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Plankton biochronology for the last 772,000 years from the western South Atlantic Ocean

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ABSTRACT

Calcareous microfossils have potential in the biostratigraphy of Pleistocene sediments and a clear relationship with paleoceanographic studies. Conversely, there are few quantitative biostratigraphic studies of chronologically-tuned events or sections in the western South Atlantic. In order to improve the stratigraphical framework for South Atlantic paleoceanographic studies, the present work attempts to review the last 772,000 years by carrying out a quantitative analysis of the calcareous nannofossil and planktonic foraminiferal assemblages by comparing them with a high resolution marine isotopic record ($\delta^{18}O$). This work is based on the analysis of two piston cores obtained from the continental slope of the Santos Basin in the Santos Drift, southeastern Brazilian Continental Margin. Twelve Pleistocene calcareous nannofossil events and twenty planktonic foraminifera events calibrated with oxygen isotopes and correlated with literature stratigraphies are discussed. This is the first calcareous plankton biochronology study for the last 772 kyr in the western South Atlantic Ocean. More studies in this region will help to establish a more precise biochronology for these calcareous microfossils. This study also presents six new biostratigraphic events of isotopically-caibrated planktonic foraminifera which can be used as markers in the western South Atlantic.

1. Introduction

Biochronological studies are scarce in sections from the South Atlantic, a water body that plays an important role in climatic and oceanic evolution (Wefer et al., 1996) and is crucial to understand global dynamics. Improved isotopic data has permitted the calibration of microfossil data (Raffi et al., 2006; Wade et al., 2011), allowing more accurate correlations between different locations, and consequently, the dating of biostratigraphic events. Over the last few decades, calcareous microfossils have shown potential use in the biostratigraphy of Pleistocene sediments and a clear relationship with paleoceanographic studies. Some examples of biochronological data include Gartner (1977), Thierstein et al. (1977), Matsuoka and Okada (1990), Raffi et al. (1993, 2006), Wei (1993), Hine and Weaver (1998), Bollmann et al. (1998), Flores and Marino (2002) and Golovina et al. (2008) for calcareous nannofossils and Aksu and Kaminski (1989), Martin et al. (1990, 1993), Jorissen et al. (1993), Martinez et al. (2007) and Wade et al. (2011) for planktonic foraminifera.

Conversely, there are few quantitative biostratigraphic studies of chronologically-tuned events or sections in the southwestern Atlantic (Vicalvi, 1999; Tokutake and Toledo, 2007; Pivel et al., 2013; Camillo et al., 2015). Unfortunately, they are time restricted, covering a maximum of 130,000 years B.P. For this reason, it is common to find local workers referring to biozone boundary ages previously defined from different localities, such as the Gulf of Mexico, Caribbean Sea and Tropical Atlantic (see Vicalvi, 1997; Antunes, 1994, 2007; Portilho-Ramos et al., 2006; Ferreira et al., 2012). Precise age determination and evaluation of the synchrony of micropaleontological data are essential for making age-control points, which then help to estimate ages and sedimentation rates or to interpret isotope, carbonate and magneto-stratigraphy records.

In order to improve the stratigraphical framework for South Atlantic paleoceanographic studies, the present work attempts to review the last 772,000 years by carrying out a quantitative analysis of the calcareous nannofossil and planktonic foraminiferal assemblages and by comparing them with a high-resolution marine isotopic record ($\delta^{18}O$).

2. Material and methods

2.1. Core locations

This work is based on the analysis of two piston cores,GL-854 - 25° 12′S, 42°37′ W, 2220 m depth and GL-852 - 25°01′S, 43°33′W, 1938 m

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depth, obtained from the continental slope of the Santos Basin in the Santos Drift, southeastern Brazilian Continental Margin during the Fugro Explorer Campaign 2007 (Fig. 1).

The Santos Basin is a large sedimentary basin that has been the focus of attention in the oil industry over the past 30 years. Despite several earlier studies and the economic interest owing to its potential hydrocarbon reserves, its paleoceanographic evolution remains poorly known. The continuity of oil-industry investigations has resulted in a growing knowledge of the basin, involving both tectono-structural approaches (Chang and Kowsmann, 1987; Macedo, 1989, 1990; Chang et al., 1992; Demercian et al., 1993; Mohriak et al., 1995; Cobbold et al., 2001; Meisling et al., 2001) and sedimentary–stratigraphic approaches (Pereira and Macedo, 1990; Pereira, 1994; Modica and Brush, 2004).

The ocean surface dynamics is controlled by the South Atlantic subtropical gyre. Present day surface hydrography is dominated by the presence of the southward-flowing warm, saline and nutrient-depleted Brazil Current (BC) (Stramma and England, 1999; Rodrigues et al., 2007). The BC flows along the Brazilian margin to the Subtropical Convergence Zone where, around 38°S, it meets the Falkland Current. Seismic studies in the Santos Basin suggest that sedimentation from the Neogene to Recent times was dominated by surface oceanic circulation redistributing the sediments transferred to the basin during both relative sea-level high stands and low stands (Duarte and Viana, 2007).

2.2. Lithology

The core description was performed at a 1:20 scale and included color (GSA Color Chart), visual grain size, lithology and primary structures. Facies classification was based on the combination of grain size and $CaCO_3$ content, the latter being estimated by the intensity of the reaction with a 10% HCl solution, frequently calibrated by calcimetric analysis. Thus, a fine-grained facies is classified as a marl when the $CaCO_3$ content reaches between 60 and 30%, carbonate-rich mud between 30 and 18%, carbonate-poor mud between 18 and 5% and mud with a $CaCO_3$ content of <5%.

