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The high-supply, current-dominated continental margin of southeastern South America during the late Quaternary

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ABSTRACT

The continental margin off the La Plata Estuary (SE South America) is characterized by high fluvial sediment supply and strong ocean currents. High-resolution sediment-acoustic data combined with sedimentary facies analysis, AMS-^{14}C ages, and neodymium isotopic data allowed us to reconstruct late Quaternary sedimentary dynamics in relation to the two major sediment sources, the La Plata Estuary and the Argentine margin. Sediments from these two provinces show completely different dispersal patterns. We show that the northward-trending La Plata paleo-valley was the sole transit path for the huge volumes of fluvial material during lower sea levels. In contrast, material from the Argentine margin sector was transported northwards by the strong current system. Despite the large sediment volumes supplied by both sources, wide parts of the shelf were characterized by either persistent non-deposition or local short-term depocenter formation. The location and formation history of these depocenters were primarily controlled by the interplay of sea level with current strength and local morphology. The high sediment supply was of secondary importance to the stratigraphic construction, though locally resulting in high sedimentation rates. Thus, the shelf system off the La Plata Estuary can be considered as a hydrodynamic-controlled end-member.

Introduction

Continental shelf systems off major rivers are usually characterized by a high supply of clastic sediments. As a consequence, deposits on continental shelf and slope are laterally extensive with high accumulation rates (Kuehl et al., 1997; Hübscher et al., 2002; Hanebuth et al., 2011). In contrast, bypassing, winnowing and erosion of sediments, sweeping by persistent unidirectional currents, and redeposition are common processes on shelves dominated by a high-energy oceanographic regime (Flemming, 1981; Ikehara, 1989; Cawthra et al., 2012). The knowledge on the general sedimentary buildup and evolution of these high-energy systems remains sparse due to difficulties in sampling the commonly coarse-grained material. The continental margin off SE South America is characterized by both the highest sediment supply by the La Plata River (Plata hereafter; Depetris and Griffin, 1968; Urien, 1972) as well as strong oceanographic currents (Möller et al., 2008; Palma et al., 2008). The Uruguay and Paraná Rivers, on the one hand, supply a suspended sediment load of 100 Mt yr^{-1} (Milliman and Farnsworth, 2011) to the Plata Estuary and the adjacent continental shelf. The shelf hosts, on the other hand, one of the worldwide strongest current regimes (Gwilliam et al., 1997; Palma et al., 2008). Prior to this study, the resulting late Quaternary stratigraphic architecture and depocenter shifts were virtually unknown.

Although continental margins represent the major sink for terrigenous particles along the source-to-sink pathway from continental interior to the deep sea, the precise routes of sediment transport remain often unknown. For instance, canyons off major rivers are usually suggested to have been the main material conduit during lower sea levels (van Wagoner et al., 1988). At the continental margin off SE South America, sediment pathways during stages of lower sea level are still matter of debate and several possible main transport routes have been proposed in the literature (Lonardi and Ewing, 1971; Urien and Ottmann, 1971; Urien and Ewing, 1974; Urien et al., 1980a,b). These alternative pathways would, however, result in completely different patterns of sediment transit and supply to the continental slope.

Here we use a combination of acoustic profiles and information from sediment cores to unravel the late Quaternary history of the SE South American margin. Reconstructing the formation and lateral migration of main depocenters reveals a comprehensive picture of sediment

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distribution and transport pathways during changes in sea level. These deposits also provide valuable information on the export of material to the associated continental slope. Thus, we were able to scrutinize the interaction of high fluvial supply with a strong oceanographic regime on system-wide sedimentation patterns.

Regional settings

Coastal morphology and seafloor physiography

The study area is located off southern Brazil, Uruguay, and northernmost Argentina at approximately 32.5 to 39.5°S (Fig. 1). The shelf width ranges from 130 km off Laguna de Castillos to more than 200 km off Cape San Antonio. The most prominent feature at the coastline is the funnel-shaped Plata Estuary (Fig. 1). In addition, several lagoons developed at the Uruguayan and Brazilian coastlines during Holocene times (e.g., Villwock, 1984; Cordeiro and Lorscheitter, 1994; García-Rodríguez et al., 2004; Fig. 1).

The inner continental shelf off the Uruguayan coast is characterized by an elongated seafloor depression, which represents the Plata paleo-valley (Urien and Ottmann, 1971; Urien and Ewing, 1974; Urien et al., 1980a,b; Laborde, 1999; Cavallotto and Violante, 2005). South of this paleo-valley, the inner shelf shows relicts of complex barrier islands and sand banks that constituted the major morphosedimentary features developed in the region during the post-glacial transgression (Urien and Ewing, 1974; Urien et al., 1980a,b; Parker et al., 2008; Violante et al., 2010).

