

New serpulid polychaetes from the Permian of western Sicily

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Two new tubeworms, “*Serpula*” *calannai* sp. nov. and “*Serpula*” *prisca* sp. nov. are described from the Permian limestone of the Sosio Valley, western Sicily. Both species possess large tubes with long free anterior portions circular in cross-section. All morphological characters, such as tube shape and ornamentation, as well as inner structure of the wall, even if barely visible due to diagenesis, are still preserved. These two new species increase the previously known diversity of the Permian serpulid community, which flourished at the shelf edge of the western sector of the Palaeotethys and disappeared thereafter. The likely Wordian age of these serpulids, and their presumed absence in younger rocks up to the Middle–Late Triassic, suggests reduction, or even extinction, of these reef-related serpulid taxa during the end-Guadalupian biotic crisis, before the end-Permian extinction.

Key words: Polychaeta, Serpulidae, tube morphology, reef community, extinction events, Palaeozoic, Permian, Italy.

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Introduction

True serpulids are commonly found in the fossil record and until recently they were considered widely distributed throughout the Mesozoic and Cenozoic, with about 46 genera and 350 species (ten Hove and Kupriyanova 2009; Kočí and Jäger 2015, among others). Small and simple forms dating back to the Middle Triassic, ca. 244 Ma, are the first records of unequivocal serpulids, although a number of problematic tubeworms of presumed serpulid affinity were reported from the Permian on (see Ippolitov et al. 2014). However, unexpected large-sized species with advanced characters, such as complex shape and ornamentation, were recently discovered in a limestone bed dated back to the middle-to-upper Permian, ca. 268–251 Ma (Sanfilippo et al. 2016, 2017b). These findings antedated serpulids’ first appearance even several millions years earlier and indicated that a surprisingly diversified serpulid community existed before the end-Permian mass extinction.

Two further new species unequivocally belonging to the serpulids, namely “*Serpula*” *calannai* sp. nov. and “*Serpula*” *prisca* sp. nov., were found in materials deposited in pa-

leontological museums in Sicily. They originate from the same Permian rocks, specifically the “Pietra di Salomone” Limestone from the Sosio Valley, western Sicily. These new specimens consist of the long unattached anterior parts of large tubes, circular in cross section.

The aims of this study are to: (i) describe these new species; (ii) determine affinities and differences between the new species and the serpulid taxa already known from the same area and time span; (iii) discuss the role played by the serpulid community of the Sosio Limestone within reef palaeoenvironments of the Permian Mediterranean Palaeotethys.

Institutional abbreviations.—PMC, Museo di Paleontologia, University of Catania, Italy; MCSNC, Museo Civico di Storia Naturale di Comiso, Ragusa, Italy.

Material and methods

The two specimens examined in the present paper originate from the “Pietra di Salomone” Limestone (Fig. 1), the larg-

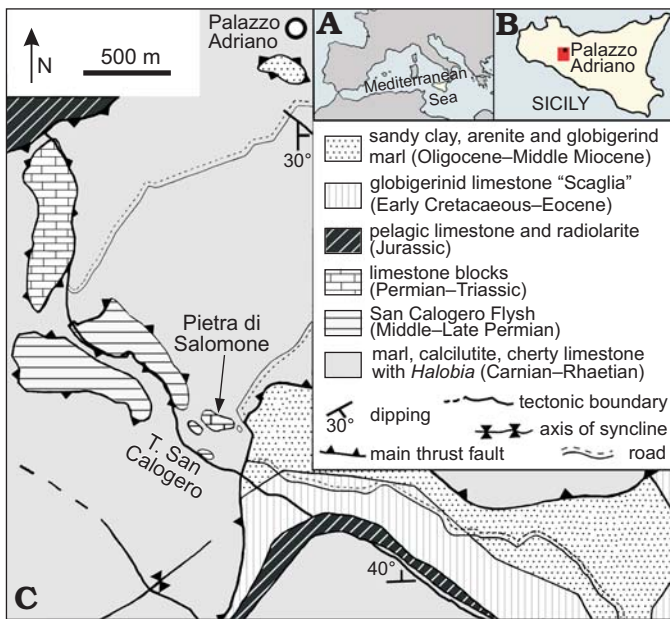


Fig. 1. **A, B.** Location of the study area in the Mediterranean and Sicily. **C.** Geological map of the Palazzo Adriano area (Sicani Mountains) showing the location of the “Pietra di Salomone” megablock (modified from Di Stefano and Gullo 1997).

est fossiliferous megablock (200 m long, 100 m wide and 30 m high) among those cropping out near Palazzo Adriano in the Sicani Mountains, western Sicily (for geological details see Sanfilippo et al. 2017b, and references therein). It consists of a coarse calcareous breccia of which the precise age is still debated, being referred to the Wordian by Flügel et al. (1991), but considered, at least partly, Capitanian, Wuchiapingian or even Changhsingian by Jenny-Deshusses et al. (2000).

