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Serpulidae from the Albian–Cenomanian (Cretaceous) of Mexico

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Abstract

Two serpulid species, *Protula*? *antiquata*? and *Propomatoceros*? sp., are recorded from the Morelos Formation (mid-Cretaceous) in Mexico. Serpulid tube structure is microcrystalline; the examined tubes are slightly diagenetically altered, but growth layers are well preserved. The short, straight growth layers with slightly curved distal ends in *Protula*? *antiquata*? occur also in some other serpulids such as the genus *Josephella*. The Mexican serpulid tubes are of a calcitic composition. The diversity of the present serpulid association is low for shallow tropical seas of the Cretaceous in comparison to rich assemblages recorded from Europe. The low diversity presumably results from some local environmental conditions such as rapid sedimentation and low nutrient content of sea water.

Key words: Polychaetes, tube worms, microstructure, mineral composition, palaeoecology

1. Introduction

Serpulidae Rafinesque, 1815 is a clade of polychaete annelids that permanently dwell in calcareous tubes (ten Hove & Kupriyanova, 2009; Kupriyanova et al., 2023). All serpulids are suspension feeders and most species encrust hard substrates, with the exception of a few free-living forms such as e.g., *Ditrupa arietina* (see ten Hove & Smith, 1990). The vast majority of serpulid species are marine animals, the sole exception being *Marifugia cavatica* Absolon & Hrabe, 1930, which lives in freshwater caves (Kupriyanova et al., 2009). Serpulids inhabit all bathymetric zones of the oceans including hadal depths (Kupriyanova et al., 2014), and may also occur in methane-seep ecosystems (Vinn et al., 2013; Rouse & Kupriyanova, 2021).

The oldest serpulids are known from the Middle Permian of Sicily (Sanfilippo et al., 2017, 2018). In the Triassic (Ziegler & Michalík, 1980; Berra & Jadoul, 1996; Cirilli et al., 1999; Stiller, 2000), they started to diversify and expand their palaeogeographical distribution, so that they were already widely distributed during the Early Jurassic. The Middle and Late Jurassic was the time of greatest serpulid diversification; this persisted throughout the Cretaceous (Jäger, 1983, 2005; Ippolitov et al., 2014; Kočí & Jäger, 2015a, b; Kočí et al., 2017, 2019; Słowiński et al., 2022).

Previously, *Serpula* sp. has been recorded from the Cretaceous Alisitos Formation in the state of Baja California (Allison, 1955). In San Luis Potosí, the Cardenas Formation (Upper Cretaceous) has yielded *Hamulus angulatus* Wade, 1926 and *Hamulus onyx* Morton, 1834 (Myers, 1968). The presence of serpulids in faunal assemblages was cursorily mentioned in a microfacies characterisation of the La Casita and Taraises formations (Cretaceous) in the state of Durango (Adatte et al., 1994). In addition, epibiontic serpulids have been recorded in a tapho-

nomic study of ostreid bivalves from the San Juan Raya Formation (Lower Cretaceous, Aptian) in the state of Puebla (Hernández-Ocaña et al., 2015), while from the same formation, Serrano-Brañas & Centeno-García (2013) described a gregarious serpulid biofacies, identified as belonging to *Serpula* sp.

Gutiérrez-Alejandro (2018) noted the presence of some tubicular remains, interpreted as serpulids, from the Cretaceous La Virgen Formation in the state of Coahuila. Serpulids also occur in the Kimmeridgian La Caja Formation in the state of Zacatecas (López-Caballero et al., 2018), while in the Lower Cretaceous of the Pilhuamo area, state of Michoacan, serpulids formed part of the encrusting fauna on gastropods (Cuadros-Mendoza & Buitrón-Sánchez, 2021).

The present note is the first study on the systematics of Cretaceous serpulids from Mexico, with some considerations regarding their palaeoecology and palaeogeographical distribution.

2. Study area

The locality that yielded the present material is locally referred to as "El Cerro Las Bocas", in the town of Papala (municipality of Taxco de Alarcon, state of Guerrero), in southern Mexico. Papala is situated approximately 8 km from the border between the states of Guerrero and Morelos, Mexico (Fig. 1). The outcrops from which the serpulids were recovered are at 60 m on the path that leads to the village of Corralejo.

