ichnogenera that collectively are indicative of the shallow-marine *Cruziana* ichnofacies of Seilacher (1967). In addition to *Phycodes*, these include *Arenicolites, Arthraria, ?Bergaueria, Chondrites, Cochlichnus, Cosmorhaphe, Cruziana, Cylindrichnus, Didymaulichnus, Elingua, ?Gordia, Helminthoida, Helminthopsis, Lobichnus, Megagrapton, Monocraterion, Monomorphichnus, Palaeophycus, Planolites, Rosselia, Rusophycus, Scolicia, Skolithos, Teichichnus* and *?Trichichnus*, to be documented in more detail at some future date.

SYSTEMATIC PALICHNOLOGY

Ichnogenus *Phycodes* Richter, 1850

Type ichnospecies: *Phycodes circinatus* Richter, 1853, p. 30, by subsequent monotypy.

Diagnosis: Horizontal, bundled burrows preserved outwardly as convex hyporeliefs. Overall pattern reniform, fasciculate, flabellate, broomlike, 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; Fillion and Pickerill, 1990).

***Phycodes templus* Han and Pickerill, 1994**
Figure 2

Diagnosis: *Phycodes* possessing two or, more typically, several horizontally interconnected broomlike or flabellate bundles that collectively form an inverted pagoda-like structure (after Han and Pickerill, 1994a).

Material: One specimen preserved in convex hyporelief on the sole of a 35 mm thick, grey-green sandstone slab. Associated ichnotaxa include *Palaeophycus striatus* Hall and *Monomorphichnus*. The slab is deposited in the Division of Natural Sciences, New Brunswick Museum, Saint John, New Brunswick, with repository number NBMG 9812.

Description: The specimen comprises a broadly arcuate burrow system, approximately 14 cm in overall length. A smooth central tunnel, approximately 5 to 6 mm in diameter, periodically branches into discrete, fan-shaped sets; 4 such sets are easily distinguishable and individual sets comprise a minimum of 2, but typically more, tightly overlapping lateral tunnels that diverge from a common locus. Individual lateral tunnels within a set are straight or slightly curved, with lengths of up to approximately 20 mm and widths of 3 to 4 mm. Individual sets may be developed either dextrally or sinistrally with respect to the central tunnel. Burrow fill is slightly finer in grain size than the enclosing host rock and apparently internally structureless; burrow wall is accentuated by an extremely thin (<0.2 mm) mudstone lining.

Remarks: Han and Pickerill (1994a) have recently provided an extensive review of the various ichnospecies of *Phycodes* and the criteria utilized in their distinction. Despite its broadly arcuate form, a characteristic not previously observed for