The fossiliferous content of these Permian megablocks is famous world-wide for its rich invertebrate fauna, first discovered and described by Gemmellaro (1887–1889). In total, more than 300 species are known from the “Pietra di Salomone” alone, belonging to several taxonomic groups such as sponges, corals, bryozoans, brachiopods, as well as to the recently discovered serpulids (see Flügel et al. 1991; Sanfilippo et al. 2016, 2017b, and references therein). Like previously described serpulids, the two new species were included in the white crinoid-rich limestone from the upper part of the “Pietra di Salomone”. Serpulid tubes were mainly found attached to sponges, while the species described herein are broken off parts of unattached anterior ends found embedded in the carbonate rock.

The fragments belonging to “*Serpula*” *calannai* sp. nov. were separated mechanically from the slightly cemented calcilutite, and glued together to reconstruct a longer, although broken, tube part. The tube was accurately cleaned to examine the whole external surface and broken longitudinally at one end to investigate its microstructure. The tube belonging to “*S.*” *prisca* sp. nov. was cleaned, but not extracted from the enclosing rock, to avoid the separation of tube portions glued together in an old restoration.

Low magnification photos were acquired with a Zeiss Discovery V8A stereomicroscope equipped with an Axio-vision acquisition system in order to document general tube morphology. Both specimens and the detached fragment were also examined uncoated under a LMU Tescan Vega Scanning Electron Microscope in Low Vacuum modality to investigate their micromorphology and microstructure.

“*Serpula*” *calannai* sp. nov. is stored in the Collection Mario Calanna of the MCSNC, while “*S.*” *prisca* sp. nov. is stored in the collections of the PMC.

Systematic palaeontology

Class Polychaeta Grube, 1850

Family Serpulidae Rafinesque, 1815

Genus *Serpula* Linnaeus, 1758

Type species: *Serpula vermicularis* Linnaeus, 1767; Recent of England.

“*Serpula*” *calannai* sp. nov.

Figs. 2, 3A–F.

Etymology: In honor of the paleontology amateur collector the late Mario Calanna (1945–2014), for his contribution to natural history collections, especially in malacology.

Holotype: MSNC 4549-33, one large tube portion (44 mm long and 7.8 mm wide), representing part of an unattached anterior erect portion, broken at both ends and partially filled by lithified sediment.

Type locality: Sosio Valley, western Sicily, Italy.

Type horizon: “Pietra di Salomone” Limestone, Wordian to upper Permian (see Material and methods).

Material.—Type material only.

Diagnosis.—Tube quite large, with a well-developed raised anterior end, circular in cross-section, with outer surface feebly rough. Ornamentations solely consisting of eristomes well developed and slightly flaring. Tube wall thick and layered.

Description.—The single available specimen is a large tube portion of the anterior end, 44 mm long and 7.8 mm wide. It is slightly bent and circular in cross-section, not increasing in diameter. Outer surface is feebly lumpy to smooth, with only irregular and inconspicuous growth lines, which are about 10 µm thick. Peristomes are well developed, differently pronounced and slightly flaring, with smooth, circular edges, locally crenulated. Peristomes are protruding up to 300 µm and irregularly spaced, at intervals of 2–6 mm. Tube wall is about 600 µm thick, with a seemingly layered internal structure, as barely visible along some sections, which cross areas that are not completely altered by recrystallization. Posterior (attached) tube portion is lacking.