3. Geological setting

The study area is located in the province of Sierra Madre del Sur, within the subprovince of Sierras y Valles Guerrerenses, which borders the subprovince of the Balsas Depression. Carbonate rocks characterise the Morelos Formation, described by Fries (1960) as a sedimentary succession of interlayered grey limestone and dolomite, with occasional bands of black flint. The major rock types are mudstone-wackestones, and wackestone-grainstones with some boundstones (García-Díaz, 2004). The age of the Morelos Formation has been determined as Albian–Cenomanian (mid-Cretaceous) (Fries, 1960; Aguilera-Franco, 2003). Fossil assemblages recorded from this unit comprise microfossils (Foraminifera and Ostracoda), calcareous algae, rudist

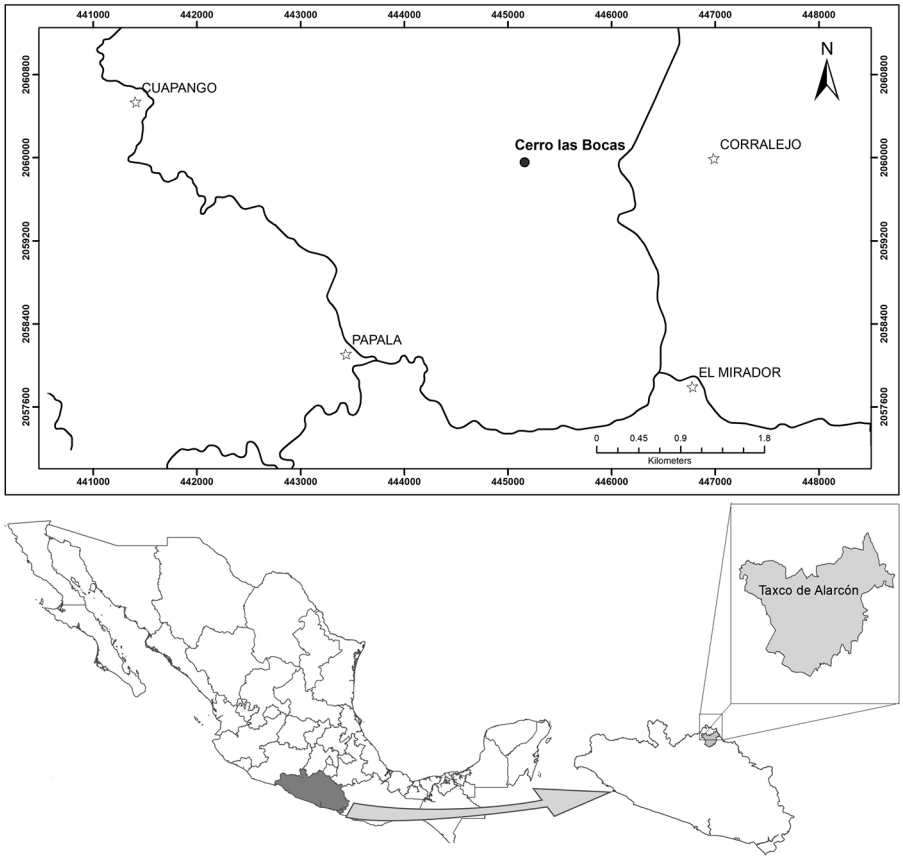

Fig. 1. Locality map.

bivalves, gastropods and echinoderms (Fries, 1960; Aguilera-Franco, 2000).

4. Material and methods

Seven beds were sampled; one sample of limestone was recovered from each bed at the base of "El Cerro las Bocas". The samples were collected at UTM co-ordinates 2059475.943 N, 443976.803 E (four samples), 2059490.182N, 444013.898 E and 2059493.929N, 44022.516 E (one sample) (Fig. 1). From each rock sample two petrographic slides were made, corresponding to transversal and longitudinal plains. The samples were lithologically characterised and microfacies identified. The composition of these thin sections was analysed by Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS). Microphotography and elemental composition of the serpulids were performed at the Laboratorio de Microscopia Electronica of the Escuela Superior de Ciencias de la Tierra (Autonomous University of Guerrero).

5. Systematic palaeontology

Family Serpulidae Rafinesque, 1815
Genus *Protula* Risso, 1826
Protula? *antiquata*? (J. de C. Sowerby, 1829)
Figs 2A, B, 3A-C, E

Material: 32 tube sections from the Morelos Formation, state of Guerrero, southern of Mexico. Thin sections repository numbers ESCT402-403, ESCT405, ESCT408, ESCT414, ESCT417-421, ESCT421, ESCT424, ESCT427.

