Journal of Asian Earth Sciences 42 (2011) 381–397

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Evolution of late Holocene coastal dunes in the Cauvery delta region of Tamil Nadu, India

L. Alappat [a,*], M. Frechen [a], R. Ramesh [b], S. Tsukamoto [a], S. Srinivasalu [c]

[a] Leibniz Institute for Applied Geophysics (LIAG), Section S3: Geochronology and Isotope Hydrology, Stilleweg 2, 30655 Hannover, Germany
[b] Institute for Ocean Management, Anna University, Chennai 600 025, India
[c] Department of Geology, Anna University, Chennai 600 025, India

ARTICLE INFO

Article history:
Received 6 November 2010
Received in revised form 5 May 2011
Accepted 16 May 2011
Available online 12 June 2011

Keywords:
Coastal sand dune
Cauvery delta
Optically stimulated luminescence dating
Quartz
Climatic variability

ABSTRACT

Widespread occurrences of coastal dunes are observed in the Cauvery delta region of Tamil Nadu in Vedaranniyam in the south east coast of India. These dunes were studied to establish the chronology of their formation and to understand their evolution using optically stimulated luminescence (OSL) dating in combination with sedimentological studies (quartz grain surface morphology using scanning electron microscope, grain size and heavy mineral analysis). The study shows that on the south-east coast of India widespread periodic dune formation/reactivation has taken place during the late Holocene to very recent times due to a variety of reasons such as climatic variation and land use changes. The sand mobility index shows that the dunes in the area have been largely active during the past century in the southern part in Nagapattinam region and many of the crests were active in the northern Cauvery delta in Cuddalore region. The angularity and fresh appearance of sand in the inland dunes suggest a short distance of sand transport and a source proximal sand deposition was proposed for the dune formation. The study demonstrates the sensitivity of sand dunes on the south east coast of India to varying climatic conditions and changes in regional land use.

1. Introduction

Coastal dunes are important landform which may record information on alternate events of dune activity and stabilisation over a prolonged period of time, and provides information about coastal evolution, palaeoclimate as well as sea level changes (Porat and Botha, 2008; Banerjee et al., 2003). Coast parallel dunes are also important as it forms an effective barrier against natural disasters such as storms and Tsunamis. The formation and reactivation of dunes are mostly related to supply of sand, wind parameters such as direction, strength, frequency and duration as well as moisture content and grain size of the sediment (e.g., Pye and Tsoar, 1990; Tsoar, 2001; Thomas and Wiggs, 2008). Wind plays an important role in stabilising a dune by allowing vegetation growth on dune surface (winds having higher drift potential hinders the plant growth over dune surface) (Tsoar, 2001, 2002; Yizhaq et al., 2009) apart from moisture content of sand, and winds that exceed the velocity threshold will initiate movement of sand with certain grain size (Bagnold, 1941). The east coast of Tamil Nadu, southern India contains numerous vegetated and non-vegetated coast parallel to sub-parallel dunes which occur as discontinuous ridges all along the coast. Among the dunes observed in the east coast of Tamil Nadu, the Vedaranniyam region (between Nagapattinam and Point Calimere) (Fig. 1) possesses a remarkable occurrence of wide, successive dunes, varying in width from few meters to several tens of meters, which may give information on the chronology of coastal development in the region and different stages of emergence. The Vedaranniyam region is a fast emerging cuspate foreland located in the south of Cauvery delta formed primarily by the southward drift of sediments by long shore currents (Sundararajan et al., 2009). In general the dunes occur with heights ranging from 0.5 to 7 m. There are only a few studies that have been carried out to understand the chronology of dune formation in east coast of India (e.g., Kunz et al., 2010a,b).

Luminescence dating is proved to be an efficient tool to find chronology of coastal sediments and has been successfully applied to inland and coastal dunes (e.g., Reimann et al., 2010; Kunz et al., 2010a,b; Quang-Minh et al., 2010; Tsoar et al., 2009; Clemmensen et al., 2009; Porat and Botha, 2008; Bateman and Godby, 2004; Frechen et al., 2004; Ballarini et al., 2003). Radiocarbon dating has only limited use due to fewer occurrences of organic material in the sand units. The chronological results from the dunes in the north (Cuddalore region) of the study area revealed evidence of early settlements and variation in monsoon activities in the region (Kunz et al., 2010a). Late Holocene to modern ages were proposed

* Corresponding author. Tel.: +91 7926314369, +91 9638778712; fax: +91 7926314900.
E-mail addresses: alappatlinto@gmail.com, lintoalappat@yahoo.co.uk (L. Alappat).

1367-9120/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jseaes.2011.05.019

