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Brief report

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A new tubeworm of possible serpulid affinity from the Permian of Sicily

ROSSANA SANFILIPPO, AGATINO REITANO, GIANNI INSACCO, and ANTONIETTA ROSSO

A new tubeworm, *Palaeotubus sosiensis* gen. et sp. nov., is described from the Permian Pietra di Salomone limestone (Sosio Valley, W Sicily). The new species is characterized by a thick tube ornamented with slightly flared peristomes and numerous longitudinal keels. The internal structure of the tube was obliterated during diagenesis, which prevents the tube unequivocal systematic attribution. Nevertheless, all preserved morphological characters strongly suggest that the new tube belongs to serpulids. When confirmed by further findings, the positive attribution of this new species to serpulids will imply that it represents the ancestor of the Serpulidae, and the earliest evidence of calcareous tubeworm polychaetes from the Palaeozoic.

Introduction

Calcareous tubeworms are common fossils throughout the Phanerozoic, but their systematics were addressed in detail only recently, when studies of the skeletal microstructure allowed to discern tentaculitids, cornulitids, trypanoporids, and other fossil tubeworms like spirorbids and serpulids (Vinn and Mutvei 2009). Serpulids (i.e., Serpulidae) are common and widely distributed in the fossil record, with about 46 genera and 350 species (ten Hove and Kupriyanova 2009) and are quite abundant in the modern seas, where they are widespread, also colonizing extreme environments (e.g., Di Geronimo et al. 1997; Kupriyanova et al. 2009, 2010, 2014; Sanfilippo 2009; Rosso et al. 2010, 2013; Sanfilippo et al. 2013, 2015; Vinn et al. 2013). The group is still virtually unknown from the Palaeozoic and the earliest records, related to the small *Filograna*-like forms, date back to the Middle Triassic (ca. 244 Ma) (see Ippolitov et al. 2014). Paleozoic records of presumed serpulids (e.g., Sandberger and Sandberger 1856; Dalvé 1948; Clausen and Álvaro 2002; Ziegler 2006) consist of erroneous interpretations of tube-like organism remains. Seemingly to all Palaeozoic spirorbids, later attributed to microconchids (Weedon 1994; Taylor and Vinn 2006), these problematic fossils, commonly reported as "*Serpula*" in early papers, proved to be trypanoporids, cornulitids, tentaculits, or hederelloids when their tube microstructures have been carefully analyzed (see Weedon 1991; Vinn and Taylor 2007; Taylor and Wilson 2008; Vinn 2013).

A new tubeworm, *Palaeotubus sosiensis* gen. et sp. nov., found in the Permian Pietra di Salomone limestone (western Sicily), is here described. This new species is certainly attributable to a calcareous tubeworm, strongly recalling a serpulid for its morphology. Unfortunately, the tube inner microstructure is not preserved owing to diagenetic recrystallisation. This lack of information coupled with the scarcity of presently available material, consisting of a single incomplete specimen, prevented an unequivocal taxonomic attribution. The new tubeworm has been cautiously considered as *incertae sedis* but its alleged affinities to serpulids have been highlighted.

Institutional abbreviations.—MSNC, Palaeontological Collections, Museo Civico di Storia Naturale di Comiso, Ragusa, Italy.

Material and methods

The single specimen examined in the present paper comes from the Pietra di Salomone, one of the fossiliferous megablocks cropping out near Palazzo Adriano in the Sicani Mountains, western Sicily (Fig. 1A, B). These Permian limestone megablocks are included in debris flow and turbidite sediments deposited in a base-of-slope setting (Fig. 1C, D). Flügel et al. (1991) considered these blocks as mainly Wordian (Murghabian) in age. However, some reef-derived pebbles within them, are possibly Capitanian (Midian) or even Wuchiapingian (Dzhulfian) in age. The same age, and probably even a Changhsingian (Dorashamian) age, was suggested by Jenny-Deshusses et al. (2000) for the Pietra di Salomone megablock. Therefore, the studied specimen might be of Wordian to latest Permian age. Further information about geological setting and age is given in Flügel et al. (1991).