Description: Angular tubes with thick wall (250–500 μm) and multiple edges in cross section; sides between edges not concave. Tubes lack attachment structures. Tube diameter 3.0–3.5 mm. Tube wall with thick external (three quarters) and thin inner layer (one quarter) and short, straight growth lines with slightly curved distal ends. About six growth lines per 0.5 mm in longitudinal section of tube. Tube microstructure microcrystalline, with angular crystals forming microstructure being 2.5 to 7.0 μm in diameter. Tube calcitic.

Remarks: These specimens are assigned to *Protula* on account of the extremely thick tube wall and long free part. '*Serpula*' *antiquata* is currently assigned either to the extinct genus *Parsimonia* Regenhardt, 1961 or, with a query, to the predominately Cenozoic and Recent genus *Protula*. The Mexican material measures only up to 3.5 mm in maximum tube diameter; although this is relatively small for tubes of *Pr. antiquata* (mostly between *c.* 3–6 mm, but up to almost 10 mm in maximum diameter), this difference in mean size does not necessarily mean that a different species is involved. This matter is discussed further below. Due to some uncertainity about the identity of genus and species we are using (?).

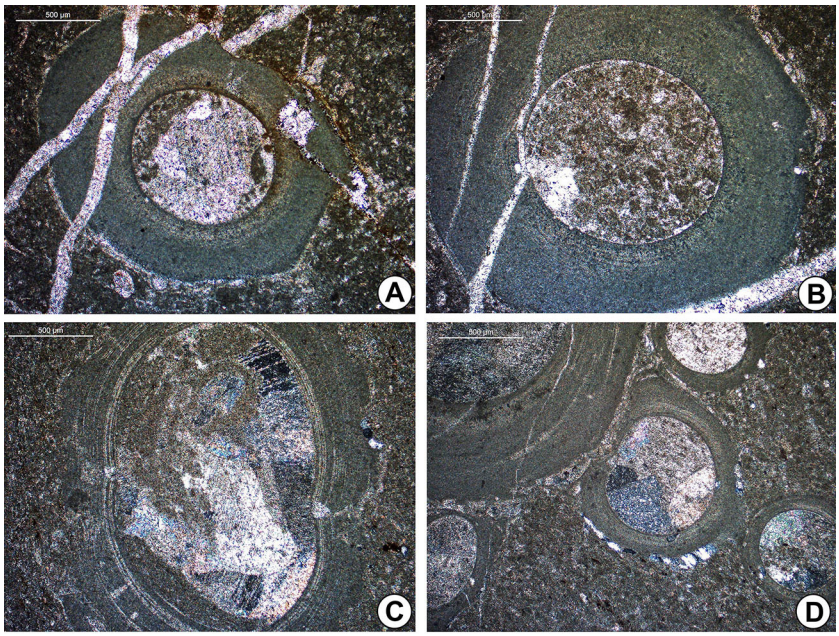

Fig. 2A, B – Angular tubes of *Protula*? *antiquata*?, in transverse section; Morelos Formation (mid-Cretaceous), southern Mexico (ESCT421); **2C, D –** Semi-circular tubes of *Propomatoceros*? sp., in transverse section; Morelos Formation (mid-Cretaceous), southern Mexico (ESCT430).

