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The coastal ridge sequence at Rio Grande do Sul: A new geoarchive for past climate events of the Atlantic coast of southern Brazil since the mid Holocene

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A B S T R A C T

We present here the first geochronometric analysis of a large succession of coastal ridges that developed south of Rio Grande do Sul inlet, aided by OSL dating of samples taken in this succession that amounts c. 306 coastal ridges. This succession allows defining epochs of enhanced coastal drift or fluvial transport to the river mouth. Additionally, changes in the preservation of ridges also suggest the additional effect of transverse winds that create blow outs, while changes in the ridge packages planview onlap suggest possible changes in the dominant longshore drift. Four OSL samples located strategically allow defining the age of five main stages of this succession. The first stage comprises 2 substages. The first substage shows ridges #1 to #36 onlapping the boundary coastal scarp northwardly, while the second (ridges #37 to #84) shows an inversion of ridge shape wedging out southwards until coast returns to be quasi parallel to the initial coastal scarp estimated to be c. 6 ka. We estimate this first stage to comprise enhanced coastal drift due to higher and sandier ridges, ending at c. 4.1 ka. The second stage (ridges #85 to #124) ridges is marked by a slight unconformity, and indicates a period of enhanced fluvial progradation and less coastal drift suggesting milder winds up to 3.6 ka. The third stage (ridges #125 to #204) initiates with erosion of ridges near the delta front, being higher and sandier ridges, suggesting enhanced coastal drift due to windier conditions, being the windiest time bracketed between 3.3 and 2.35 ka. The fourth stage (ridges #205 to c. #270) shows again, as second stage, a tendency of wedging out southwards, suggesting enhanced fluvial progradation, estimated between 2.34 and 1.7 ka. The fifth stage is defined by a complete change of coastal plain progradation, due to the rapid recycling of beach ridges into a complex of blow outs and arcuate sand dunes. Ridges are sparsely recognized in cases they developed during short lived events of enhanced longshore drift, with an outstanding group (ridges #288 to #290) that we correlate to a 1.1–0.9 ka cooling event. Future studies, improving the chronostratigraphy of the beach ridges succession at Rio Grande and comparing it with the Paraná river delta ridges, will help understanding the complex environmental history of South America, that include a reversal of the longshore drift, given the fact they are among the most complete upper Holocene geoarchives available.

1. Introduction

Coastal beach ridge successions could be very good geoarchives to understand the recent climatic and environmental evolution of a region (cf. Otvos, 2000; Reimann et al., 2011; Dörschner et al., 2012; Hinojosa et al., 2016; Vespremeanu-Stroe et al., 2016). The southern coast of Brazil, shows extensive development of beach ridge successions but their significance for understanding the climate history of this part of the South American continent is still unexploited. This is partly related to the scarcity of detailed stratigraphic studies of the very last coastal events and the lack of instrumental records that show a short to medium term evolution of coastal parameters, in spite of the thousands of km of coast that is today heavily populated. For instance, a very important aspect on

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coastal evolution is determining the real value of longshore sediment transport (LST) or drift, based on field measurements. Instead, many models are applied to estimate the LST flow (Martinho et al., 2006, 2010; Dillenburg et al., 2006; Dillenburg and Hesp, 2009), but they are based on events of coastal erosion and growth, while no field measurements of longshore coastal currents or LST are shown. Thus, the best way to learn about the coastal dynamics given the lack of instrumental deployed at the coastal or shoreface environments, is to extrapolate the effect of the wave structure during fair weather and storms, on the coast of Rio Grande do Sul state (RGDS). On this sense, the work of Guimarães et al. (2014) is one of the best as it takes all data available offshore, but it still faces the problem that those results cannot be confronted against shore data of similar quality. As a result, longshore drift is still a qualitative issue, instead of being quantified by instrumental records. In this scenario, it is clear for most authors that the present-day dominant longshore drift is northeast directed (cf. Dillenburg and Hesp, 2009), but that is composed by two different modes: A fair weather mode that moves the sand in the southwest direction, and a storm mode that has a dominant effect and moves the sand northeastwards.

The state of RGDS is characterized by an extensive, slightly sinuous and 620 km long and NE–SW orientation (Fig. 1). It includes the Cassino Beach, considered one of the longest sandy beaches worldwide (Dillenburg et al., 2004). All this extension consists of unconsolidated deposits from quaternary rivers and beach deposits, and most authors consider that the modern shore does not receive sand contributions from modern sources (cf. Dillenburg and Hesp, 2009). However, studies of the modern dynamics of the Rio Grande estuary located right at the north end of the Cassino Beach suggest the contrary. The detailed study compiled by Asmus (2007) showed that bottom samples taken across a year showed high contents of sand (January: 42%, June: 26% and October 33%, average of 10 bottom samples). This bottom composition plus the fact measured stream velocities reached 1.5 m/s, with modeled velocities for flood discharge peaks would reach up to 4 m/s, suggest that there should be some active sand transport along the Rio Grande estuary seawards, and therefore it could be considered a potential modern sand source.

