Renata Hanae Nagai

**Mid to Late Holocene paleoceanographic changes in the
Southern-Southeastern Brazilian shelf**

Tese apresentada ao Instituto Oceanográfico da Universidade de São Paulo, como parte dos requisitos para obtenção do título de Doutor em Ciências, Programa de Oceanografia, área de Oceanografia Geológica.

Orientador: Prof. Dr. Michel M. de Mahiques

Co-orientador: Prof^a. Dr^a. Silvia Helena de Mello e Sousa

São Paulo

2013

Universidade de São Paulo

Instituto Oceanográfico

Mid to Late Holocene paleoceanographic changes in the Southern-Southeastern Brazilian shelf

Renata Hanae Nagai

Tese apresentada ao Instituto Oceanográfico da Universidade de São Paulo, como parte dos requisitos para obtenção do título de Doutor em Ciências, Programa de Oceanografia, área de Oceanografia Geológica

Julgada em/Evaluated in ____/____/____

_____	_____
Prof(a). Dr(a).	Conceito/Grade
_____	_____
Prof(a). Dr(a).	Conceito/Grade
_____	_____
Prof(a). Dr(a).	Conceito/Grade
_____	_____
Prof(a). Dr(a).	Conceito/Grade
_____	_____
Prof(a). Dr(a).	Conceito/Grade

“Sem ética e competência não se faz ciência.”

Prof. Dr. Ricardo R. Brentani (*In memoriam*)

Acknowledgements

This work was only possible due to the support of innumerable people that closely participated in the personal and professional fields of my life in the last 4 years (and beyond). Specially, none of this would be possible without the love and support of my **family**. I am forever thankful to my parents **Maria Aparecida** and **Helio Mitsuo Nagai**, my sister **Paula Junie Nagai** and my partner **Diogo Luiz Paes dos Santos**.

The constant thirst for knowledge and love for science of my supervisor **Prof. Dr. Michel M. Mahiques** (a.k.a. *Chefinho*) – you are the best!, and co-supervisor **Prof. Dr. Silvia H. M. Sousa** pushed me to go further and inspired me.

As no science is ever done alone, especially paleosciences, a number of collaborators participate providing lab infrastructure and data discussion in Brazil and overseas. The sedimentary organic and inorganic composition of the sediments had incredible support from IOUSP **Prof. Dr. Rubens C.L. Figueira** and his students (**Dr. Andressa Ribeiro**, **Charles E.A. Silva**, and **Alexandre B. Salaroli**) and **Prof. Dr. Marcia Caruso Bicego**.

The mineralogy data could not have been obtained without **Prof. Dr. Fernando Rocha** from Aveiro University (Portugal) and **Dr. M. Virginia A. Martins** to whom I am very grateful for the help with the benthic foraminifera and hospitality in my stay in Aveiro.

The geochemical analysis in foram shells were done during a short stay in at the MARUM Institute in Bremen (Germany) this was only possible because **Dr. Stefan Mulitza** agreed to collaborate and receive me there, and due to **Dr. Henning Kunhert** for the patience in showing me the Mg/Ca lab procedures (and explaining a thousand times how the ICPMS worked!), I am indebted to you both. While in my stay in Bremen, I had contact with **Dr. Till Hanebuth** and his working group, to whom I am also thankful for the hospitality and data discussion in the Argentina Meetings. And a special thanks to **Vera B. Bender** (now Dr.) for the good moments in Bremen in and out of the office!

I am also indebted with **Prof. Dr. Cristiano M. Chiessi**, with his never ending enthusiasm over science, for all the data discussion, reference sharing and advices. And many other USP professors for giving the background knowledge and tools necessary to achieve this

work goals, such as **Prof. Dr. Alexander Turra**, **Prof. Dr. Francisco W. Cruz**, **Prof. Dr. Ilana Wainer** and **Prof. Dr. Tércio Ambrizzi**.

During these PhD years not only hard work and discussions were important, a good working environment and some fun were also very much necessary. After endless hours at the stereo-microscope the girls (**Carlinha**, **Liz**, **Naira**, **Nancy**, **Pi**, **Poli** and **Thaísa**) at the lab still made me laugh! A special thanks to **Cintia** for all the doubt taking in the benthic foram identification. The help from the undergraduate students **Daniel** (now MSc.), **Ianco**, **Mariana** and **Tito** is also very much appreciated.