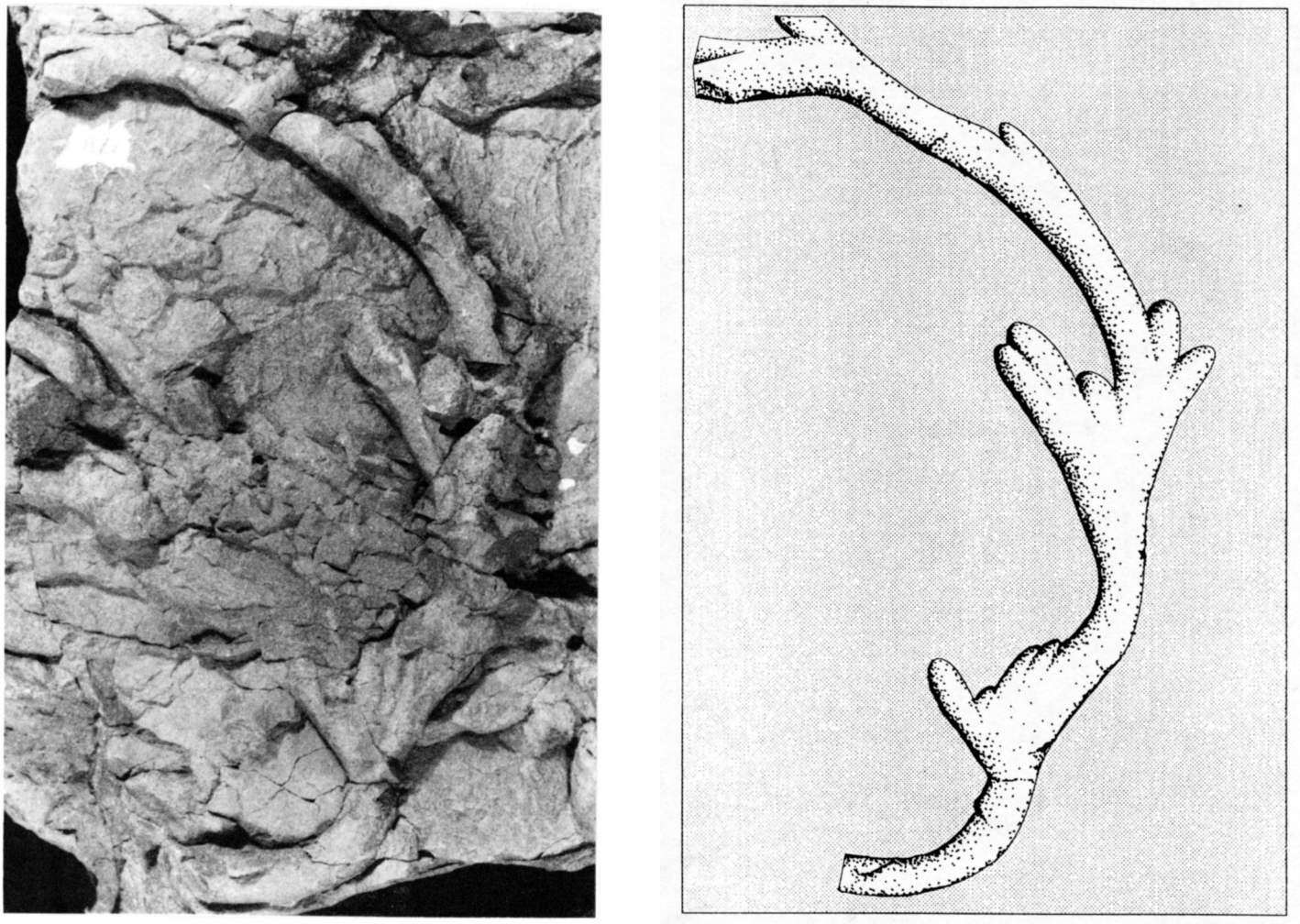

Fig. 2. Photograph and schematic representation of *Phycodes templus* Han and Pickerill, 1994 from the Chapman Sandstone (Dockendorff Group) of northeastern Maine; NBMG 9812; x 1.3.

the ichnospecies, the specimen described herein clearly illustrates the horizontally interconnected broomlike or flabellate burrow bundles that typify *P. templus*. As such we regard it as conspecific.

DISCUSSION AND CONCLUSIONS

This new recording of *P. templus* has two important consequences. First, it represents only the second recording of the ichnotaxon, the only previous examples being documented by Han and Pickerill (1994a, b). Second, it extends the environmental range of its producing organism(s) from deep-water marine to shallow subtidal marine.

As noted by Pemberton and Frey (1982), in ichnology there are large numbers of monospecific ichnogenera, usually a result of highly specialized behaviour of the producing organism(s) or of genetically isolated behavioural patterns. Yet most of these ichnogenera result not from uniqueness of behaviour, but rather from indiscriminate mixing of ichnogeneric and ichnospecific ichnotaxobases or, in the terminology of Fürsich (1974), 'significant' and 'accessory' ichnotaxobases. As recently discussed by Pickerill (1994), the adoption of different taxonomic philosophies by the same or different authors has resulted in intense taxonomic splitting, lumping, or even both. With respect to the ichnogenus *Phycodes*, we regard the most fundamental or significant behavioural pattern to be the presence of one or a few primary unbranched tunnels that distally give rise to variably shaped or developed secondary branched burrow systems. As discussed by Han and Pickerill (1994a), it is the style and disposition of these subsequent branches that enables differentiation of individual ichnospecies. Although in *Phycodes* taxonomic splitting has resulted in the formulation of what we consider at least a dozen valid ichnospecies (see Han and Pickerill, 1994a), the nomenclatural scheme appears reasonable and with careful analysis individual ichnospecies can be adequately differentiated.

Following publication of Han and Pickerill (1994a) we became aware of a paper by Yang (1984) on the systematic ichnology of shallow marine Silurian strata of the Yangtze Gorges, China. In this publication Yang formulated a new ichnogenus, *Yangziichnus*, with type ichnospecies *Y. yichangensis*. His diagnosis was, in part, as follows:-

> "The burrow system, a large spiral curved form parallel to bedding, comprises a series of continuous, zigzag-arranged, spindle-shaped burrows that collectively form a herringbone. Subsequently formed herringbone sets develop from the inside of previous sets in order to retain a spirally developed course." (Yang, 1984, p. 708, *trans. litt., partim*).

