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SERPULID TUBES AS POTENTIAL PALAEOENVIRONMENTAL MARKERS

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ABSTRACT

Early Cretaceous Serpulid polychaete tubes are found with unusually high densities along mixed carbonate-siliciclastic deposits, outcropping at the coastal rocky cliffs at Ericeira (belonging to Ribeira d´Ilhas Formation, West Portugal). This study aims to obtain insight into key environmental factors promoting this specific proliferation during a short time period and if the fossilized tubes can be used as paleoenvironmental markers of specific conditions. High-resolution petrographic and geochemical studies were conducted on Serpulid tubes and related materials to test their potential.

Keywords: Invertebrados marinos, Mineralogía, Tubos, Geoquímica, Paleoambiente.

1. INTRODUCTION

Serpulids are sedentary polychaetes that produce calcareous tubes (Montefalcone *et al.,* 2022). Their evolutionary record stretches from the Middle Triassic to the present; they have a cosmopolitan distribution and are mainly associated with marine environments (Yang *et al.,* 2012; Vinn, 2013). The Serpulidae Family is the only one where the polychaete forms a biomineral tube with the calcium carbonate ingested or extracted from the water column; some environmental factors affect the morphology and mineralogy of the tube (Chan *et al.,* 2012; Smith *et al.,* 2013). Typically, their presence can inform seawater acidification level, sedimentation/accumulation rate, current intensity and water productivity (Kupriyanova & Badyaev, 1998; Ten Hove & Kupriyanova, 2009; Montefalcone *et al.,* 2022). Some species can form dense populations of reef-like structures acting as primary frame builders. Because of their short life span, they can provide informa-

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tion on the environmental conditions prevailing in specific areas where they thrive (Montefalcone *et al.,* 2022).

Along Barremian (Early Cretaceous) coastal deposits outcropping at Ericeira (Portugal), an unusual high-density of serpulidae tubes accumulation was identified at one sedimentary horizon (Figure 1). Their conspicuous abundance and singular stratigraphic occurrence deserve further attention. The main goal of the investigation is to unravel the past environmental conditions promoting this stratigraphically restricted, 2m thick delimited proliferation of serpulid tubes and evaluate if their occurrence and specific geochemical traits which can ultimately serve as paleoenvironmental indicators.

Figure. 1. Geographic location and sampled materials. A- Local framing of sampled outcrops within the same sedimentary horizon. B and C- examples of serpulid tubes (colonies) collected during fieldwork.

2. METHODOLOGY

In order to cover a broad spectrum of carbonate materials, several types of samples were collected during fieldwork. These include serpulid tubes from areas with high density (colonies), oyster shells occurring at the same stratigraphic level, matrix samples representing background sedimentation during skeletal development and recrystallized carbonate features. Furthermore, in order to achieve a better understanding of the data, modern samples of serpulidae tubes and related bivalve shells were also gathered from different coastal environments through Portugal, from both open coastal areas to restricted lagoon areas. During the Early Cretaceous, sedimentation at the studied area was characterized by an intercalation of siliciclastic and carbonate deposits. This alternation is a reflection of changes in depositional environment throughout the Early Barremian (Ribeira d´Ilhas For-

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mation) with inner platform environments being replaced with carbonate sedimentation during a period of marine transgression (Dinis *et al.,* 2016).

High-resolution petrographic, mineralogical and geochemical analyses was designed to characterize the existing high variety of materials. SEM-EDS analysis (Scanning Electron Microscopy - Energy Dispersive Spectroscopy) was conducted at facilities of the Department of Geosciences of the University of Aveiro using a Tescan VEGA including high-resolution ultra-structure imaging and micro-analytical capacity. Geochemical analysis of powdered samples was conducted at the Institute for Geology, Mineralogy and Geophysics (Ruhr-Universität Bochum, Germany) and ~~at~~ Institut für Geologie Leibniz (Universität Hannover, Germany). Obtained carbon and oxygen-isotope composition, and major and trace elemental composition can be combined with independent proxies obtained from complementary techniques.