After work and during coffee pauses the companionship of friends from the undergraduate times were fundamental **Cintia** (again), **Hell**, **Luciana**, **João Carlos**, **Marcus**, and **Marcos** and the not so close but always present **Michael**, **Paulinha** and **Simone**. (love you guys!). And during the weekends my dear friends **Cacá**, **Caio**, **Cidão**, **Dani**, **Digo**, **Fi**, **Futoshi**, **July**, **Lê**, **Sumô** and **Tchou** brought me back to the social world and gave me perspective outside science (after 20 many years still have you all as my friends is a privilege!).

At last but not least I am very grateful to everyone from of the administrative and technical staff of all the involved institutions, especially those part of the **IOUSP** community, for making this work possible.

This work would not be possible without the support and funding of **FAPESP** for core collection, geochemical analysis and my scholarship (FAPESP n° 2009/01594-6). Also supplementary financial support contributions were received from **USP Pró Reitoria de Pós-Graduação** and **GLOMAR**.

Summary

Resumo	xiii
Abstract	xiv
1. Introduction	1
1.1. Primary productivity: the link between ocean and climate	1
1.2. Mid- and Late Holocene	2
2. Objectives	5
3. Study area	6
3.1. Sedimentology	6
3.2. Modern oceanographic settings	9
3.3. Modern climatic conditions	12
4. Materials and methods	17
4.1. Chronology	17
4.2. Sedimentological analysis	18
4.3. Geochemical analyses	19
4.3.1. Sedimentary organic matter	19
4.3.2. Calcium carbonate (CaCO ₃)	21
4.3.3. Sedimentary inorganic constituents	21
4.3.4. Mineralogy	23
4.3.5. Neodymium (Nd) isotopes	25
4.4. Microfaunal analyses	26
4.4.1. Chemical composition of planktonic foraminifera tests	27
4.4.1.1. Elemental ratios in planktonic foraminifera tests - Mg/Ca ratios	28
4.4.1.3. Stable oxygen ($\delta^{18}\text{O}_c$) and carbon ($\delta^{13}\text{C}$) isotopic composition	31

4.4.2. Benthic foraminifera community	34
5. Results.....	37
5.1. Core 7605 (27°6.24'S, 47°48.24'W – Itajaí/SC)	37
5.1.1. Chronology	37
5.1.2. Sedimentological analyses	38
5.1.3. Geochemical analysis	39
5.1.4. Microfaunal analyses	46
5.1.4.1. Chemical composition of planktonic foraminifera tests	46
5.1.4.2. Benthic foraminifera community.....	47
5.2. Core 7610 (25°30.48'S, 46°38.1'W – Cananéia/SP).....	53
5.2.1. Chronology	53
5.2.2. Sedimentological analyses	55
5.2.3. Geochemical analysis	56
5.2.4. Microfaunal analyses	64
5.2.4.1. Chemical composition of planktonic foraminifera tests.....	64
5.2.4.1.1. Elemental ratios in planktonic foraminifera tests - Mg/Ca and Ba/Ca ratios	64
5.3. Core 7616 (25°5.88'S, 45°38.64'W – Santos/SP).....	66
5.3.1. Chronology	66
5.3.2. Sedimentological analyses	68
5.3.3. Geochemical analysis	70
5.3.4. Microfaunal analyses	77
5.3.4.1. Chemical composition of planktonic foraminifera tests	77
5.3.4.2. Benthic foraminifera community.....	79
6. Discussion	85

6.1. Mid- to Late Holocene hydrodynamic changes in the S/SE Brazilian shelf - depositional processes and sediment provenance.....	85
6.2. Paleoproductivity changes in the S/SE Brazilian shelf during Mid- and Late Holocene ..	93
6.3. Tracing Mid- and Late Holocene La Plata River influence over the S Brazilian continental shelf – insolation driven changes.....	101
6.4. Surface waters temperature and salinity changes in the Santos Basin in the last 7000 years	106
7. Summary and conclusions	114
8. References	116
Plate 1	143
Plate 2	144

Table index

Table 1– Cores locations coordinates (latitude and longitude) and water depth, and sedimentary column recovery.	17
Table 3– Diagnostic peaks and weighting factors applied for the identified minerals.....	24
Table 3 – ^{14}C AMS radiocarbon dating results for core 7605 and 2σ calibrated age ranges, no age inversion in radiocarbon dates was observed.	37
Table 4 – ϵNd data obtained for core 7605.	46
Table 5 - ^{14}C AMS radiocarbon dating results for core 7610 and 2σ calibrated age ranges, no age inversion in radiocarbon dates was observed.	54
Table 6 - ^{14}C AMS radiocarbon dating results for core 7616 and 2σ calibrated age ranges, no age inversion in radiocarbon dates was observed.	67
Table 7 – ϵNd data obtained for core 7616.	75

