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Interaction of the South American Monsoon System and the Southern Westerly Wind Belt during the last 14 kyr

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ABSTRACT

Surface currents and sediment distribution of the SE South American upper continental margin are under the influence of the South American Monsoon System (SAMS) and the Southern Westerly Wind Belt (SWWB). Both climatic systems determine the meridional position of the Subtropical Shelf Front (STSF) and probably also of the Brazil–Malvinas Confluence (BMC). We reconstruct the changing impact of the SAMS and the SWWB on sediment composition at the upper Rio Grande Cone off southern Brazil during the last 14 cal kyr BP combining sedimentological, geochemical, micropaleontological and rock magnetic proxies of marine sediment core GeoB 6211-2. Sharp reciprocal changes in ferri- and paramagnetic mineral content and prominent grain-size shifts give strong clues to systematic source changes and transport modes of these mostly terrigenous sediments. Our interpretations support the assumption that the SAMS over SE South America was weaker than today during most of the Late Glacial and entire Early Holocene, while the SWWB was contracted to more southern latitudes, resembling modern austral summer-like conditions. In consequence, the STSF and the BMC were driven to more southern positions than today's, favoring the deposition of Fe-rich but weakly magnetic La Plata River silts at the Rio Grande Cone. During the Mid Holocene, the northern boundary of the SWWB migrated northward, while the STSF reached its northernmost position of the last 14 cal kyr BP and the BMC most likely arrived at its modern position. This shift enabled the transport of Antarctic diatoms and more strongly magnetic Argentinean shelf sands to the Rio Grande Cone, while sediment contributions from the La Plata River became less important. During the Late Holocene, the modern El Niño Southern Oscillation set in and the SAMS and the austral tradewinds intensified, causing a southward shift of the STSF to its modern position. This reinforced a significant deposition of La Plata River silts at the Rio Grande Cone. These higher magnetic silts with intermediate Fe contents mirror the modern more humid terrestrial climatic conditions over SE South America.

1. Introduction

The SE South American continental margin (ca. 22°–55° S) is under influence of tropical and extratropical climatic and oceanographic regimes (Fig. 1). Its northern sector (22°–38° S) is affected by the warm southward-flowing Brazil Current and its southern sector (38°–55° S) by the cold northward-flowing Malvinas Current (Palma et al., 2008). Both currents meet and merge in the Brazil–Malvinas Confluence (BMC) at ~38°. As a continuation of the BMC on the shelf, the Subtropical Shelf Front (STSF) divides cold and fresh Subantarctic Shelf Waters from warm and salty Subtropical Shelf Waters (Piola et al., 2000). From landside, the La Plata Drainage Basin (LPDB) releases large amounts of freshwater and sediments through the La Plata Estuary into this complex shelf system. The northeastward-directed Brazilian Coastal Current carries this Plata Plume Water at the inner continental shelf along Uruguay and towards SE Brazil (Souza and Robinson, 2004). This near-surface flow displays high seasonal and interannual variability (Piola et al., 2005). Models and observations indicate that during austral summer the buoyant upper layer flows more southwestward and the low salinity Plata Plume Water is constrained south of 32° S (Piola et al., 2000; Palma et al., 2008). At interannual time scales the plume's northeastward spreading is also modulated by alongshore southwesterly winds, being most extreme during La Niña events. In contrast, although El Niño peaks are associated with largest river outflows, the plume spreading is limited by anomalously strong northeasterly winds (Piola et al., 2005).

Several sediment-based paleostudies have recently provided clues on the past extent of these water masses off SE South America. A multi-proxy approach of Mahiques et al. (2009) was able to show changes in the northward reach of the Plata Plume Water on the