The "Sosio Limestone" is world-wide famous for its well preserved and very rich invertebrate fauna. Overall, more than 520 species have been described from the Sosio Limestone and more than 300 species from the Pietra di Salomone megablock (Fig. 2). This fauna comprises foraminifera, sponges, corals, bryozoans, brachiopods, gastropods, bivalves, ammonoid and nautiloid cephalopods, trilobites, ostracodes, and other crustaceans, as well as crinoids, blastoids, and fossils of uncertain taxonomic assignment (see Flügel et al. 1991; Jenny-Deshusses et al. 2000; Ernst 2000; Jones et al. 2015, and references therein). The specimen described herein was found in the white crinoid-rich limestone from the upper part of the Pietra di Salomone, by one of us (AR) in October 2014, during field works lead by the MSNC, within the Riserva Naturale Orientata Monti di Palazzo Adriano e Valle del Sosio. Associated faunas include the crinoids *Palermocrinus jaekeli* Gislen, 1924 and *Heterobrachiocrinus fabianii* Yakovlev, 1938, the gastropods *Bellerophon sosiensis* Gemmellaro, 1889 and

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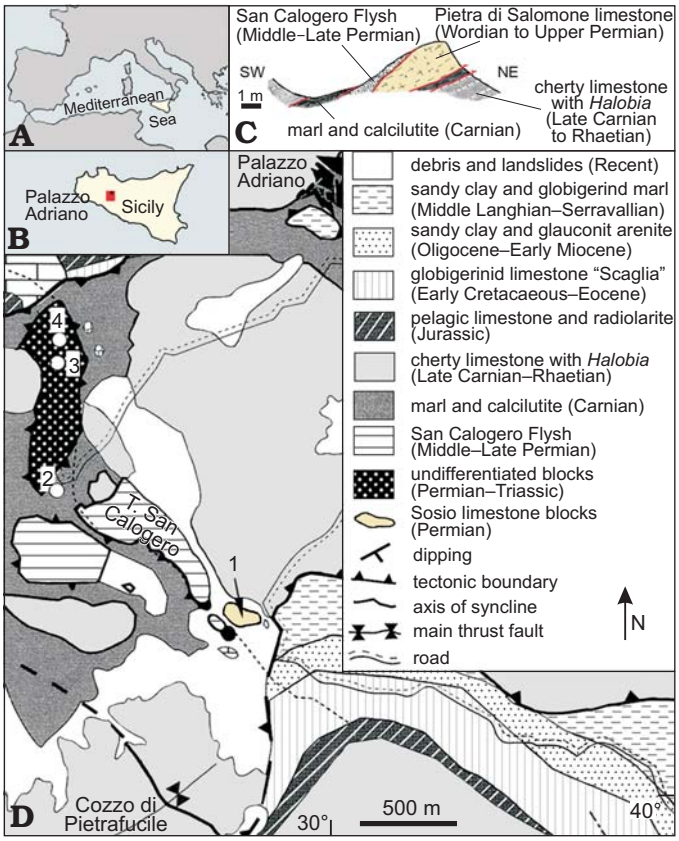


Fig. 1. Location of the study area in Mediterranean (**A**) and Sicily (**B**). Section across the Torrente San Calogero and the Pietra di Salomone block (**C**), modified from Flügel et al. 1984. Geological map of the Palazzo Adriano area (**D**), showing the location of the Pietra di Salomone block (modified from Di Stefano and Gullo 1997). 1, Pietra di Salomone limestone; 2, Rupe di Passo di Burro; 3, Petra dei Saracini; 4, Rupe di San Calogero.

Plocostoma piazzii (Gemmellaro, 1889), and the brachiopods *Coscinaria communis* (Gemmellaro, 1894) and *Martinia* sp.

The specimen was separated mechanically from the slightly cemented calcilutite containing cm-sized fossils and accurately cleaned to examine the whole external surface. Low magnification photos were acquired with a Zeiss Discovery V8A stereomicroscope equipped with an Axiovision acquisition system, in order to document general tube morphology. The specimen was also examined uncoated under a LMU Tescan Vega Scanning Electron Microscope in Low Vacuum modality, to investigate its micromorphology.

Systematic palaeontology

Class Polychaeta Grube, 1850

Family incertae sedis

Genus *Palaeotubus* nov.

Etymology: From Latin *palaeo*, ancient and *tubus*, tube; referring to the ancient age of the tubular fossil.

Type species: *Palaeotubus sosiensis* gen. et sp. nov., monotypic; see below.

Diagnosis.—The same as for the monotypic type species.