Figure index

Figure 1– Location map, showing studied cores (7605, 7610 and 7616) site collection locations with an (a) schematic drawing of the main oceanic currents influencing the S/SE Brazilian shelf the Brazil Coastal Current (BCC) and the Brazil Current (BC), following the works of Souza and Robinson (2004) and Silveira et al. (2000); and (b) Distribution of the mean diameter (Φ) of the surface sediments, modified after Mahiques et al. (2004) and Gyllencreutz et al. (2010).	7
Figure 2– (a) Geological framework of the South American continent (modified from Clapperton, 1993 by Mahiques et al., 2008). In a zoom, (b) the schematic geological map of the Paraná River basin (from Depetris and Pasquini, 2007) and (c) a schematic diagram of the relative contribution of major tributaries to La Plata River's mean total discharge (from Pasquini and Depetris, 2007).	10
Figure 3 – South America main atmospheric features the (annual mean 850 hPa geopotential height NCEP-NCAR reanalysis (Kalnay et al. (1996). Where SALLJ stands for the South America Low Level Jet and H for the South Atlantic High.	14
Figure 4 – Cross plot between C/N ratio and $\delta^{13}\text{C}$ values, highlighting distinguish sources of organic matter in sediments and in settling particles, redrawn from Meyers (1994).	20
Figure 5- Latitudinal changes of the ϵNd values found by Mahiques et al. (2008) in SE South America upper margin.	26
Figure 6 – (a) vertical distribution of various planktonic foraminifera species in the Southwest Atlantic, highlighting <i>G. ruber</i> (pink) occurrence in the upper part of the water column (modified from Chiessi et al., 2007); and (b) the relationship between <i>G.ruber</i> (pink) abundance (%) and seawater temperature ($^{\circ}\text{C}$), black dots represent global sediment trap data obtained by Záric et al. (2005), with the optimum temperature range of this species delimited by the gray bar, and red dots represent SE Brazilian continental margin plankton net data from Sousa et al. (submitted).	29
Figure 7 - Age model and uncorrected sedimentation rates ($\text{cm}\cdot\text{kyr}^{-1}$) for core 7605. Age model was based on calibrated radiocarbon ages (red circles), interpolations were obtained through the mixed effect model described by Heegard et al. (2005) – solid line; and the 95% confidence interval - dashed lines.	38

Figure 8– Particle size distribution (PSD), frequency (%) in each size class (ϕ) are indicated by colour-filled contours (legend in bottom), ϵ Nd data, the results of the grain size variations Correspondence Analysis (CA) for core 7605, and representative grain size frequency distributions (size class % versus Φ) for the corresponding core age levels (dashed lines) and labels on the CA-plots.	39
Figure 9 - Along core 7605 distribution of CaCO_3 contents and sedimentary organic matter (TOC and N_{tot} contents, isotopic composition of the organic matter $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and C/N ratio). Black circles represent data and solid gray curves a moving average for every 3 samples.....	40
Figure 10 - (a) cross plot between TOC and N_{tot} , showing significant correlation between variables ($p < 0.05$) and highlighting three distinct groups of sediment samples; and (b) $\delta^{13}\text{C}$ vs. C/N plot, the different fields correspond to end member sources for organic matter preserved in sediments (modified from Meyers, 1994).	41
Figure 11 - Cross plots of (a) Fe vs. Al; (b) Ti vs. Al; (c) Ba/Al vs. TOC; and (d) Ba/Ca vs. TOC. The first three plots (a, b and c) presented statistically significant values ($p < 0.05$) of the Correlation Coefficient.	42
Figure 12 - Along core distribution of (a) sedimentary inorganic constituents (Al, Fe, Ti, Ca and Ba) and (b) elemental ratios (Fe/Ca, Ti/Ca, Ba/Ca and Ba/Al) obtained for core 7605. Black circles represent data and solid black curves a moving average for every 3 samples.	43
Figure 13 - Along core 7605 distribution of the main mineralogical components identified for the $< 63 \mu\text{m}$ size fraction and the Detrital Mineral Index (DM) and Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) indexes. Black circles represent data and solid black curves a moving average for every 3 samples.	45
Figure 14 – <i>G. ruber</i> (pink) $\delta^{18}\text{O}_c$ and $\delta^{13}\text{C}$ composition; alkenone based SST curve from core 7606 (Bicego, 2008); and $\delta^{18}\text{O}_{w-ivc}$ estimates for core 7605. Black circles represent data and solid gray curves a moving average for every 3 samples.	47
Figure 15 – Along core 7605 distribution of benthic foraminifera density ($\text{tests} \cdot 10\text{cc}^{-1}$), epifauna and infauna species percentages, and benthic foraminifera based indexes BFAR ($\text{tests} \cdot \text{cm}^{-2} \cdot \text{kyr}^{-1}$) and BFHP (%). Black circles represent data and solid gray curves a moving average for every 3 samples.	48