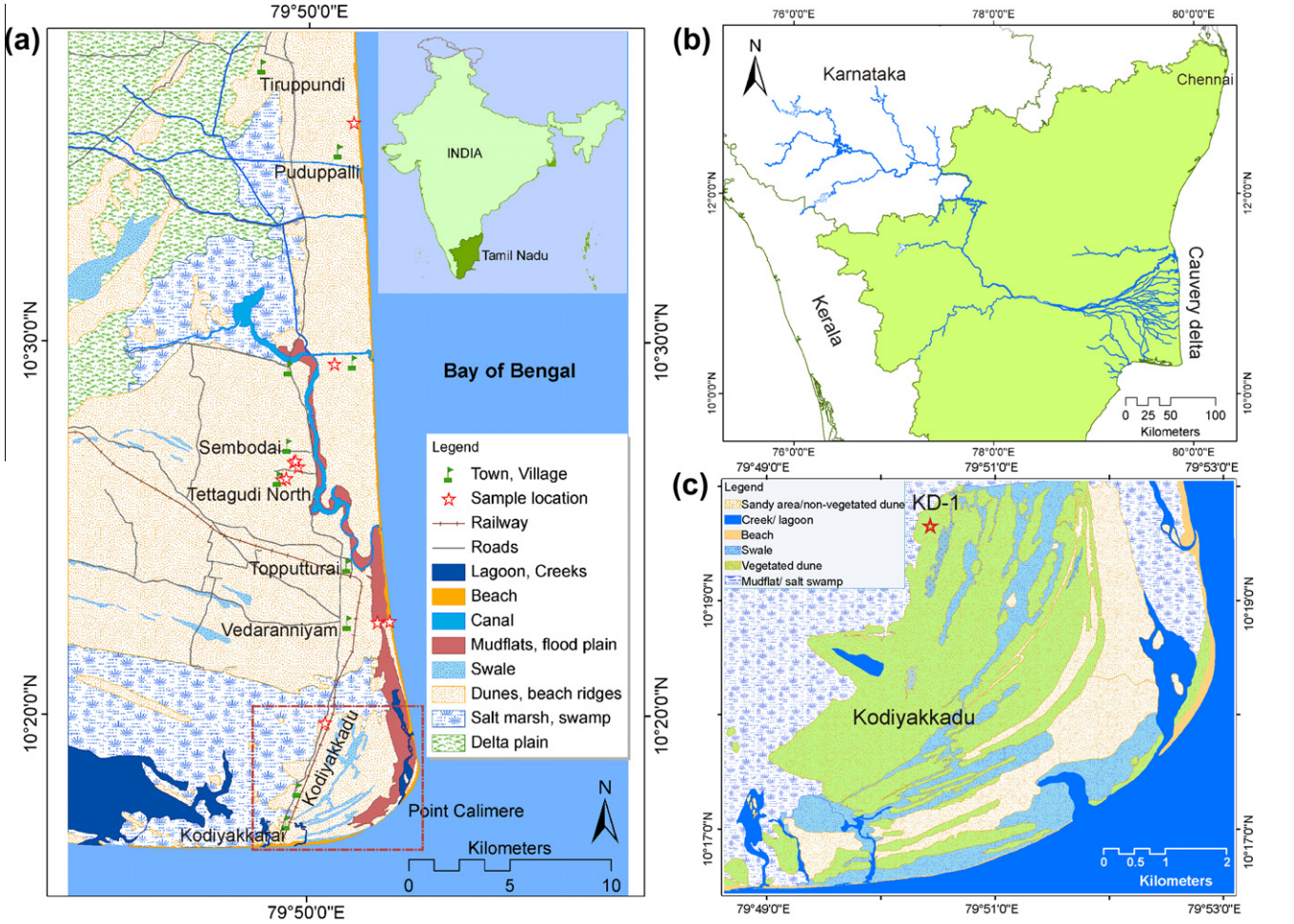

Fig. 1. Map showing the sampling locations and basic geomorphology of the study area. Inset, map of India shows the location of Tamil Nadu where the Cauvery delta is located (Fig. 1a). The drainage basin of Cauvery River is spread across parts of Karnataka and Tamil Nadu, from where it brings sediments to the coast (Fig. 1b). A detailed geomorphology map of the southern tip of Cauvery delta in Kodiyakkarai region showing successive development of beach ridges parallel and sub-parallel to the coast (Fig. 1c).

for various stages of dune formation in this area using optically stimulated luminescence (OSL) dating of dune sand. Other studies that used OSL dating for coastal deposits in the east coast of India include Murray and Mohanti (2006) and Thomas (2009).

This study aims to set up a detailed chronological frame to understand the formation and reactivation history of coastal dunes of Tamil Nadu, in particular to the Cauvery delta region. Establishing the chronology of dune formation in the east coast of India may be of help in understanding the response of this landscape to climatic variability and anthropogenically induced activities such as settlements, change in agriculture and land use pattern. Dunes may be used as a proxy to extend the record of terrestrial climate variability and variation in precipitation for the periods beyond instrumental records. Studies on coastal evolution on a decadal time scale also provides information about the sand accretion and will help in the planning of coastal management, land use tools and policies and protection strategies with respect to modern wind climate. We present 28 OSL dates from 10 profiles to establish the chronology of dune formation and use sedimentological techniques (grain size analysis, heavy mineral analysis, and Scanning Electron Microscopic (SEM) analysis of quartz surface) to examine the possible sediment transport, depositional mechanism and provenance of sediments. An index for 'dune mobility' (Lancaster, 1988), also called 'potential dune surface sand activity' (Bullard et al., 1997) was calculated to assess the dune activity in the region. The index was also compared with the recently published OSL ages (Kunz et al., 2010a,b) from the north of the study.

2. Study area and samples

The study area (Fig. 1) is located in the southern part of Cauvery delta between the latitudes and longitudes of N10°16′–10°40′ and E79°45′–79°54′. The Point Calimere region is characterised by moderate to low energy coast, where as the coast in the north of Vedaranniyam is a wave dominated microtidal coast (Sundararajan et al., 2009). The dunes in the area occur as isolated outcrops in the inland area and as linear dune ridges parallel to the coast towards shore region. The vegetation cover varies from sparse (Sembodai region) to very dense, (in Kodiyakkadu region) dominated by palm trees, tamarind, cashew and coconut trees in the inland region and by casuarinas, eucalyptus and other shrubs and creepers in the coastal region. The southern part in Kodiyakkadu (Fig. 1c) is part of a wild life sanctuary and is located within the Kodiyakkarai reserve forest. In the inter-dunal depressions (swales) the soil is fertile, rich in clay and silt, and is widely converted to agricultural lands for paddy, vegetables and aquaculture ponds.

The highest temperature in the study area occurs during the pre-monsoon period (March–May) between 28 °C and 40 °C. The region experiences a semi-arid to dry sub-humid climate and has