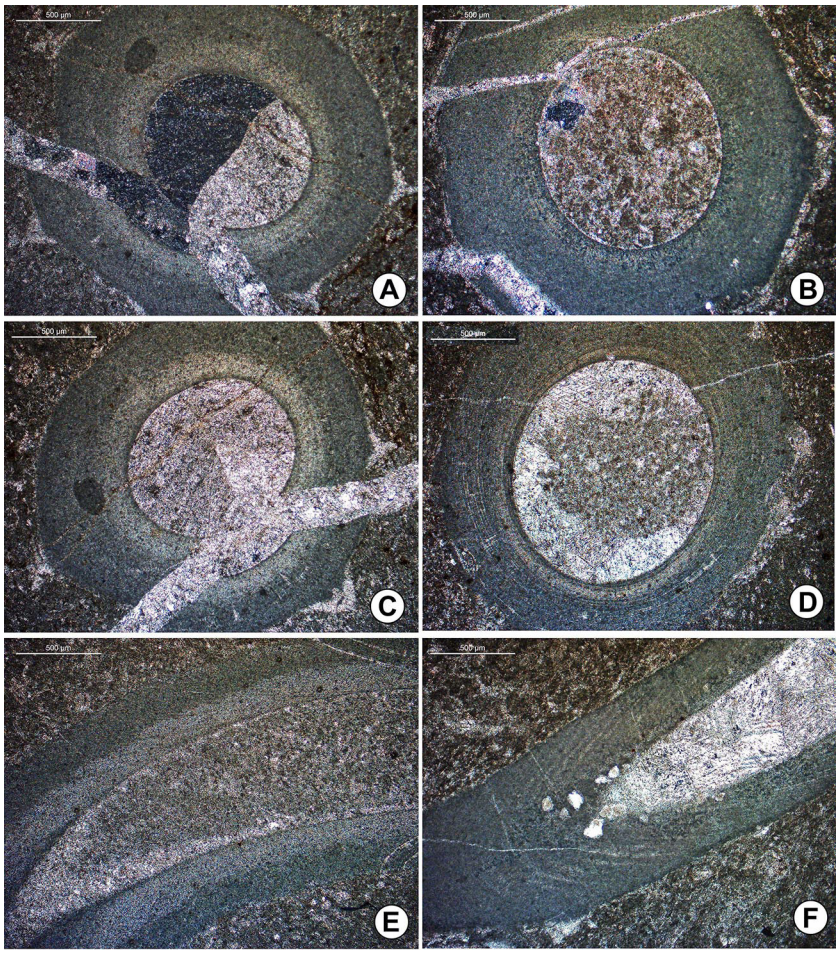

Fig. 3A-C – Angular tubes of *Protula*? *antiquata*?, in transverse section; Morelos Formation (mid-Cretaceous), southern Mexico; **D –** Semi-circular tubes of *Propomatoceros*? sp., in transverse section; Morelos Formation (mid-Cretaceous), southern Mexico; **E –** *Protula*? *antiquata*?, in longitudinal section; **F –** *Propomatoceros*? sp. in longitudinal section. **A, B –** Repository number ESCT424; **C –** Repository number ESCT418; **D –** Repository number ESCT406; **E –** Repository number ESCT400.

Genus *Propomatoceros* Ware, 1975
Propomatoceros? sp.
Figs 2C, D, 3D, F

Material: 19 tube sections from the Morelos Formation, state of Guerrero, southern Mexico. Thin sections repository numbers ESCT400-401, ESCT404, ESCT406, ESCT410, ESCT421, ESCT423, ESCT428-430, ESCT432-433.

Description: Small tubes, 2.0–3.0 mm in diameter, with moderately thick wall (up to 300 µm); weakly developed, longitudinally rounded dorsal keel and numerous fine growth lamellae in tube cross section. Tube apparently single layered; attached part with widened base, solid, lacking chambers.

Remarks: These specimens are assigned tentatively to *Propomatoceros* on account of the presence of a single, weakly developed dorsal keel. Near-circular, rather than triangular cross sections, are less characteristic of this genus.

6. Discussion

6.1. Tube microstructure and composition in *Protula*? *antiquata*?

The short, straight growth layers with slightly curved distal ends in this form occur also in some other serpulids such as species of the genus *Josephella* (Sanfilippo, 1996; Vinn et al., 2008a, b), although the majority of Mesozoic serpulids have better-developed, chevron-shaped growth lamellae in the longitudinal tube section (Weedon, 1994; Vinn & Furrer, 2008). The microcrystalline tube microstructure of both external and inner layers in *Protula*? *antiquata*? (Fig.