Palaeotubus sosiensis sp. nov.

Figs. 3, 4.

Etymology: Named after the type locality, in the Sosio Valley area.

Holotype: A unique incomplete unattached tube (MSNC 4499) broken at both ends.

Type locality: Sosio Valley, western Sicily (Italy).

Type horizon: Pietra di Salomone limestone, Wordian to Upper Permian.

Diagnosis.—Tube free, relatively thick and solid, circular in cross-section. Longitudinal keels smooth. Peristomes circular and slightly flared.

Description.—The holotype is 17 mm long and slightly bending, due to a change in growth direction in correspondence of a feeble peristome. The specimen consists of a tube fragment rather massive and solid, not increasing in diameter, circular in cross-section, 3.8 mm in diameter at its distal end (Fig. 3A, B). Lumen 2.7 mm wide (Figs. 3C, 4D). Sculpture consisting of 12 continuous, straight, robust, and smooth longitudinal keels, in equal distances of about 900 μm from each other (Fig. 4B, C). Two low prominent transverse rings representing peristomes, one of which slightly flared indicating the growth direction and the pristine position of the tube opening (Figs. 3A, B, 4A, B). A change in growth direction is evident in correspondence of a slight peristome, increasing the bent aspect of the tube (Fig. 3A, B). Feeble transverse growth lines revealed by careful observation, best visible in the interspaces between keels. They are ca. 0.2 mm spaced, their faint concavity facing distally (Fig. 4B, C). Tube outline regularly undulated in cross section, for the alternation of shallow rounded depressions and angular peaks, these latter corresponding to the transverse keels' profiles (Fig. 4D, E). Tube wall ca. 0.5 mm thick, the structure presumably obliterated by diagenetic recrystallisation, but with an inner part formed by prevailing small and relatively loose crystals (Fig. 4F), grading to an outer part mostly with larger and more densely patched crystals (Fig. 4G).

Remarks.—The studied tube of *P. sosiensis* gen. et sp. nov. only superficially resembles those of other common Palaeozoic organisms with the only character in common being the tubular calcareous skeleton. Among these fossils are the sabellid *Glomerula* Nielsen, 1931 and other tubeworms such as tentaculitids, cornulitids, and trypanoporids in the past affiliated with annelids and more recently transferred to lophophorates (see Vinn and Mutvei 2009).

In the absence of the internal structure and initial cemented tube portion, comparisons will be attempted exclusively on the basis of morphological characters of the erect part. Tubes of *Glomerula* differ from the studied one in lacking longitudinal keels, and in having irregular wall thickness and lumen diameter (see Vinn et al. 2008a). Further differences are the typical glomerate coiling and the minute size of the tube showed by the older (i.e., Palaeozoic) representatives of *Glomerula* (Nielsen 1931; Ippolitov et al. 2014).

Some tentaculitids, cornulitids, and trypanoporids tubular shells, only roughly similar to *P. sosiensis* gen. et sp. nov. in their general morphologies, sizes and in having growth lines,

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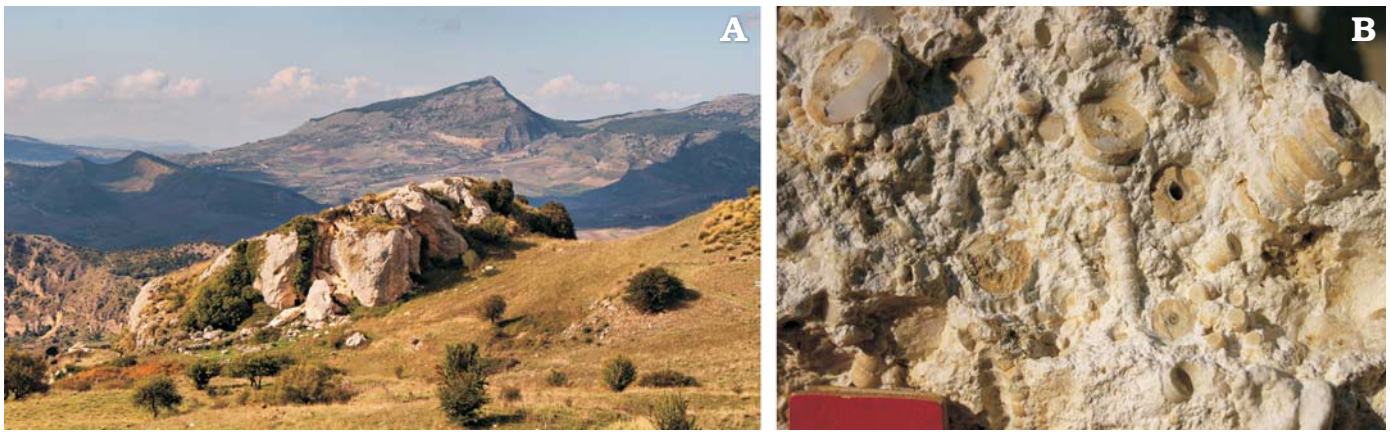