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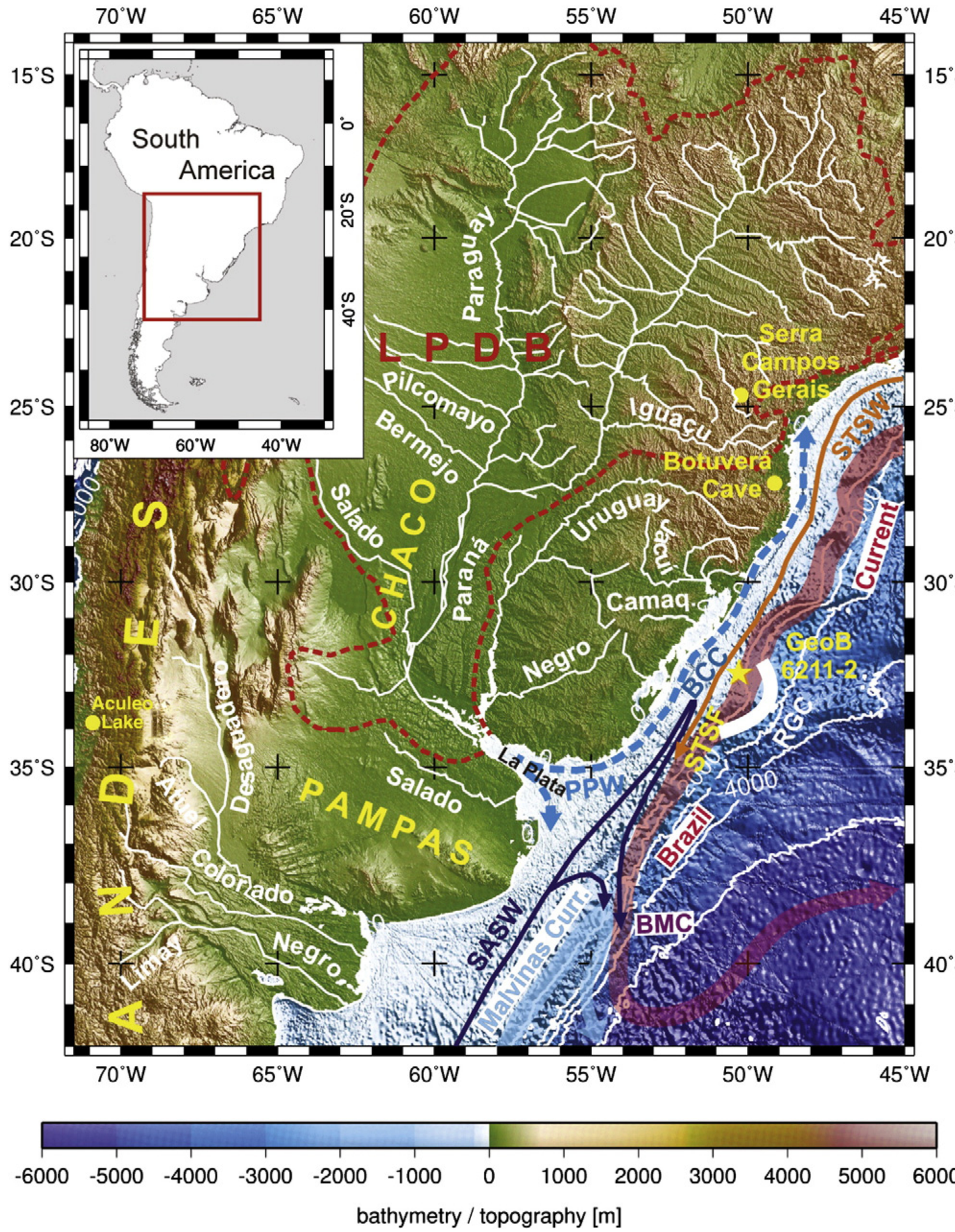

Fig. 1. Study area at the continental margin of SE South America showing the location of gravity core GeoB 6211-2 (yellow star) at the Rio Grande Cone (RGC, marked as thick white contour line). On land, the main geographic features and rivers (white lines) are shown with locations of sites cited in this study (yellow dots). Contour currents (transparent, thick arrows) are imposed after the GEBCO bathymetry (0.5 min grid). The Subantarctic Shelf Water (SASW) and the Subtropical Shelf Water (STSW) are marked as thin, opaque arrows. The Plata Plume Water (PPW) together with the Brazilian Coastal Current (BCC) is displayed as a dashed blue line. The Brazil and the Malvinas Currents encounter each other in the Brazil–Malvinas Confluence (BMC) (oceanography after Piola et al., 2008). The location of the investigation area (red square) in respect to South America is inserted in the upper left corner of the figure.

inner shelf off SE Brazil. They explained a low terrigenous sediment input between 5.2 and 3.0 cal kyr BP by weaker southwesterly winds driven by the Southern Westerly Wind Belt (SWWB) and by lower humidity in SE South America. Higher terrigenous input was observed after 3.0 cal kyr BP and linked to the development of the modern South American Monsoon System (SAMS) and the La Plata River discharge. While Mahiques et al. (2009) were only mentioning sediments originating from the LPDB, Gyllencreutz et al. (2010) assumed the Argentinean shelf as provenance for anomalously sandy sediments deposited at the South Brazilian shelf between 7.0 and 5.0 cal kyr BP. According to their view, the termination of this sediment flux was caused by an intensified Plata Plume Water outflow, creating a barrier for the Subantarctic Shelf Water off the La Plata Estuary; evidently, these two interpretations are in conflict. In addition to the latter two studies dealing with shelf processes, Laprida et al. (2011) were able to reconstruct latitudinal changes in the paleoposition of the BMC during MIS 6 and 8 based on planktonic foraminifera. However, it is not known to date, if and how far the STSF and the BMC shifted during the Holocene. Our study seeks for evidence of postglacial shifts in the STSF position and tries to answer the question whether only LPDB sediments or also Argentinean shelf sediments reached latitudes north of 38° S during the last 14 cal kyr. We investigate multi-proxy source and transport signatures of postglacial terrigenous sediments off South Brazil and use their records to reconstruct Holocene sediment dynamics and oceanographic variations at the SE South American upper continental margin.

An intensification of the SAMS during the Holocene has been made responsible for precipitation changes over SE South America by several studies (e.g., Behling, 1997; Cruz et al., 2005). Other