Available online at www.sciencedirect.com
ScienceDirect
Geomorphology 82 (2006) 295 – 308
GEOMORPHOLOGY
www.elsevier.com/locate/geomorph

The formation and evolution of the barrier islands of Inhaca and Bazaruto, Mozambique

S.J. Armitage [a,b,*], G.A. Botha [c], G.A.T. Duller [b], A.G. Wintle [b], L.P. Rebêlo [d], F.J. Momade [e]

[a] Oxford University Centre for the Environment, Dyson Perrins Building, South Parks Road, Oxford, OX1 3QY, United Kingdom
[b] Institute of Geography and Earth Sciences, University of Wales, Aberystwyth, Ceredigion, SY23 3DB, United Kingdom
[c] Council for Geoscience, KwaZulu-Natal Unit, P.O. Box, Pietermaritzburg, 3220, South Africa
[d] Instituto Geológico e Mineiro, Departamento de Geologia Marinha, Estrada da Portela, Zambujal, Apartado 7586, 2721-866 Alfragide, Portugal
[e] Direcção Nacional de Geologia, P.O. Box 217, Maputo, Mozambique

Received 19 October 2005; received in revised form 17 May 2006; accepted 17 May 2006
Available online 7 July 2006

Abstract

The barrier islands of Inhaca and Bazaruto are related to the extensive coastal dune system of the Mozambican coastal plain, south-east Africa. Optically stimulated luminescence (OSL) dating of key stratigraphic units indicates that accretion of sediment within these systems is episodic. Both islands appear to have been initiated as spits extending from structural offsets in the coastline. Superposition of significant quantities of sediment upon these spits during subsequent sea-level highstands formed the core of the islands, which were anchored and protected by beachrock and aeolianite formation. At least two distinct dune-building phases occurred during Marine Oxygen Isotope Stage (MIS) 5, tentatively attributed to marine transgressions during sub-stages 5e and 5c. Although some localized reactivation of dune surfaces occurred prior to the Holocene, large quantities of sediment were not deposited on either island during the low sea-levels associated with MIS 2. Significant dune-building and sediment reworking occurred immediately prior to and during the Holocene, though it is not clear whether these processes were continuous or episodic. Significant erosion of the eastern shoreline of Bazaruto suggests that it is far less stable than Inhaca and may suffer further large-scale erosion. A model is presented for the formation of barrier islands along the Mozambican coastal plain.

Keywords: Coastal evolution; Barrier islands; Inhaca; Bazaruto; Mozambique; OSL

1. Introduction

Along the south-east coast of Africa, there is a continuous coastal plain that runs from Durban in the Republic of South Africa to Beira in Mozambique. The Mozambican coastal plain is up to 440 km wide south of the Save River, narrowing southward towards the Maputaland coastal plain, south of Maputo (Fig. 1). Extensive coastal dune systems of Neogene to recent age characterize the coastal zone which is dominated by a composite accretionary coastal barrier dune cordon, containing some of the highest coastal dunes in the world (Cooper and Pilkey, 2002; Botha et al., 2003).

* Corresponding author. Oxford University Centre for the Environment, Dyson Perrins Building, South Parks Road, Oxford, OX1 3QY, United Kingdom. Tel.: +44 1865 285086.
E-mail address: simon.armitage@ouce.ox.ac.uk (S.J. Armitage).

0169-555X/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.geomorph.2006.05.011

Inland of this dune cordon are extended parabolic, sinuous crested and hummocky dunes. Due to the dune sand cover and absence of natural exposures or sections that display the stratigraphic relationships between dune sand bodies, the age relationships between these aeolian deposits have only recently begun to be understood. Extensive field investigation and geological mapping of the Maputaland coastal plain in South Africa, combined with ground penetrating radar and infrared stimulated luminescence dating studies (Botha and Porat, 2000; Botha et al., 2003), have revealed a history of aeolian deposition and polyphase reworking during the Pleistocene and Holocene. These processes have yielded a complex and dynamic coastal dune system for which the regional lithostratigraphic framework has been described by Maud and Botha (2000). Additional geochronological detail regarding the accretion of the coastal barrier dune and closure of coastal lakes and estuaries during the mid-Holocene has been derived from radiocarbon dating of beachrocks, lacustrine infill deposits and marine shells in southern Maputaland (Ramsay, 1995; Wright et al., 2000; Miller, 2001; Wright, 2002; Ramsay and Cooper, 2002).