Remarks.—The combination of tube characters of “*Serpula*” *calannai* sp. nov. are considered sufficient to describe it as a new species. Particularly, this species clearly differs from the other five serpulids recently mentioned from the same area (Sanfilippo et al. 2016, 2017b) by the relevant size of the tube, which is significantly larger and thicker than those

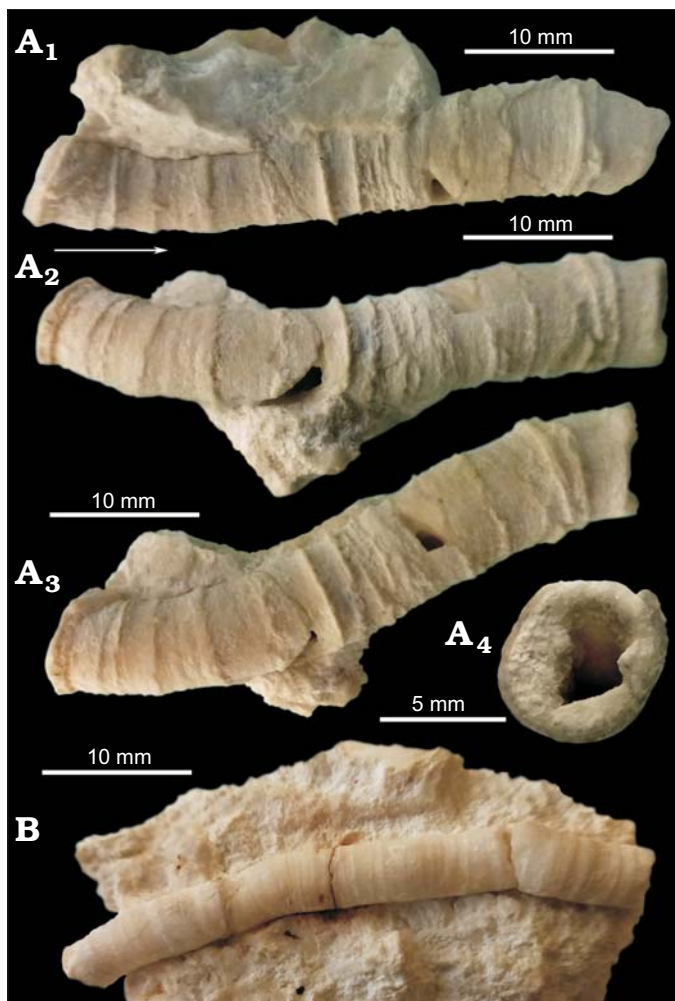


Fig. 2. New serpulid polychaetes from the Wordian to upper Permian, “Pietra di Salomone” Limestone, Sicily, Italy. **A.** “*Serpula*” *calannai* sp. nov. (holotype MSNC 4549-33); general views (A₁–A₃), cross section of tube, white limestone partly filling lumen (A₄). **B.** “*Serpula*” *prisca* sp. nov. (holotype PMC.S5.15.09.2017); general view of anterior end, partially embedded in rock. Arrow indicates growth directions for all tubes.

of these other species, and by the presence of evident peristomes. Obvious differences also exist with species that have erect anterior ends, but show different co-occurring characters: *Palaeotubus sosisensis* Sanfilippo, Reitano, Insacco, and Rosso, 2016, has a tube ornamented by a number of longitudinal keels; *Serpula distefanoi* Sanfilippo, Rosso, Reitano, and Insacco, 2017b, has a tube end with evident growth lines and a rougher outer surface; Serpulidae gen. et. sp. indet. sensu Sanfilippo et al. 2017b, has a very smooth tube, with regular growth lines and only weak annulations but no peristomes. “*S.*” *calannai* sp. nov. only roughly recalls *Propomatoceros permianus* Sanfilippo, Rosso, Reitano, and Insacco, 2017b, of which exclusively its posterior part is known. However, it is not unlikely that, even if this latter species developed an anterior adult part circular in cross section and ornamented with peristomes (as it is in some other serpulid species), it would have retained typical transverse ribs that are lacking in “*S.*” *calannai* sp. nov.

