Palaeogeography, Palaeoclimatology, Palaeoecology 292 (2010) 35–43

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Trypanites ichnofacies: Palaeoenvironmental and tectonic implications. A case study from the Miocene disconformity at Foz da Fonte (Lower Tagus Basin, Portugal)

Ana Santos [a,*], Eduardo Mayoral [a], Carlos Marques da Silva [b], Mário Cachão [b], José Carlos Kullberg [c]

[a] Departamento de Geodinámica y Paleontología, Facultad de Ciencias Experimentales, Campus de El Carmen, Universidad de Huelva, Avda. 3 de Marzo, s/n, 21071 Huelva, Spain
[b] Departamento de Geologia and Centro de Geologia, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal
[c] Departamento de Ciências da Terra and Centro de Investigação em Ciências e Engenharia Geológica, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal

ARTICLE INFO

Article history:
Received 13 May 2009
Received in revised form 10 March 2010
Accepted 11 March 2010
Available online 17 March 2010

Keywords:
Bioerosion
Trypanites ichnofacies
Endolithic communities
Transgressive surface
Disconformity
Miocene
Burdigalian

ABSTRACT

A well preserved bioeroded surface occurs at the unconformity separating Cretaceous limestones and Lower Miocene sediments, outcropping on the western coast of the Peninsula of Setúbal (Central West Portugal). The ichnoassemblage present in this bioeroded surface is herein assigned to the *Trypanites* ichnofacies. The preservation characteristics of the borings reflect several episodes of encrustation/boring and physical erosion. The erosional truncation of bioerosive structures, and the predominant preservation of the largest borings (*Gastrochaenolites* isp.) in the ichnocoenoses are herein related with repeated phases of bioerosion and physical abrasion occurred during an Early Miocene transgressive pulse. The recognition of this bioeroded transgressive surface also allowed confirming the presence, at that time, of an emergent topographic relief related to salt domes formed earlier, probably already during Palaeogene times.

1. Introduction

Preservation of rocky palaeoshore indicators along modern coastlines is limited and commonly confined to favourable localities. As a rule, these environments are susceptible to tectonic uplift and erosion degradation over short periods of geological time (Johnson et al., 1998). However, the wealth of publications about this particular subject clearly demonstrates that fossil rocky shores are more common than previously believed and can occur in a wide range of rock types and ages (Radwanski, 1970; Palmer, 1982; Brett and Brookfield, 1984; Wilson, 1985, 1987; Johnson and Baarli, 1987; Johnson, 1988a,b; Pirazzoli et al., 1994; Brett, 1998; Bertling, 1999; Johnson and Baarli, 1999; Ekdale and Bromley, 2001; Benner et al., 2004; Plag, 2006; Johnson, 2006; Santos et al., 2008; Cachão et al., 2009).

A hardground is a stratigraphic discontinuity in carbonate seafloors where lithification has taken place before the development of a permanent sedimentary cover (synsedimentary lithification) (Voigt, 1959; Goldring and Kaźmierczak, 1974; Bromley, 1975). These conditions may occur near the end of a transgressive cycle in a carbonate sequence, producing a hardground as the maximum flooding surface (Taylor and Wilson, 2003). Thus, hiatus beds have stratigraphic and sedimentologic value in that they allow identification of surfaces at which sedimentation was interrupted for a significant time (Wilson, 1985; Wilson and Palmer, 1992; Taylor and Wilson, 2003; Santos et al., 2008), and also can be related to sea level changes (e.g., Kendal and Schlager, 1981; Fürsich et al., 1991; Ghibaudo et al., 1996; Cachão et al., 2009).

Euendoliths, which deeply penetrate lithified substrates, correspond to benthic organisms that produce permanent dwelling structures (domichnia) in hard substrates (Ekdale and Bromley, 2001), and usually significantly bioerode the host rock. The exhumation of cemented substrates provides extensive surfaces for infestation by benthic epilithic and euendolithic organisms. This may result in the development of hard lithified substrate ichnocenoses assigned to the *Trypanites* ichnofacies.

The study of the distribution and preservation mode of these trace fossils provide invaluable data for the understanding of hard substrate biota. The presence and the activity of the different benthic organisms that inhabited the substrate are recorded as a composite ichnofabric (Ekdale et al., 1984; Bromley and Ekdale, 1986). According to the range of tolerance of benthic organisms, successive suites of trace fossils appear. Each stage of substrate evolution is marked by organisms able to colonize the substrate under those specific conditions. Therefore, encrustations and/or borings in unconformity surfaces are the best confirmation of the existence of an ancient rocky-shore (Johnson, 2006), and are paramount for reconstruction of the palaeoenvironments

* Corresponding author. Fax: +34 959 219440.
E-mail address: asantos@dgyp.uhu.es (A. Santos).

0031-0182/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.palaeo.2010.03.023

related to sedimentary discontinuities (Ghibaudo et al., 1996; Cachão et al., 2009).

According to Johnson and Ledesma-Vázquez (1999) rocky palaeoshores and their biota are inherently interesting because they represent the palaeoecological history of a complex ecosystem, and because they have the potential to solve associated geological problems.

In this context, the aims of this study are twofold: (1) to survey the palaeoecological succession of encrusting and bioeroding organisms of the ichnoassemblage exhibited by the fossil rocky-shore biota; and (2) to show the relevance of trace fossil analysis to palaeoecological and tectonic studies, based on the Miocene geological history of the Arrábida Chain (Central West Iberian Peninsula, Portugal).