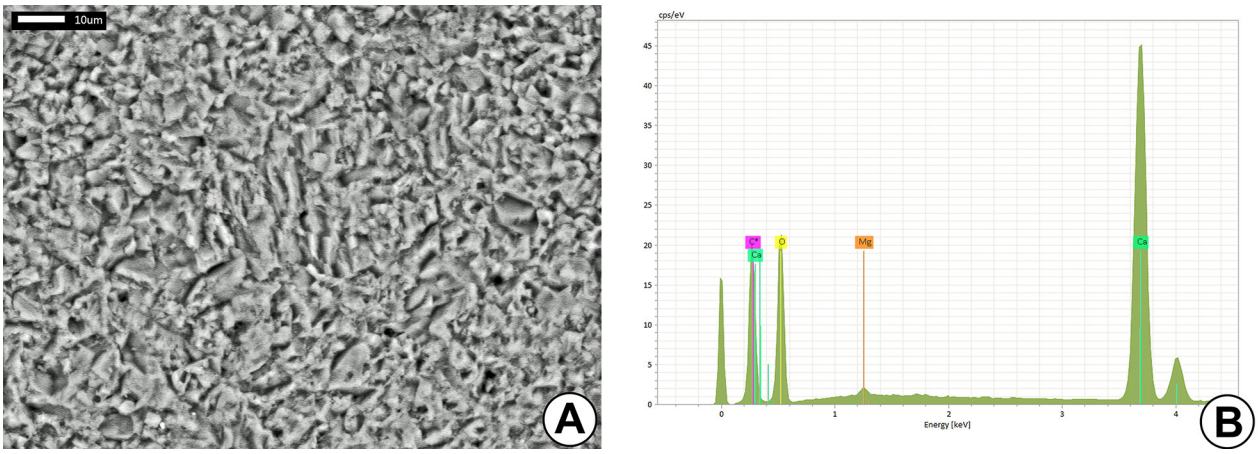

Fig. 4A – Tube microstructure of *Protula*? *antiquata*?; **B –** Elemental composition of tube wall in *Protula*? *antiquata*?.

4A) is likely the result of a moderate diagenetic alteration of microstructure on a microscale. Any more profound alteration of tube structure would have resulted in the loss of growth lines; however, these are well visible in the material studied. The original tube microstructure of the external layer in some Cenozoic species of *Protula* was a semi-ordered IOP one, as identified in European material (Vinn, 2007). One can hypothesise that this could have been altered into a homogeneous structure during diagenesis. An EDS study of elemental composition of the tube in *Protula* suggests a calcitic composition, because if aragonite had been present, elevated levels of strontium, characteristic of the biomineral aragonite (Fig. 4B), would have been noted. Calcitic serpulids were presumably common in the calcite seas of the Cretaceous (Vinn, 2020). To date, only the mineral composition of the extant *Protula diomedea* Benedict, 1887 has been determined: 92.4 per cent aragonite and 5.8 per cent calcite (Vinn et al., 2008a).

6.2. Diversity and palaeobiogeography

The diversity of the serpulid faunule studied is low for the shallow tropical seas of the Cretaceous, in comparison to Europe. The low diversity presumably results from some local environmental peculiarities such as nutrient-poor waters and rapid sedimentation. The clayey and calcareous sedimentary rocks in the Cretaceous of Europe usually yield five to 22 species and several genera of serpulids (Jäger 1983, 2005; Kočí & Jäger, 2015a, b; Kočí et al., 2017, 2019). The Mesozoic serpulids from the Americas are poorly known. A recently recorded faunule from the Lower Cretaceous of Argentina comprised two species (Luci et al., 2021), whereas in Mexico extinct serpulids have mostly been recorded cursorily as part of accompanying faunas, without systematic descriptions. The present lot from the Morelos Formation is dominated by *Protula*?; this has a long free tube part which may have been beneficial under conditions of rapid sedimentation (Jäger, 1983). The low diversity of the Mexican faunule might also be ascribed to the paucity of hard substrates; such are necessary for more diverse associations as the majority of serpulid species depend on the availability of hard substrates. Moreover, it could be speculated that most serpulids could not cope with rapid sedimentation. From a palaeobiogeographical point of view the Mexican serpulids do not differ much from taxa recorded from the Cretaceous of Europe. Extra-European records of *Protula*? indicate that this genus had become distributed across the Atlantic by the end of the Lower Cretaceous. *Protula antiquata* is frequent in the Albian Gault Clay of southern England, but is also common in marly limestones and sandy limestones of Cenomanian age in England, France and northern Germany (Jäger, 2005). These age assignment correspond to that of the Mexican material. At that time, the North Atlantic Ocean did either not yet exist or was very narrow, so that the distance between what today is Mexico and Europe was much smaller. However, there is an important difference between the Mexican and European material of *P. antiquata*. This species may have a single, weakly developed longitudinal edge or low keel in the attached tube portion, but no longitudinal ornament at all in the free anterior portion. In contrast, in the tube cross sections of Mexican specimens, the presence of a slightly higher number of weak elements of longitudinal ornament cannot be overlooked. *Propomatoceros*? sp. bears a certain resemblance with *Mucroserpula* and *Propomatoceros* as recorded from the Lower Cretaceous of Argentina, showing that such morphotypes were widely distributed in the Cretaceous of the Americas.

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