The outer shelf is characterized by a morphological step at around 80 m, which was reported to be related to a sea-level lowstand delta system (Urien and Ewing, 1974; Urien et al., 1995). Several canyons dissect the continental slope off northern Argentina and Uruguay. Some of these canyons cut back into the shelf break but do not show

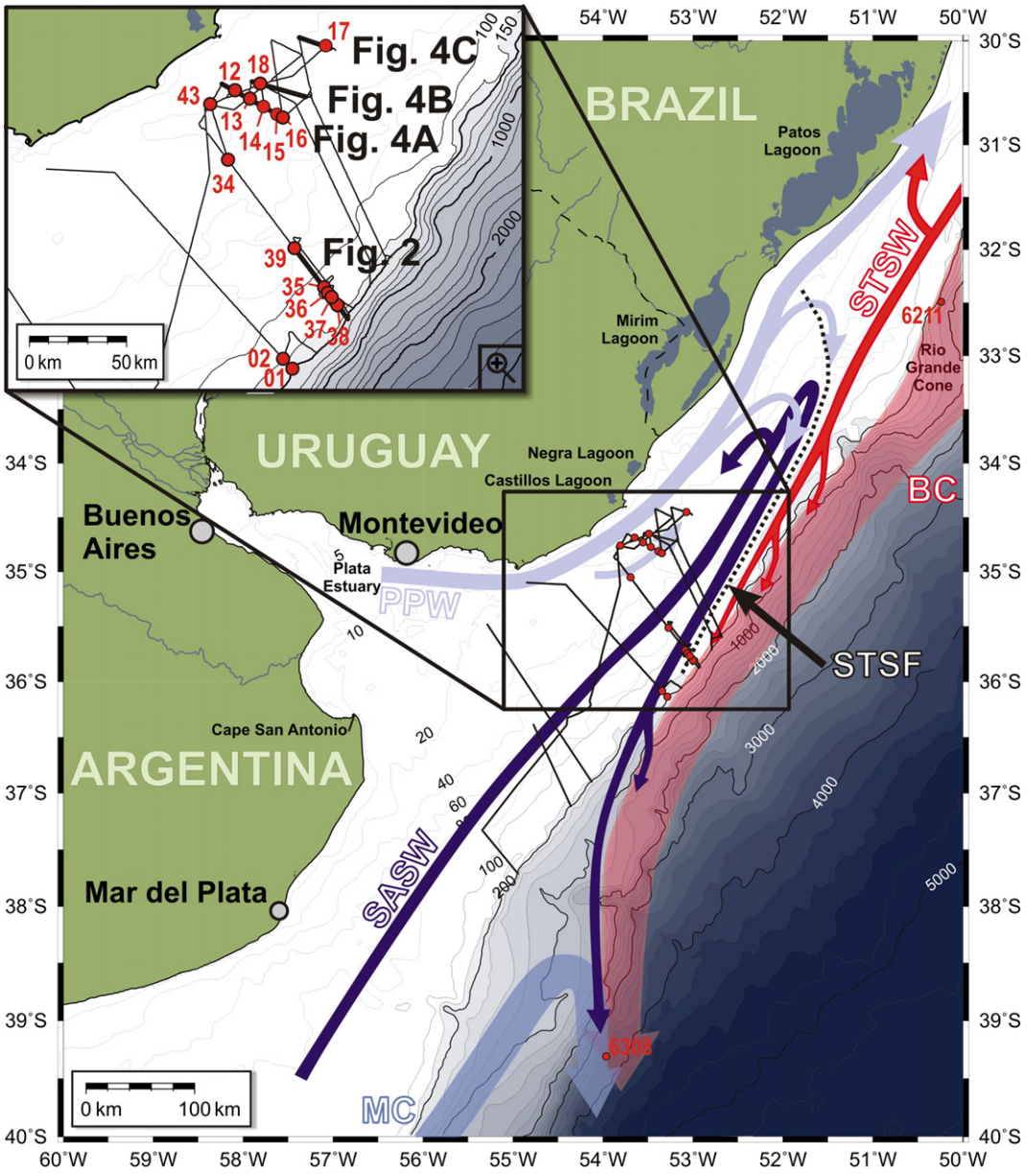

Figure 1. Map of the study area showing acoustic profiles, core positions, and oceanography (base map modified from Bender et al., 2013). Core positions of cruise M78/3 are displayed in short form (e.g., GeoB13817-2 is depicted as "17"). Core positions from cruises M46-2 and M46-3 are displayed as 4-digits (e.g., GeoB6211-2 is depicted as "6211"). Shelf water masses (PPW = Plata Plume Water; SASW = Subantarctic Shelf Water; STSW = Subtropical Shelf Water), their front (STSF = Subtropical Shelf Front), and currents at the continental slope (BC = Brazil Current; MC = Malvinas Current) are displayed as arrows based on Piola et al. (2008). Bathymetric data stems from Martins and Corrêa (1996) and GEBCO (2008). Inlay map shows a magnification of the Uruguayan shelf and location of the acoustic profiles displayed in Figs. 2 and 4 (thick black lines).