Figure 16 –Dendrogram classification resulting from the R-mode cluster analysis (correlation method joined by UPGMA) based on the 12 species with relative abundances higher than 3% in at least 10% of the samples from core 7605.....	49
Figure 17 – Along core 7605 distribution of the relative frequencies of the 12 benthic foraminifera species considered as representative (>3% in at least 10% of samples), grouped according to the R-mode cluster analysis. Black circles represent data and solid gray curves a moving average for every 3 samples.	51
Figure 18 - Benthic assemblage parameters along core 7605 distribution. Where: R – species richness; H' – diversity; and J' - equitability.	53
Figure 19 - Age models and uncorrected sedimentation rates (cm·kyr ⁻¹) for core 7610. Age model was based on calibrated radiocarbon ages (red circles), interpolations were obtained through the mixed effect model described by Heegard et al. (2004) – solid line; and the 95% confidence interval - dashed lines	54
Figure 20 - Particle size distribution (PSD), frequency (%) in each size class (φ) are indicated by colour-filled contours (legend in bottom), εNd data, the results of the grain size variations Correspondence Analysis (CA) for core 7610, and representative grain size frequency distributions (size class % versus Φ) for the corresponding core age levels (dashed lines) and labels on the CA-plots.	55
Figure 21 – Along core 7610 distribution of CaCO ₃ contents and sedimentary organic matter (TOC and N _{tot} contents, isotopic composition of the organic matter δ ¹³ C and δ ¹⁵ N and C/N ratio). Black circles represent data and solid gray curves a moving average for every 3 samples.....	57
Figure 22 – (a) cross plot between TOC and N _{tot} , showing significant correlation between variables (n-1=103; α= 0.05) and highlighting three distinct groups of sediment samples; and (b) δ ¹³ C vs. C/N plot, the different fields correspond to end member sources for organic matter preserved in sediments (modified from Meyers, 1994).	58
Figure 23 – Cross plots of (a) Fe vs. Al; (b) Ti vs. Al; (c) Ba/Al vs. TOC; and (d) Ba/Ca vs. TOC. Statistically significant values (p<0.05) of the Correlation Coefficient are shown.	59
Figure 24 – Along core distribution of (a) the sedimentary inorganic constituents (Al, Fe, Ti, Ca and Ba) and (b) the elemental ratios (Fe/Ca, Ti/Ca, Ba/Ca and Ba/Al) obtained for core 7610. Black circles represent data and solid gray curves a moving average for every 3 samples.....	61

Figure 25 - Along core 7610 distribution of the main mineralogical components identified for the < 63 µm size fraction and the Detrital Mineral Index (DM) and Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) indexes. Black circles represent data and solid gray curves a moving average for every 3 samples.	63
Figure 26 - Crossplot between Mg/Ca ratios against (a) Mn/Ca and (b) Fe/Ca ratios, for core 7610, low R ² values highlight no contamination.....	65
Figure 27 - Along core distribution of chemical composition of <i>G. ruber</i> (pink) (Mg/Ca ratios, δ ¹⁸ O _c and δ ¹³ C composition) and Mg/Ca based SST and δ ¹⁸ O _{w-ivc} estimates obtained for core 7610.....	66
Figure 28 - Age model and uncorrected sedimentation rates (cm·kyr ⁻¹) for core 7616. Age model was based on calibrated radiocarbon ages (red circles), interpolations were obtained through the mixed effect model described by Heegard et al. (2005) – solid line; and the 95% confidence interval - dashed lines	68
Figure 29 – Particle size distribution (PSD), frequency (%) in each size class (φ) are indicated by colour-filled contours (legend in bottom), εNd data, the results of the grain size variations Correspondence Analysis (CA) for core 7616, and representative grain size frequency distributions (size class % versus Φ) for the corresponding core age levels (dashed lines) and labels on the CA-plots.	69
Figure 30 – Along core 7616 distribution of CaCO ₃ contents and sedimentary organic matter (TOC and N _{tot} contents, isotopic composition of the organic matter δ ¹³ C and δ ¹⁵ N and C/N ratio). Black circles represent data and solid gray curves a moving average for every 3 samples.....	70
Figure 31 - (a) cross plot between TOC and N _{tot} , showing significant correlation between variables (n-1=103; α= 0.05) and highlighting three distinct groups of sediment samples; and (b) δ ¹³ C vs. C/N plot, the different fields correspond to end member sources for organic matter preserved in sediments (modified from Meyers, 1994).	71
Figure 32 - Cross plots of (a) Fe vs. Al; (b) Ti vs. Al; (c) Ba/Al vs. TOC; and (d) Ba/Ca vs. TOC. Statistically significant values (p<0.05) of the Correlation Coefficient are shown.	72
Figure 33 - Along core distribution of (a) the sedimentary inorganic constituents (Al, Fe, Ti, Ca, and Ba) and (b) the elemental ratios (Fe/Ca, Ti/Ca, Ba/Ca and Ba/Al) obtained for core 7616. Black circles represent data and solid gray curves a moving average for every 3 samples.....	73