Contrary to the specific attribution, the generic allocation is difficult, owing to the absence of preserved characters of taxonomical importance (e.g., Weedon 1994, Vinn and Mutvei 2009, Vinn et al. 2008) in the available material, because neither the morphology of the attached tube portion nor the pristine structure of the tube wall are fully known. Like some species of the genus *Vermiliopsis* Saint-Joseph, 1894, “*Serpula*” *calannai* sp. nov. possesses distinct peristomes, but its tube does not increase in diameter and lacks the longitudinal keels typical of that genus (Jäger 2005, 2011; ten Hove and Kupriyanova 2009). In contrast, particularly large-sized tubes with circular anterior ends and evident peristomes can be present in *Serpula* (Sanfilippo and Mòllica 2000; ten Hove and Kupriyanova 2009; Sanfilippo et al. 2013). Consequently, we provisionally assign the new species to “*Serpula*”, a genus name often misused to allocate species of the family Serpulidae whose characters are insufficiently known and/or do not allow an unequivocal generic attribution (see Jäger 1993). If further specimens will be found, including attached tube parts with less altered wall structure, it would be possible to support the present attribution more consistently or disregard it.

“*Serpula*” *calannai* sp. nov. resembles the present-day *S. cavernicola* Fassari and Mòllica, 1991, more than the other species in the genus, for its very long erect part with a relevant diameter and comparable, and even major, wall thickness, as well as for the occurrence of peristomes. However, *S. cavernicola* has longitudinal keels. This species also shows a special micromorphology of the outer surface (Sanfilippo and Mòllica 2000: figs. 1, 2), which seems to be different from that of *S. calannai*. In the new species growth lines are obvious and perfectly preserved (Fig. 3E) evidencing that the outer surface is not affected by any process of destructive taphonomic processes (e.g., abrasion, dissolution).

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

“*Serpula*” *prisca* sp. nov.

Figs. 2B, 4A–D.

Etymology: From Latin *priscus*, ancient; referring to both the age of the outcrop where the species was found, and to the primordial position of the species in the serpulid family.

Holotype: PMC.S5.15.09.2017, a fragment, broken at both ends, of a slightly curved free anterior tube portion. The fragment is 43 mm long and 3.9 mm wide, and appears recrystallized.

Type locality: Sosio Valley, western Sicily, Italy.

Type horizon: “Pietra di Salomone” Limestone, Wordian to upper Permian (see Material and methods).

Material.—Type material only.

Diagnosis.—Tube relatively large, with a well-developed raised anterior end. Tube circular in cross-section, outer surface smooth with very thin growth lines and nearly imperceptible longitudinal striations.

Description.—The single specimen consists of a slightly curved tube fragment corresponding to a long anterior tube

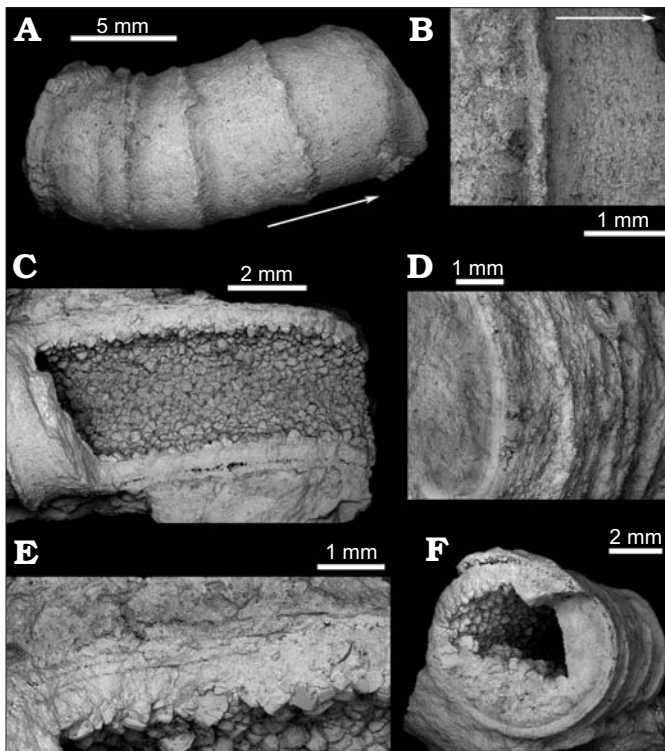


Fig. 3. Serpulid polychaete “*Serpula*” *calannai* sp. nov. (holotype MSNC 4549-33) from the Wordian to upper Permian, “Pietra di Salomone” Limestone, Sicily, Italy. **A**. Tube fragment before assembling. Growth direction, inferred from the slightly flaring peristomes, marked by an arrow. **B**. Detail of a peristome and growth lines. **C**. Longitudinal fracture of tube displaying wall section and inner surface covered by secondary crystals. **D**. Oblique view of tube showing prominence of ornamentations. **E**. Detail of C showing layered structure of tube wall, only locally preserved. **F**. Circular cross section of tube, with relatively thick wall locally showing its likely original layering. All SEM images.