2. Geologic and tectonic setting

The Foz da Fonte study area (Fig. 1) is localized in the West Iberian Margin (WIM). This margin evolved during the Alpine Cycle and was conditioned by several tectonic events: 1) from Late Triassic to Early Cretaceous several extensional basins were formed, related to the early phases of the North Atlantic opening (Wilson et al., 1989; Rasmussen et al., 1998; Kullberg, 2000); 2) during the Late Cretaceous, after it became a passive margin, alkaline magmatism and salt diapirism were widespread in the whole region, (Kullberg et al., 2006a; Miranda et al., 2009); 3) during the Miocene (Burdigalian–Tortonian) a compressional episode related to the North directed convergence between the Eurasian and African plates took place (Ribeiro et al., 1990; Kullberg et al., 2006b). This superposition of tectonic events was responsible for major unconformities and hiatus in the entire onshore region of the WIM.

Regional geological mapping (e.g. Manuppella (coord.), 1994) clearly shows that the Palaeogene deposits of the Sesimbra–Foz da Fonte area are geometrically and genetically associated with the Cova da Mijona salt dome. In the axis of this structure the Miocene sediments lie directly, slightly unconformable, on the Cretaceous units (Fig. 2). The Foz da Fonte is one of the most relevant and better exposed outcrops where that hiatus is represented.

The bioeroded surface of Foz da Fonte is associated with a low angle unconformity, and it occurs directly imprinted on strongly lithified Cretaceous (Albian) fossiliferous limestones. These limestones also show evidences of emersion and incipient karst development mainly concentrated around fractures produced by a dyke field related to a doloritic sill intruded in the Albian limestones, approximately 10 m below the bioeroded surface. This intrusion was dated by $^{40}Ar/^{39}Ar$ geochronology, resulting in a reverse isochron age of 93.8 ± 3.9 Ma (Miranda et al., 2006, 2009). Evidences of emersion and karstification prior to the transgressive Lower Miocene depositional cycle indicate that in the western sector of the forthcoming Arrábida Chain, some emerged relief structures already existed, prior to the onset of this small tectonic chain. Those reliefs are the Sesimbra and Cova da Mijona salt domes, located to the East and Southeast of the study area, related to Late Cretaceous/Early

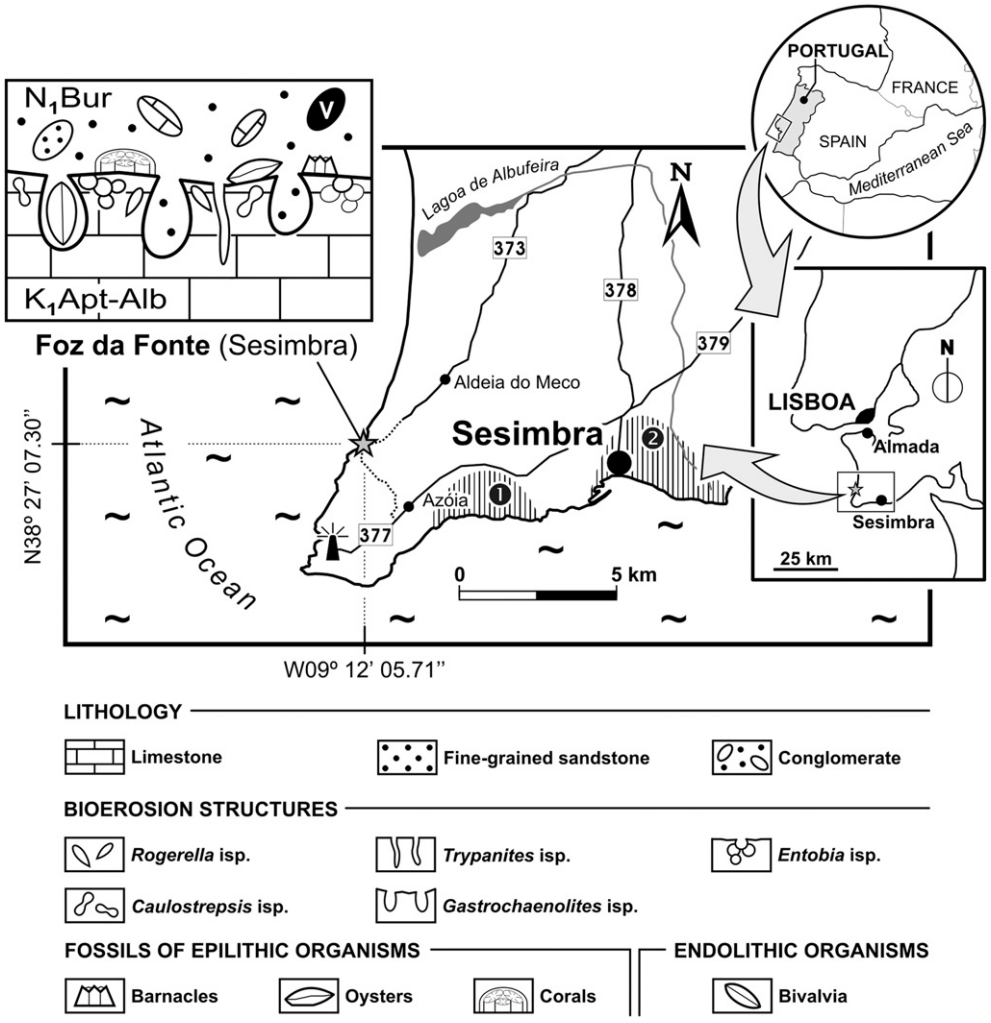

Fig. 1. Geographical and geological setting of Foz da Fonte outcrop (Central West Portugal) featuring bioerosion structures associated with the studied hardground. Dashes are the emerged areas related of: 1 — Cova da Mijona dome; 2 — Sesimbra diapir.