Figure 34 - Along core 7616 distribution of the main mineralogical components identified for the < 63 μm size fraction and the Detrital Mineral Index (DM) and Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) indexes. Black circles represent data and solid gray curves a moving average for every 3 samples.	76
Figure 35 - Crossplot between Mg/Ca ratios against (a) Mn/Ca and (b) Fe/Ca ratios, for core 7616, low R^2 values highlight no contamination.....	77
Figure 36 - Along core distribution of chemical composition of <i>G. ruber</i> (pink) (Mg/Ca ratios, $\delta^{18}\text{O}_c$ and $\delta^{13}\text{C}$ composition) and Mg/Ca based SST and $\delta^{18}\text{O}_{w-ivc}$ estimates obtained for core 7616. Black circles represent data and solid gray curves a moving average for every 3 samples.	78
Figure 37 - Along core 7616 distribution of benthic foraminifera density (tests $\cdot 10\text{cc}^{-1}$), epifauna and infauna species percentages, and benthic foraminifera based indexes BFAR (tests $\cdot \text{cm}^{-2}\cdot \text{kyr}^{-1}$) and BFHP (%).Black circles represent data and solid gray curves a moving average for every 3 samples.	80
Figure 38 - Dendrogram classification resulting from the R-mode cluster analysis (correlation method joined by UPGMA) based on the 13 species with relative abundances higher than 3% in at least 10% of the samples from core 7616.	81
Figure 39 - Along core 7616 distribution of the relative frequencies of the 13 benthic foraminifera species considered as representative (>3% in at least 10% of samples), grouped according to the R-mode cluster analysis. Black circles represent data and solid gray curves a moving average for every 3 samples.	82
Figure 40 – Benthic assemblage parameters along core 7616 distribution. Where: R – species richness; H' – diversity; and J' - equitability.	84
Figure 41 - Upper panel - Left: Particle size distribution (PSD) for cores 7605, 7610, and 7616, where frequency % in each size class is indicated by colour-filled contours (legend in top). Right: Results of a Correspondence Analysis (CA) of grain size variations. Lower panel: Representative grain size frequency distributions (size class % versus Φ), for the cores. The corresponding core age levels are indicated with dashed red lines and labels on the CFA-plots	88