Fig. 2. **A**. The general appearance of the Pietra di Salomone megablock viewed from the East. **B**. Detail of the rock at mesoscale. Scale bar 30 mm.

differ from it in having: (i) smooth or ornamented surfaces with mostly transverse features, such as annulations or ribs, (ii) internal septa, and (iii) pseudopunctae and microscopic pores in the tube wall.

In contrast, the skeleton of *P. sosiensis* gen. et sp. nov. shows the greatest morphologic affinities with tubes constructed by polychaete serpulids. Characters supporting an attribution to serpulids are: (i) the tube size, consistent with that of medium-to-large sized serpulids, (ii) the ornamentation, including longitudinal keels and peristomes, which are diagnostic in the serpulids palaeontological systematics, and (iii) the micromorphology of the outer surface of the tube, made up of growth lines that fit well with those known for serpulids. These characters, and in particular the tube size and its ornamentation, have been considered as important features for the identification of fossil serpulid genera (e.g., Ippolitov et al. 2014).

Based on these morphological characters, differences/affinities with some particularly similar serpulid genera are discussed. A few serpulid genera share characters observed on *P. sosiensis* gen. et sp. nov. although not contemporaneously co-occurring. Tubes circular in cross-section and bearing longitudinal keels are present in *Serpula* Linnaeus, 1758, *Vermiliopsis* Saint-Joseph, 1894, *Semivermilia* ten Hove, 1975, *Metavermilia* Bush, 1905, and *Pyrgopolon* de Montfort, 1808. In particular, the genus *Serpula* has some species with tubes reaching 5 mm in diameter but showing no more than 5–7 longitudinal keels (Zibrowius 1968; ten Hove and Kuprianova 2009; Sanfilippo et al. 2013). Tubes of *Pyrgopolon* and *Vermiliopsis* have a comparable thickness, but differ from the described specimen as they rapidly increase in diameter and show a maximum of 7–9 keels (Jäger 2005, 2011; ten Hove and Kupriyanova 2009), except for a single Recent species of *Pyrgopolon* which has up to 12 longitudinal ridges (ten Hove 1973). Superficially similar tubes with circular keeled distal ends can be present in the genus *Semivermilia*, as in the case of *S. crenata* (Costa, 1861). However, tubes are sensibly smaller and thinner than that of *P. sosiensis* gen. et sp. nov., with a maximum of 7 longitudinal keels (Zibrowius 1968; Bianchi 1981). Some species of the genus *Metavermilia* are similar to *P. sosiensis* gen. et sp. nov. for size, wall thickness and number of longitudinal keels. In particular, the Pleistocene to Recent *M. multicristata* (Philippi, 1844), has 5–7 keels distributed all around the tube end, although they are thinner and denticulate (Zibrowius 1971; D'Onghia et al. 2015). Thus, the number of longitudinal keels appears as one of the most relevant features in *P. sosiensis* gen. et sp. nov., as the great majority of Recent and fossil serpulid species possesses no more than 7 keels.

Besides general morphology and ornamentation, the inner structure of the tube wall recently revealed to be of diagnostic importance for the assignment of tubeworms to taxonomic groups (e.g., Weedon 1991; Vinn and Taylor 2007; Taylor and Wilson 2008; Vinn and Mutvei 2009; Vinn et al. 2008a–c; Vinn 2013). Nevertheless, as the inner structure is not well preserved in the studied tube, and its appearance only weakly points to a probable serpulid-like two-layer organization, the