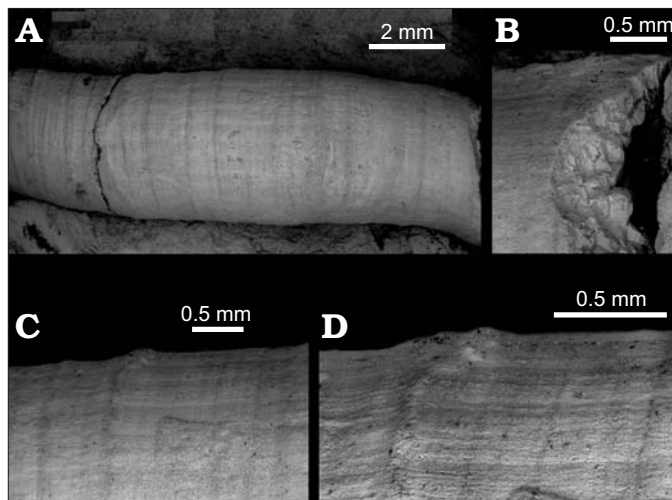


Fig. 4. Serpulid polychaete “*Serpula*” *prisca* sp. nov. (holotype PMC. S5.15.09.2017) from the Wordian to upper Permian, “Pietra di Salomone” Limestone, Sicily, Italy. **A**. Central portion of the tube glued together, with only feeble growth lines on its outer surface. **B**. Tube wall with large secondary calcite crystals pointing to complete recrystallization. **C**. Close-up of outer surface showing very thin and smooth growth lines. **D**. Magnification of C, with closely spaced, relatively prominent growth lines, crossed by nearly imperceptible longitudinal striations. All SEM images.

portion. It is circular in cross-section with a constant diameter of 3.9 mm. Lumen 3.3 mm wide. Tube wall 0.3 mm thick. Outer surface smooth, with very thin and smooth growth lines spaced at intervals of usually 100 to 300 μm , but locally more closely spaced and evident. Even thinner and nearly imperceptible longitudinal striations, locally intersect the growth lines. Posterior encrusting tube portion unknown. Original microstructure of the tube wall not preserved.

Remarks.—Even incomplete, the measurements of the fragment most probably indicate that it belonged to an adult specimen. The available tube portion provided distinctive characters justifying the erection of a new species. “*Serpula*” *prisca* sp. nov. has a unique, extremely smooth tube, that differs from all other serpulids from the Sosio Limestone, only superficially resembling *Serpulidae* sp. nov. indet. Sanfilippo et al. 2017b. Nevertheless, the latter species is smaller-sized, shows more evident growth lines than *S. prisca* sp. nov. and lacks longitudinal striations.

Like for the previous species, generic allocation is difficult, mostly because of the absence of the posterior attached part. The tube roughly resembles that of species belonging to *Protula* Risso, 1826, which may have comparable long raised anterior tube portions, not (noticeably) increasing in diameter, and lacking keels and peristomes. The delicate micromorphology with imperceptible longitudinal striations is somewhat similar to that of some scaphopod gadiliniidae shells (Scarabino 1995), but differs for disposition of growth lines. Also, the smooth outer morphology of the new species is comparable to that observed in *Protula* but in this species the outer surface is rougher (RS, unpublished data). In absence of a more fitting genus, we provisionally assign this species to “*Serpula*”, pending further support from more complete tubes with attached portions. Large secondary calcite crystals occur in the tube wall, whose original structure has been obliterated by diagenesis. The tube of *S. prisca* sp. nov. does not show any evidence of a worst preservation in respect to that of the other species (*S. calannai* sp. nov.) described herein: both species come from the same outcrop, thus presumably underwent similar process of fossilization which led to similar degree of diagenetic preservation (heavy recrystallization, with large secondary calcite crystals). In spite of this, tubes of the two species possess different micromorphology. The tube of *S. calannai* sp. nov. displays a lumpy surface, with irregular growth lines, about 10 micron thick (Fig. 3E). In addition, several well-developed peristomes occur in the tube of *S. calannai* sp. nov. They are irregularly spaced and surprisingly very frequent along the tube (at intervals of 2–6 mm). Conversely, tube of *S. prisca* sp. nov. is perfectly smooth and lacks even slightly developed peristome. Also, both tubes represent anterior erect parts that largely differ in size: *S. calannai* sp. nov. is twice the size of *S. prisca* sp. nov. (outer diameter 7.8 mm and 3.9 mm) and has a thick wall, twice that of the other.