Inhaca and Bazaruto are barrier islands within the relatively unstudied Mozambican portion of the coastal plain (Fig. 1). The regional geology reflects late Jurassic volcanism followed by marine inundation since the lower Cretaceous, during which time the region south of the Save River was a major depocentre (Flores, 1973). Bedrock in the Vilanculos area consists of Neogene evaporites. Structures associated with the Urema graben, the southern extension of the African Rift, extend southwards to this area (Flores, 1973; Förster, 1975). The Maputo Bay area is underlain by Eocene and Neogene marine deposits but is less affected by tectonism (Achimo et al., 2004). Whereas the linear coastline from Inhambane to Vilanculos could reflect structural control, the location of Inhaca Island in Maputo Bay reflects a palaeotopographic influence during the marine transgressions and regressions of the Pleistocene. Cooper and Pilkey (2002) regarded these islands as having formed as spits generated at structural offsets in the coastline, close to the break of slope of the continental shelf, during a period when sea-level was as high as at the present day. Subsequent aeolian deposition raised the relief of both islands, while the cementation of aeolian deposits to form aeolianite, and beach sediments to form beachrock, served to protect them from marine erosion. Both islands face the open Indian Ocean and are backed by wide back-barrier bays characterized by extensive sub- and inter-tidal sand bars (Cooper and Pilkey, 2002). Due to the steep, narrow continental shelf (Fig. 1), neither island was more than 5 km from the coast during the Marine Oxygen Isotope Stage (MIS) 2 low sea-level (Cooper and Pilkey, 2002).

Sediment supply is high due to the presence of several major rivers in the region and the large quantities of unconsolidated aeolian sands in the littoral zone. Coastal sediment transport by longshore currents is predominantly northwards due to the preponderance of SE Trade Winds and swell regimes (Ramsay, 1994). The Agulhas Current flows southwards off Bazaruto but forms a large eddy in Maputo Bay leading to northerly flow off Inhaca (Flemming, 1981). The mean spring tidal range is ~3 m. Both islands receive annual rainfall of ~1000 mm (Cooper and Pilkey, 2002). The compact nature of Inhaca and Bazaruto and the stratigraphic relationships revealed along the eroded coastline make these islands ideal for studying both the evolution of barrier islands and the more general geomorphic development of the south-east African coastal dune complex to which they belong.

Several studies have described the evolution and main geomorphic units of Inhaca (Hobday, 1977; Cooper and Pilkey, 2002), Bazaruto (Cooper, 1991; Cooper and Pilkey, 2002) and the south-east African coastal plain (Maud and Botha, 2000; Botha et al., 2003). However, these studies contain very few absolute ages. Optically stimulated luminescence (OSL) is the ideal dating method for these sediments, as outlined in a recent review by Duller (2004). The aim of this paper is to produce a model for the evolution of barrier islands along the Mozambique coast by using OSL to date the main geomorphic units of Inhaca and Bazaruto.

1.1. Inhaca

Inhaca consists of two distinct, north–south-oriented dune ridges (Fig. 2). The seaward ridge appears to contain an aeolianite core, which is exposed at Cabo Inhaca. This aeolianite is notched at 5–6 m above present sea-level, a feature which Hobday (1977) ascribes to the MIS 5e high sea-level event. A nearly continuous fringe of beachrock is exposed in the intertidal zone along the ocean margin of the island, and less continuously elsewhere. Both active and vegetated, NW-oriented, ascending parabolic dunes form the eastern dune cordon, attaining a maximum elevation of 120 m. The western dune cordon along the embayed Barreira Vermelha coastline (Muacanhia, 2004) of Inhaca is characterized by high bluffs that reveal a core of planar cross-bedded aeolianite overlain by a decalcified weathering profile of reddened sands. In