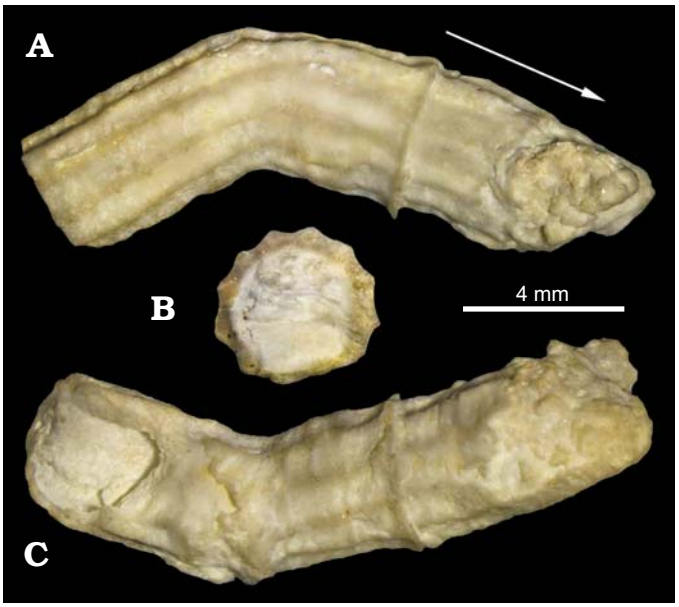


Fig. 3. The alleged serpulid *Palaeotubus sosiensis* gen. et sp. nov., holotype (MSNC 4499) from Pietra di Salomone limestone, Palazzo Adriano (Sicani Mountains, W Sicily); Wordian to upper Permian. The specimen was accurately cleaned from the rock but the white limestone is still visible infilling the tube lumen. Two opposite side views (**A**, **C**), growth direction arrowed, cross section (**B**).

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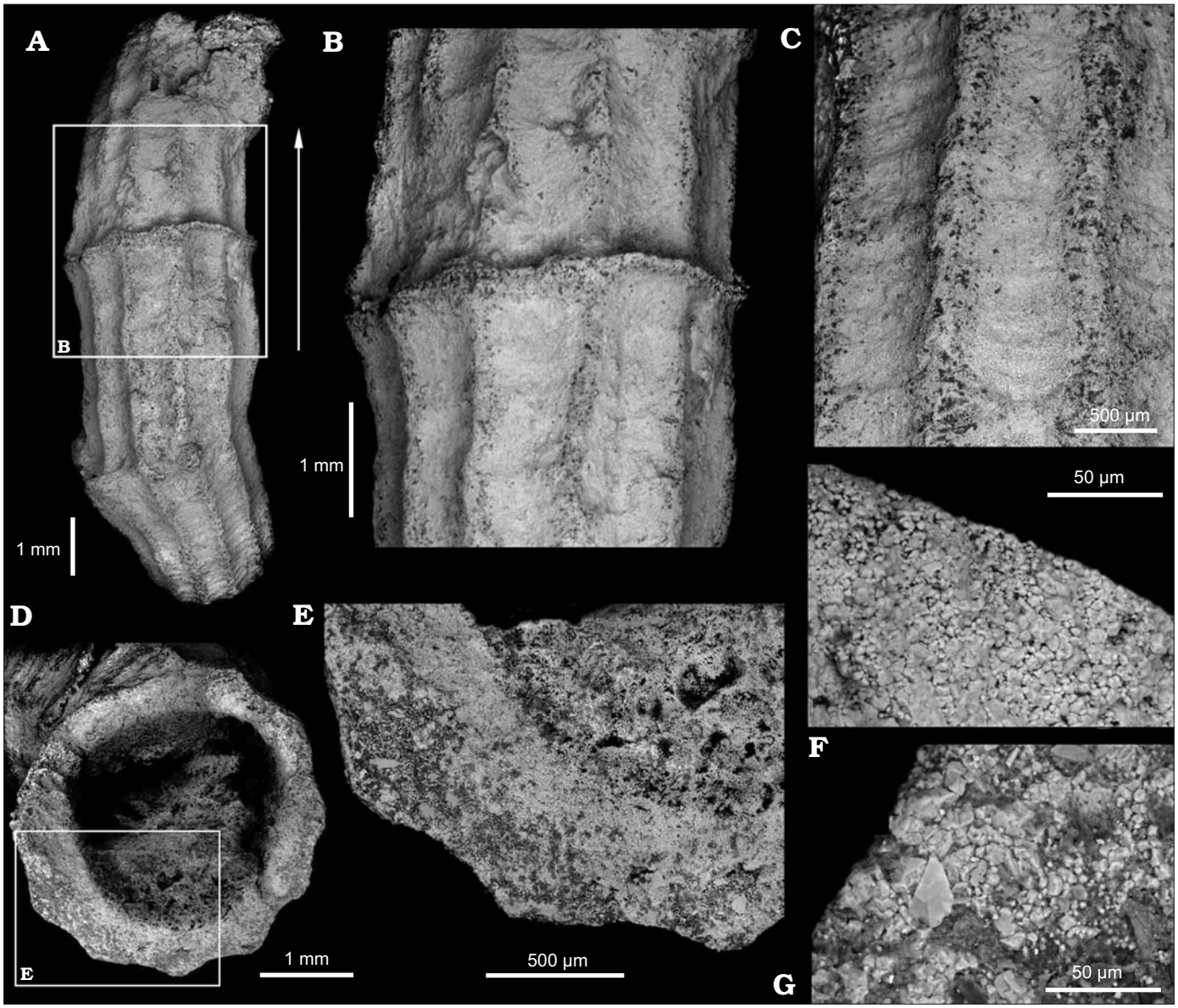


