Aeolian Research 28 (2017) 13–28

Contents lists available at ScienceDirect

Aeolian Research

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

Origins of late- Pleistocene coastal dune sheets, Magdalena and Guerrero Negro, from continental shelf low-stand supply (70–20 ka), under conditions of southeast littoral- and eolian-sand transport, in Baja California Sur, Mexico

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ARTICLE INFO

Article history:
Received 14 February 2017
Revised 4 July 2017
Accepted 5 July 2017

Keywords:
Quaternary
Continental shelf
Marine transgression
Coastal dunes

ABSTRACT

Shallow morpho-stratigraphic sections (n = 11) in each of two large coastal dune sheets including the Magdalena (7000 km^2) and Guerrero Negro (8000 km^2) dune sheets, from the Pacific Ocean side of Baja California Sur, Mexico, have been analyzed for dune deposit age. The shallow morpho-stratigraphic sections (~2–10 m depth) include 11 new TL and 14C ages, and paleosol chronosequences, that differentiate cemented late Pleistocene dune deposits (20.7 ± 2.1 to 99.8 ± 9.4 ka) from uncemented Holocene dune deposits (0.7 ± 0.05 to at least 3.2 ± 0.3 ka). Large linear dune ridges (5–10 m in height) in the dune sheet interiors trend southeast and are generally of late Pleistocene age (~70–20 ka). The late Pleistocene dune deposits reflect eolian transport of marine sand across the emerged continental shelf (30–50 km southeast distance) from low-stand paleo-shorelines (−100 ± 25 m elevation), which were locally oriented nearly orthogonal to modeled deep-water wave directions (~300° TN). During the Holocene marine transgression, onshore and alongshore wave transport delivered remobilized shelf-sand deposits to the nearshore areas of the large dune sheets, building extensive barrier islands and sand spits. Submerged back-barrier lagoons generally precluded marine sand supply to dune sheet interiors in middle to late Holocene time, though exceptions occur along some ocean and lagoon shorelines. Reactivation of the late Pleistocene dune deposits in the dune sheet interiors lead to generally thin (1–3 m thickness), but widespread, covers of Holocene dune deposits (0.41 ± 0.05 to 10.5 ± 1.6 ka). Mechanical drilling will be required to penetrate indurated subsoil caliche layers to reach basal Pleistocene dune deposits.

1. Introduction

Large coastal dune sheets in the central west coast of North America are widely dispersed (Fig. 1), reflecting abundant, but highly localized, coastal sand supply from 1) major rivers, 2) alongshore littoral transport, and/or 3) long-term accumulations of sand in adjacent continental shelf areas (Cooper, 1958, 1967; Dupré and Tinsley, 1980; Blount and Lancaster, 1990; Murillo De Nava et al., 1999; Knott and Eley, 2006; Peterson et al., 2007, 2009, 2015). Two of the largest coastal dune sheets in North America, the Magdalena and Guerrero Negro dune sheets in Baja California Sur, Mexico, (Inman et al., 1966; Murillo De Nava et al., 1999; Kasper-Zubillaga and Zolezzi-Ruiz, 2007) are not associated with major rivers. The present Pacific Ocean shorelines of the Baja California Peninsula are generally characterized by narrow beaches, rocky headlands, and pocket-beach embayments. Such segmented littoral systems were probably too disconnected to have supplied the substantial abundances of littoral sand that produced the Magdalena and Guerrero Negro dune sheets. However, paleo-shoreline

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http://dx.doi.org/10.1016/j.aeolia.2017.07.003
1875-9637/

