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Integrated assessment of bioerosion, biocover and downwearing rates of carbonate rock shore platforms in southern Portugal

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ABSTRACT

Bioerosion on rocky shores has been frequently reported as an important mechanism in coastal evolution, with less attention focussed on determining the bioprotective role organisms may have in mediating coastal erosion. This work aims, for the first time, to provide an integrated assessment of both traversing microerosion meter (TMEM) downwearing rates and activity of intertidal organisms on two carbonate shore platforms in southern Portugal. Paired substations positioned on the same substrate but differing in biological cover (one with bare rock and the other with algal cover colonised between the first and final readings) were monitored for eighteen months using a TMEM. At each station, the volume of burrows produced by macro borers was measured. Downwearing rates were lower in the surfaces protected by algal turf except in the station that experienced the longest time of exposure to subaerial conditions. In contrast, TMEM downwearing rates were higher in the areas containing the higher volume of burrows. Both downwearing rates and burrow volumes were negatively correlated with the mechanical strength of the substrate as measured by Schmidt Hammer rebound.

1. Introduction

Processes representing interactions between ecological and geomorphological parameters have an important role in landscape evolution (Trudgill, 1988; Naylor et al., 2002; Corenblit et al., 2008). One such process is bioerosion, which involves chemical and/or mechanical weathering promoted by animals and plants, and which has been frequently identified as an important mechanism of carbonate shore modification, namely with regard to erosion processes (e.g., Schneider and Torunski, 1983; Trenhaile, 1987; Spencer, 1988; Rasmussen and Frankenberg, 1990; Naylor and Viles, 2002; Naylor et al., 2002, in press; Spencer and Viles, 2002; Pinn et al., 2005; Stephenson and Thornton, 2005; Fornós et al., 2006; Gómez-Pujol et al., 2006; Porter et al., 2010a,b).

Carbonate rocky coasts, in particular, are often morphologically complex due to carbonate rocks' vulnerability to chemical weathering. This creates an advantage for several organisms because one attachment strategy involves chemical attack, increasing the number of species that can colonize carbonate substrata compared with non-carbonate substrate (Trudgill, 1988; Bromley and Heinberg, 2006). For instance, piddocks (boring bivalves) are endolithic molluscs whose mantles secrete a chelate that dissolves carbonate substrates (Trudgill, 1988; Pinn et al., 2005; Bromley and Heinberg, 2006). Conversely, encrusting organisms such as balanid barnacles, which secrete skeletal extensions in order to allow adhesion to very irregular substrates (Bromley and Heinberg, 2006), and several algae, may provide protect the surface by defending the substrate against waves and thermal variations (i.e. bioprotection, Naylor and Viles, 2002; Naylor et al., 2002).

This study assessed both the role of bioeroding macro borers to the modification of carbonate shore platforms and the role of macro algae play in modifying downwearing processes, in the central part of the Algarve region, southern Portugal. Previous studies, to our knowledge, have not quantified the combined

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effect of bioerosion and bioprotection on carbonate shore platform dynamics. This therefore provides new understanding of the roles of bioeroders and bioprotectors in influencing the evolution of coastal morphology.

2. Study area

The study area (Fig. 1) is located along the southern coast of Portugal (the Algarve region), where carbonate rocks shore platforms of several different lithotypes including carbonate siltstone, limestone, biocalcarenite, and calcarenite are common. The Algarve region sits within the Mediterranean morphoclimatic system with annual mean temperature of 18 °C. Summer is long, hot, and dry, whereas winter is short and mild with precipitation averaging up to 800 mm (Ribeiro, 1986). The Algarve coast experiences a mesotidal regime ranging from 1.36 to 2.70 m during neap tides and from 0.19 to 3.87 m during spring tides (Instituto Hidrográfico, 2011). The offshore wave climate is dominated by waves from the WSW (71% of occurrences) followed by the SE sector (23% of occurrences; Costa et al., 2001). The orientations of the various coastal sectors determine the amount of wave energy they receive (Moura et al., 2006; Bezerra et al., 2011). The study area includes two coastal sites: Chiringuito and Maria Luísa, referred to as sites CH and ML, respectively (Fig. 1).