A reproduction of the holotype of *Y. yichangensis* is herein included as Figure 3. Irrespective of its spiral development, the fundamental or significant behavioural trait exhibited by the specimen is the successive development distally of

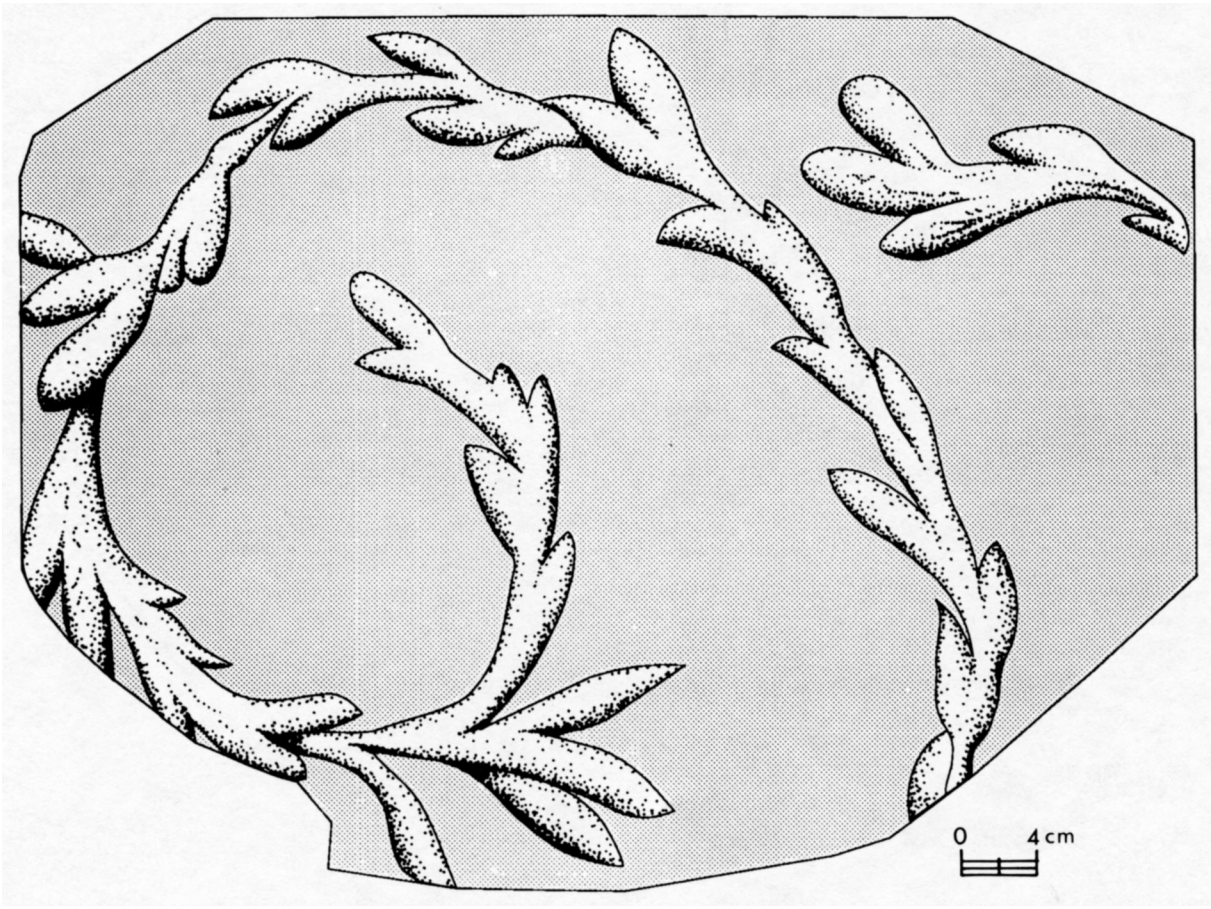

Fig. 3. Holotype of *Yangziichnus yichangensis* Yang, 1984, herein designated as *Phycodes yichangensis* (Yang).

secondary branches, a behavioural pattern present in all ichnospecies of *Phycodes*. We therefore believe that this material should more correctly be assigned to *Phycodes*; nevertheless, we also accept that the nature of the development of the secondary branches is sufficiently different from existing ichnospecies that the ichnospecific epithet warrants retention. Therefore, from henceforth, we suggest the material be regarded as *Phycodes yichangensis* comb. nov. Morphologically, *P. yichangensis* most closely resembles *P. templus* as described herein, and previously by Han and Pickerill (1994a). Nevertheless, there are sufficient differences to warrant separation of the two ichnospecies. First, in *P. templus* individual burrow sets are obviously more bundled, but not as systematically developed as in *P. yichangensis*. Second, because of its spiral course, successive branching of individual sets in *P. yichangensis* is always in a sinistral manner, whereas in *P. templus* successive sets may develop sinistrally and, or, dextrally. Third, all known examples of *P. templus* possess a thin mudstone lining, whereas Yang (1984) emphasized in his descriptions of *P. yichangensis* that the material was unlined. Collectively, these criteria should easily enable differentiation of these two morphologically similar, at least superficially, ichnotaxa.

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