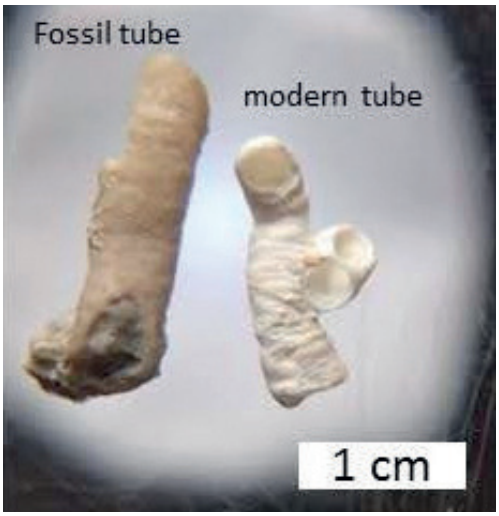

Figure 2. An example of the serpulid tubes taken under the scanning microscope for further ana-lysis.

3. PRELIMINARY RESULTS

Preliminary results of high-resolution (SEM-EDS) petrography and elemental point analysis revealed that for both modern and ancient Barremian tubes, there is a similar elemental composition of magnesian calcium carbonate, presenting traces of Al and Si, suggesting continental debris influence during the process of biomineralization. In contrast, coeval bivalve shells do not share these results. In ancient samples of the serpulid tubes, a slightly lower content of Mg was observed. However, between ancient (1wt%) and modern tubes (3wt%), the difference is accounted for due to the expected mineralogical stabilization of higher-Mg calcite into its more stable low-Mg calcite composition during early to later diagenetic processes (e.g., Reijmer *et al.,* 2014).

Preliminary geochemical results show a persistent depletion in Carbon isotopes between all tubes and their neighbouring shells. This holds for both modern and ancient samples. Some ancient tubes have lowered values (more negative) for the oxygen isotopes than their modern counterparts.

The precipitation of calcium by both modern and ancient shells is relatively consistent. However, all tubes (modern and ancient) exhibit slightly lower calcium (Ca) concentrations because of their relative higher magnesium (Mg) concentrations. This trait is the most conspicuous among all measured elements. The biomineralization process differs between tubes and shells, whether ancient or modern. Additional and complementary information will help to refine current knowledge and determine the potential of serpulidae tubes as a paleoenvironmental marker.

4. DISCUSSION

Preliminary data from both modern and ancient Barremian tubes demonstrates a comparable composition of calcium carbonate with magnesium concentrations and traces of Al and Si, since it was not verified for the coeval bivalve shells, the hypothesised is by the way the serpulid incorporates terrigenous elements on the tube secretion process, having a grain of quartz encrusted on it, process that is not done by the bivalves. Also, the presence of these traces suggests the influence of terrestrial debris during the process of biomineralization.

The observed decrease of values in oxygen isotopes between ancient tubes and their neighbouring shells can be attributed to the partial recrystallization of some of the tubes, but the most promising gathered materials are the tubes that preserve their close-to-original O-isotope composition.

When comparing sampled tubes to their accompanying shells, the biomineralization process shows significant changes, characterized in the tubes by the precipitation of high concentrations of Mg (high-magnesium calcite). In ancient tubes this difference is not as significant, but this can be attributed to the process of mineralogical stabilization of ancient materials (high-Mg calcite into low-Mg calcite during early diagenesis).

Despite the lower Mg content in ancient serpulid tubes, the difference regarding their modern counterparts is considered negligible, resulting from early to later diagenetic processes, including mineralogical stabilization. Geochemical data indicate a uniform reduction in carbon-isotope values in all tubes compared to adjacent shells, which are persistent in modern and ancient samples. Ancient tubes have more negative oxygen-isotope values, which can be attributed to their partial recrystallization.

5. CONCLUSION

Serpulid tubeworms record alterations in the environment through the morphology and mineralogy presented by their tubes and the distribution

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of their populations. The formation of colonies takes more than decades to form and is known from the geological past to modern times, to be restricted to specific environments. (Montefalcone *et al.,* 2022).

The goal of determining the specific conditions that encourage the proliferation of serpulidae in the selected study area is still in progress. An initial examination of available petrographic and geochemical data indicates that the biomineralization process differs significantly between serpulid tubes and their neighbouring shells. This holds for both ancient and recent cases. The relation found between the concentration of Ca and Mg in the tubes vs. shells adds further complexity to unravel the cause of these patterns. Preliminary interpretations suggest that serpulid tubes are a promising carbonate archive and can serve as a paleoenvironmental indicator, but additional testing is necessary to refine our current understanding.

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