On the other hand, the local continental shelf extends more than 150 km from the shore attaining maximum depths between 100 and 140 m and a slope of c. 0.06. The shoreface is very wide and shallow and Toldo et al. (2006) suggest a local boundary at a depth of 10 m, where deposits are dominantly sandy. According to Fachin (1998), the shoreface geomorphology is different to the south or north of the Rio Grande estuary. To the south, and for c. 60 km, it shows gradually decreasing depth seawards, while to the north; he observed a high concentration of sand ridges oriented roughly parallel to the shore. This difference south and north from Rio Grande estuary, creates an important effect on wave attenuation, which seems to be more important south of Rio Grande estuary according to Guimarães et al. (2014), limiting the effects of storm waves. Local storms today considered as the main forcing of longshore drift (directed to the NE, cf. Dillenburg and Hesp, 2009), are

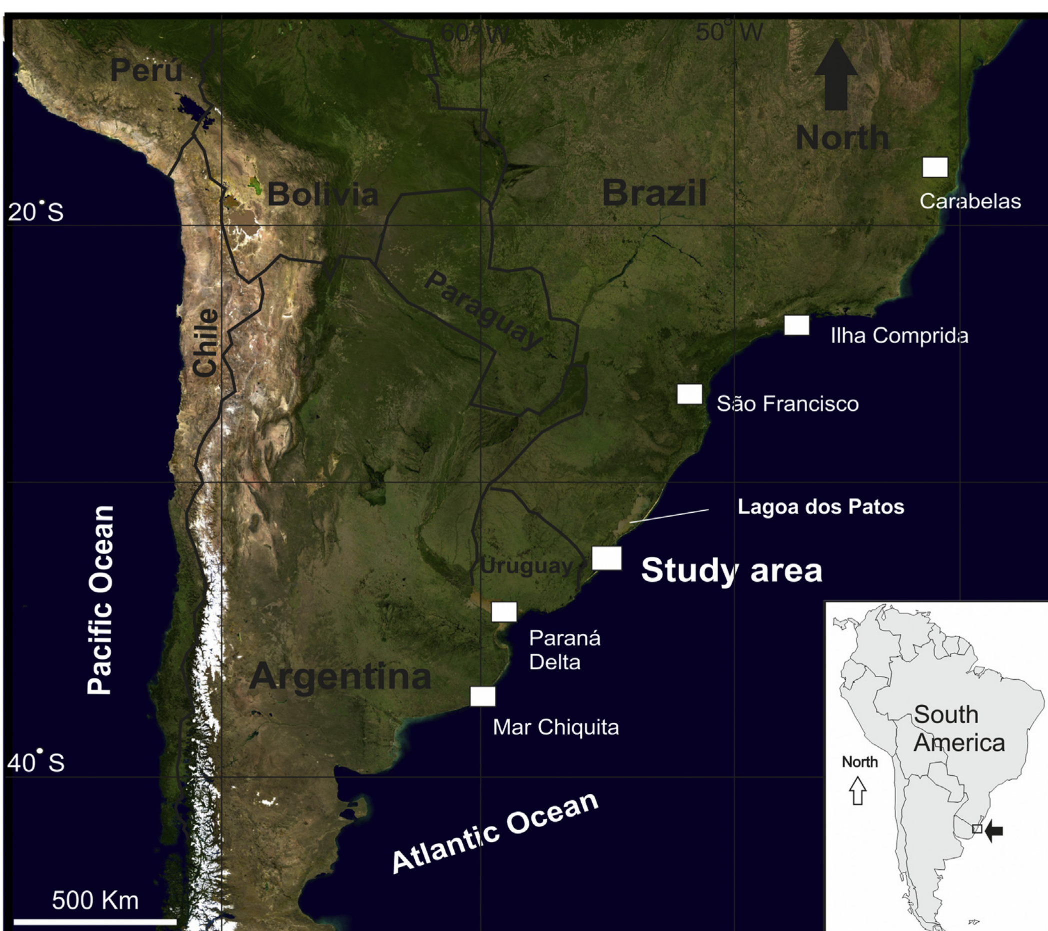

Fig. 1. Location map of the study area and other coastal realms mentioned in the text.