If these tubes belonged to the same species, the dimensional range (variability of the diameter of 4 mm) would be too large, and the hypothesis of an intraspecific variability

ity would be little supportable. Likewise, the difference in thickness of the tube wall (0.3 mm) is likely too much to fit into a variability. It should also be considered that usually the raised parts of the tubes maintain substantially a constant diameter and a constant wall thickness. It is likely that tubes with such obvious differences belong to two different species rather than represent variants of the same species.

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

Conclusions

Since their origin till nowadays serpulids represent a relevant component of coral/algal/metazoan bioconstructions in shallow-shelf habitats (among others Nishi 1996; Di Geronimo et al. 2002; Mallela 2007), as well as in bathyal (Sanfilippo 2009a; Rosso et al. 2010; Kupriyanova et al. 2011; D’Onghia et al. 2015) and cave environments (Rosso et al. 2013, Sanfilippo et al. 2013, 2015, 2017a; Guido et al. 2017). Increase in abundance and diversity of serpulids throughout geological time appears to be related to the presence of reef ecosystems, where skeletons of frame-builders constituted heterogeneous substrata available for colonization. This is the case with some Jurassic sponge build-ups (among others Pisera 1991) and Jurassic–Cretaceous coral reefs, comprising abundant and diversified serpulid associations (among others Parsch 1956; Jäger 1993, 2011), and recently acquired data (Sanfilippo et al. 2016, 2017b, present paper) suggest that this scenario may also explain high diversity of serpulids in the Permian. At that time eight serpulid species belonging to five nominal genera, *Palaeotubus*, *Filograna*, “*Serpula*”, *Propomatoceros*, and *Pyrgopolon*, thrived in the Palaeotethys metazoan bioherms, already exhibiting different shapes and ornamentations.

As a whole, the stout and well-calcified serpulids from the Sosio Valley, flourishing in metazoan reef-like build-ups dominated by sponges, crinoids and brachiopods, may represent an adaptive response to an exposed shallow-shelf environment. Furthermore, the frame of reef-builders probably offered differentiated microenvironments including sheltered parts, where minute and brittle forms like *Filograna*, or species like “*S.*” *calannai* sp. nov. and “*S.*” *prisca* sp. nov., having tubes with long anterior ends raising from the substrate, were adapted to live. Analogously to living species of *Protula* (see Sanfilippo 2009b: 2021–2022), in the new species the presence of an anterior part raising from the substrate for a considerable length also suggests a life habit in relatively sheltered environments of the shallow-water reef, less exposed to hydrodynamic action.

This surprisingly diversified Permian serpulid community was associated with heavily mineralized demosponges and calcisponges able to produce carbonate frameworks that reached their maximum extent and high diversity during the middle Permian, in the Guadalupian (Sremac et al.

2016). However, these habitats were strongly affected by the end-Guadalupian (pre-Lopingian) biotic crisis, presumed to be linked to global warming, ocean acidification and anoxia events. This crisis caused a steady decrease in biodiversity, especially for some groups (brachiopods, molluscs) and the demise of sponge-metazoan reefs (Clapham et al. 2009; Bond et al. 2010; Sremac et al. 2016). A concomitant decrease in diversity and a virtual disappearance paralleling the fate of other taxa could be hypothesized also for serpulids, which formed a part of the diversified reef-dwelling community. Indeed, serpulids so far have not been recorded from younger Permian and Lower Triassic rocks, up to the simple-shaped *Filograna* specimens, found in sheltered shallow shelf settings of the very late Middle Triassic (Flügel et al. 1984; Cirilli et al. 1999; Stiller 2000; among others).

If the Wordian or Capitanian age for the Sosio megablocks is confirmed (see above), it seems that the serpulid palaeocommunity might have indeed suffered a sharp reduction to almost extinction during the end-Guadalupian biotic crisis, before the end-Permian extinction. However, data on late Permian–Early Triassic serpulids are still fragmentary and further research is needed to fill this gap.

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