2.1. Chiringuito site (CH)

The current intertidal shore platform is ca. 150 m wide, dips 3° seaward and is carved into carbonate siltstone. Three clearly defined sub-zones (lower, mid and upper intertidal) were identified, based on their conspicuous and characteristic color, best observed during spring season (Fig. 2A): (i) reddish in the lower zone (dominated by red algae); (ii) brown-greenish in the mid zone dominated by brown algae; and (iii) light gray in the upper zone dominated by balanids and limpets. The surface of the mid

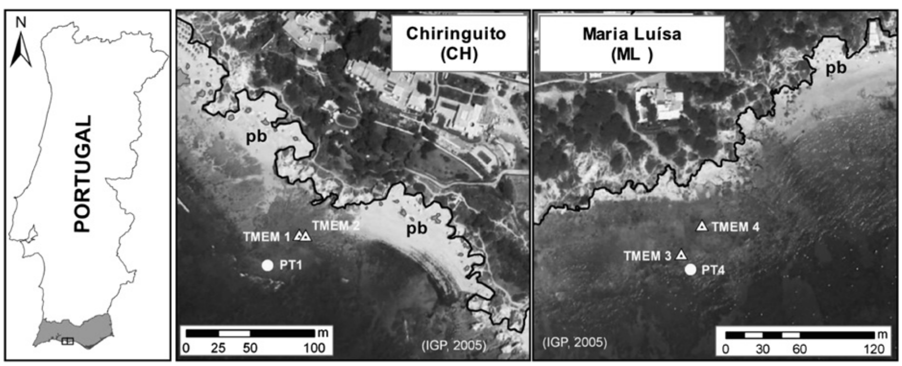

Fig. 1. Study area location. Maria Luísa is located 2 km eastward of Chiringuito. The locations of TMEM stations for monitoring downwearing using a traversing microerosion meter are shown (triangles), as are locations of pressure transducers (PT- white circles) for measuring wave height and period; pb-pocket beach.

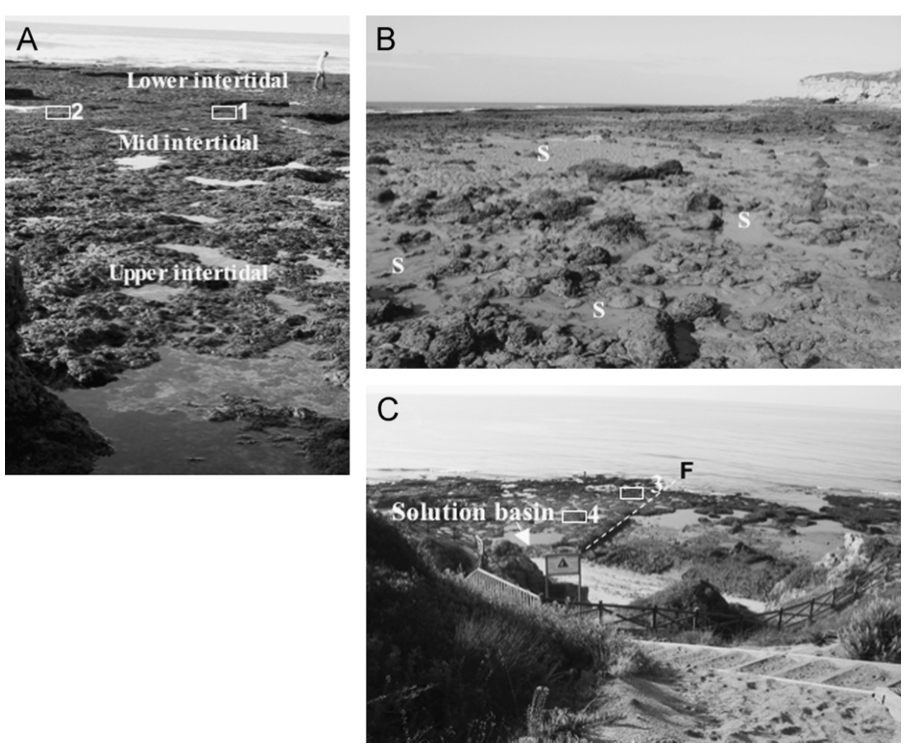

Fig. 2. (A) Chiringuito shore platform showing a relatively smooth mid intertidal zone. (B) Sandy patches (S) on the shore platform of Maria Luísa after a spring tide. (C) Maria Luísa shore platform—dashed line points a fault (F). Numbered rectangles in (A) and C) point the TMEM stations.