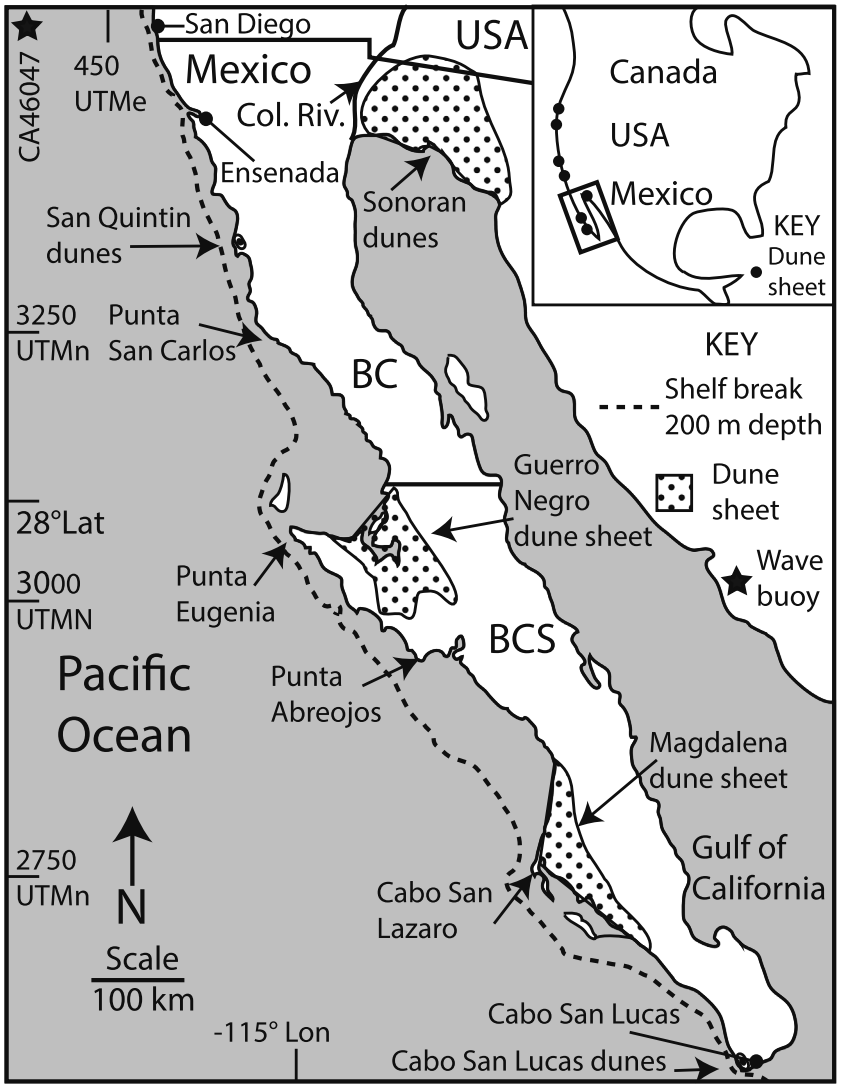

Fig. 1. Map of coastal dune sheets in Baja California (BC) and Baja California Sur (BCS), Mexico, including the large Magdalena and Guerrero Negro dune sheets (stippled pattern) and the small dune fields at San Quintin and Cabo San Lucas (arrows). The large Sonoran or Gran Desierto coastal dune sheet (Blount and Lancaster, 1990) occurs at the mouth of the Colorado River (bold line) at the northern end of the Gulf of California. Locations of four other major dune sheets are shown in the U.S.A. Pacific Coast (solid circles in map inset) (Cooper, 1958, 1967). The west coast continental shelf break in in the Baja Peninsula, is shown at the 200 m depth bathymetric contour (dashed line). The 100 m mid-shelf depth bathymetric contour is shown in Fig. 2B.

orientations and littoral transport continuities could have differed greatly from the present coastline during late Pleistocene marine low-stands. Could late Pleistocene paleo-sea levels, shoreline orientations, and paleo-wind/wave stress forcing conditions over the Baja California Sur continental shelf have combined to deliver the large quantities of littoral sand (Carranza-Edwards et al., 1998) that accumulated by eolian transport in the Magdalena and Guerrero Negro coastal dune sheets?

In this article, we present thermoluminescence and radiocarbon sample ages from shallow dune deposits in the Magdalena and Guerrero Negro dune sheets (Fig. 1) and relate the deeper sample ages (≥2 m depth) of the dated dune deposit migrations to marine low-stand conditions during the last ~ 70 ka (70×10^3 yr). Under the conditions of latest Pleistocene marine low-stands, ~50–100 m depth below mean sea level (MSL), the paleo-shoreline orientations offshore of the Magdalena and Guerrero Negro coastal dune sheets were sufficiently oblique to modeled ocean wind/wave stress (Alder and Hostetler, 2015) to effectively trap littoral sand on the adjacent continental shelf areas. Onshore directional wind stress, established from preserved linear dune form orientations (Murillo De Nava et al., 1999) demonstrates the potential for eolian transport (southeast direction) of littoral sand across the emerged inner-shelf to produce the large Magdalena and Guerrero Negro dune sheets.

Alluvial down-cutting during lowered sea levels produced incised valleys in the dune sheet areas that were subsequently submerged during the Holocene marine transgression. The Holocene marine transgression remobilized some of the submerged inner-shelf sand deposits to supply the nearshore development of 1) extensive barrier islands and sand spits (Fryberger et al., 1990; Jiménez et al., 1994) and 2) localized migratory dune fields, located along the south side of the Guerrero Negro dune sheet.

Recent reactivation of the late Pleistocene dune deposits, located southeast of the submerged lagoons in both the Magdalena and Guerrero Negro dune sheets, has led to thin covers of Holocene sand that mantle large relict dune ridges and deflation areas in the dune sheet interiors. The results of this study help to confirm the framework model of shelf marine low-stand depocenters in supplying sand to some of the lager coastal dune sheets in the central West Coast of North America (Peterson et al., 2007, 2015).