2.2.1. Core GL-854

Core GL-854 had a recovery of 2038 cm of a continuous record with no observed hiatuses, composed of carbonate-rich mud intercalated with carbonate-poor mud and marl. A total of 409 samples were studied for both micropaleontological and geochemical studies; each sample was 2 cm thick and taken at 5 cm intervals throughout the core. According to the adopted age model the sample interval results in a temporal resolution of approximately one sample every 2 kyr.

2.2.2. Core GL-852

Core GL-852 also provided a continuous record with no observed hiatuses and had a recovery of 2030 cm, composed of carbonate-poor mud intercalated with carbonate-poor mud and marl. This core was sampled for both micropaleontological and geochemical studies at 10 cm intervals between the core top and 1040 cm and 5 cm intervals from 1045 cm to the base of the core (2030 cm). GL-852 has 302 studied samples resulting in a temporal resolution of approximately one sample every 0.5–1 kyr.

2.3. Calcareous nannofossil and planktonic foraminifera preparations

Quantitative analyses of calcareous nannofossils and planktonic foraminifera of cores GL-854 and GL-852 were performed using relative abundances (%) of selected species for both biostratigraphic analyses in order to compare our data with those previously published.

For calcareous nannofossil slide preparations we followed the modified pipette strew slide technique (Antunes, 1997), whereby a small amount (0.2 g) of sediment is selected, placed in a vial with a constant volume of distilled water, stirred and then left to disintegrate for a few hours. After stirring again, a small amount of the suspension is pipetted onto a coverslip, dried on a hotplate, and then the coverslip is affixed to a labeled glass slide using Canada balsam. Slides were examined using a Zeiss Axio Image 2 optical microscope under cross-polarized light, at 1600× magnification. The taxonomic frameworks of Perch-Nielsen (1989); Bown (1998 and references therein) and Antunes (2007) have been followed for identification. For quantitative analysis, at least 300 nannoliths were counted per slide in a random number of fields of view. This allows a 95% level of confidence to be reached for all species present in at least 1% abundance (Patterson and Fishbein, 1989). Then, a second counting was employed to remove noise due to particularly abundant species (small placoliths <3 μm).

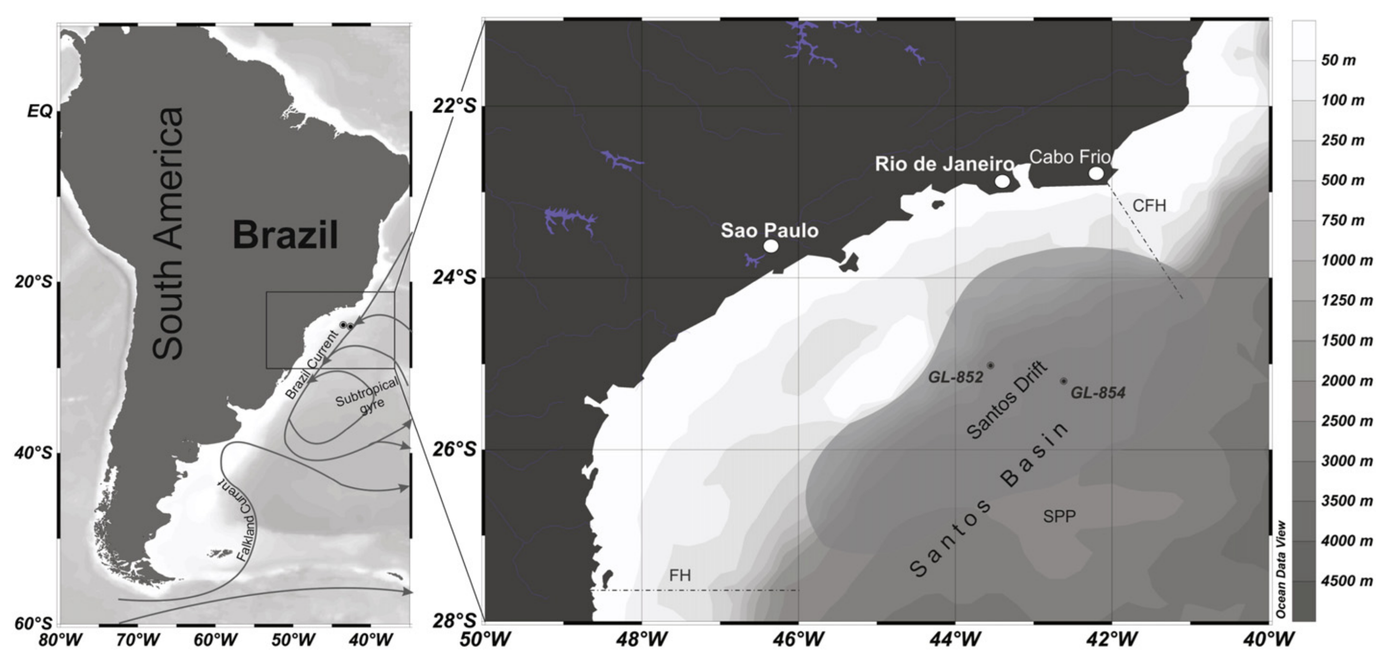

Fig. 1. Core locations and schematic figure of the oceanography and physiography of the study area. Arrows indicate surface flows and the shaded area the location of the Santos Drift. Dashed lines delimit the Santos Basin. FH: Florianopolis High; CFH: Cabo Frio High; SPP: Sao Paulo Plateau.