Fig. 4. SEM images of the alleged serpulid *Palaeotubus sosiensis* gen. et sp. nov., holotype (MSNC 4499) from Pietra di Salomone limestone, Palazzo Adriano (Sicani Mountains, W Sicily); Wordian to upper Permian. **A**. General view showing the entirely keeled tube (arrowed the growth direction, inferred from the slightly flaring peristomes). **B**. Close up of a peristome and longitudinal keels. **C**. Detail of keels and growth lines. **D**. Cross section of the tube. **E**. Tube wall. **F**. Detail of the tube wall showing prevalently small and loosely patched crystals on its inner part. **G**. Detail of the tube wall showing prevalently large and densely patched crystals on its outer part.

attribution of *P. sosiensis* gen. et sp. nov. to one of these systematic groups can neither be excluded nor substantiated.

It is similarly impossible to use a further unequivocal diagnostic character to discriminate between Palaeozoic tube-dwelling lophophorates, which share initial portions with small, sometimes spherical, embryonic shell chambers (e.g., Vinn and Mutvei 2009; Vinn and Zatoń 2012), from serpulids which show initial portions consisting of opened tiny tubes (e.g., Sanfilippo 1998: pl. 2: 2). Thus, the lack of both characters prevents the nature of the studied tube to be ascertained reliably.

Paleotubus sosiensis gen. et sp. nov. presumably thrived in a shallow-marine environment, corresponding to the outer edge of a carbonate platform. The robust and massive tube of the new species would represent an adaptive response to exposed and waved shallow-reef environment.

Stratigraphic and palaeogeographic range.—Type locality and horizon only.

Concluding remarks

Serpulids are polychaetes confidently documented since the Middle Triassic (Vinn et al. 2008a, c; Ippolitov et al. 2014) with characteristic very simple forms from China (Stiller 2000). In contrast, records of Palaeozoic tubeworms formerly sometimes considered as belonging/related to serpulids, are now currently attributed to different groups, as is the case of some minute

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typically glomerate coiled tubes, first related to the sabellid genus *Glomerula* (Ippolitov et al. 2014), also on the basis of their inner structure (Vinn et al. 2008a). Moreover, as suggested by Ippolitov et al. (2014), the status of the formally described Palaeozoic species *Serpula testatrix* Etheridge, 1892 is questionable, because its tubes are small and peculiarly coiled as in *Glomerula*. Further Palaeozoic (Permian) records of presumed serpulids are those reported as "*Vermilia*" *obscura* King, 1850 and *Serpula pusilla* Geinitz, 1848. Their old descriptions and figures did not provide morphological details, and Ippolitov et al. (2014: 140) commented that "their potentially serpulid nature was yet to be re-investigated".

In this context, if the serpulid origin for *P. sosiensis* gen. et sp. nov. was confirmed by future findings, it would be the earliest representative within the family. The existence of this species would document an ancestral serpulid characterized by a solid, thick and multi-keeled tube, predating currently known first appearance of serpulids represented by *Filograna*-like forms with small and tiny tubes. In that case the new serpulid would push the origins of the entire group back to the Permian.

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