Figure 42 – Relative sea-level curves along the SE South American coast. (A) Southern Rio de la Plata, based on Cavalotto et al. (2004); (B) Salvador (Martin et al., 2003); and (C) envelope for the Brazilian coast north of 28°S (solid lines) and south of 28°S (dashed lines) from Angulo et al. (2006). (From: Gyllencreutz et al., 2010)	88
Figure 43 – Latitudinal changes of the ϵNd values obtained for sediment samples between 55 and 20°S by Mahiques et al. (2008) and the ϵNd values obtained for core 7605 (yellow hexagons) and core 7616 (purple cross) with sample estimated age (kyr cal. BP).	89
Figure 44 – Along core distribution of the below 10 μm fraction (%), sortable silt mean size (ϕ) and Fe/Ca ratios all three cores. Black line and dots represent core 7605; orange, 7610; and purple, 7616.	92
Figure 45 – Schematic drawing showing variation of benthic foraminifera microhabitat depth following the TROX model (Jorissen et al., 1995) and the depth critical levels of oxygen. Modified from: Jorissen (1999)	96
Figure 46 – Comparison between $\delta^{18}\text{O}$ temperature estimates from <i>G. ruber</i> (p) (black dots) with annual mean (dashed line), winter (blue line) and summer (red line) temperature of the first 50m of water column, highlighting that <i>G. ruber</i> (p) records mean annual to summer conditions between 25 and 27°S.	103
Figure 47 – (a) <i>G. ruber</i> (pink) $\delta^{18}\text{O}$ values, (c) TOC contents and (d) Ti/Ca ratio values from core 7605 compared with (b) alkenone based SST estimates from core 7606 (Bícego, 2008), (e) from Al/Si ratio from a core collected at the Uruguay slope (Chiessi et al., 2010), (f) $\delta^{18}\text{O}$ values from Botuverá Cave speleothem record (Wang et al., 2007) and (g) summer insolation at 30°S.	104
Figure 48 - Spatial distribution of precipitation anomalies between HT and HM (HM-HT) based on 61 proxy-records from SE South America. Positive anomalies are represented as blue dots (HM wetter than HT) and negative anomalies as red (HM drier than HT), the orange dot indicating that the HT presented dry and wet episodes.	105
Figure 49 – Mid- and Late Holocene Mg/Ca based SST estimates (red) and seawater isotopic $\delta^{18}\text{O}$ (blue) and $\delta^{13}\text{C}$ (green) composition derived from the chemical analysis of the planktonic foraminifera <i>G. ruber</i> (pink) tests for cores 7610 and 7616. Where data variation (shaded lines); 3 point moving average (bold lines); and significant linear regression (dashed lines).....	106

Figure 50 – Stacked Mg/Ca based temperature ($^{\circ}\text{C}$), $\delta^{18}\text{O}_{\text{w-ivc}}$ and $\delta^{13}\text{C}$ records of the cores obtained by averaging the detrended records; interpolation was done using the largest time interval spacing found in the records (= 60 years). Periods with above mean values are painted in red and with below mean values in blue. 109

Figure 51 – Comparison between our (g) stacked record of Mg/Ca based SST ($^{\circ}\text{C}$) for the SW Atlantic and (f) South America Summer Monsoon precipitation changes recorded by a $\delta^{18}\text{O}$ from a speleothem from Central Brazil (Stiriks et al., 2012); (e) Mg/Ca based SST ($^{\circ}\text{C}$) for the E Equatorial Atlantic (Weldeab et al., 2005); (d) Mg/Ca based SST ($^{\circ}\text{C}$) for the W Equatorial Atlantic (Lea et al., 2003); (c) frequency of El-Niño events per 100 years (Moy et al., 2002); (b) North Atlantic Deep Water – NADW - variations recorded by $\delta^{13}\text{C}$ in *C. wuellerstorfi* tests (Oppo et al., 2004); and (a) percentages of HSG in the N Atlantic marking Bonds events also marked in blue numbered (Bond et al., 2001). 113

Appendix index

Appendix 1 - Main sedimentological (grain size) and geochemical (sedimentary organic matter and inorganic constituents, mineralogy, and planktonic <i>G. ruber</i> (p) isotopic composition) data obtained for core 7605. (CD).....	145
Appendix 2 – Core 7605 benthic foraminifera community data, identified taxa microhabitat classification and relative frequency (%), and values of density (tests·10cc ⁻¹), percentages of fragments, non-identified specimens, epifauna and infauna specimens, productivity indexes BFHP (%) and BFAR (tests·cm ⁻² ·kyr ⁻¹) and ecological parameters richness (S), Shannon diversity (H') and equitability (J'). Where: epifauna (E) and infauna (I). (CD)	145
Appendix 3 – Main sedimentological (grain size) and geochemical (sedimentary organic matter and inorganic constituents, mineralogy, and planktonic <i>G. ruber</i> (p) isotopic and elemental composition) data obtained for core 7610. (CD)	145
Appendix 4 – Main sedimentological (grain size) and geochemical (sedimentary organic matter and inorganic constituents, mineralogy, and planktonic <i>G. ruber</i> (p) isotopic and elemental composition) data obtained for core 7616. (CD)	145
Appendix 5 - Core 7616 benthic foraminifera community data, identified taxa microhabitat classification and relative frequency (%), and values of density (tests·10cc ⁻¹), percentages of fragments, non-identified specimens, epifauna and infauna specimens, productivity indexes BFHP (%) and BFAR (tests·cm ⁻² ·kyr ⁻¹) and ecological parameters richness (S), Shannon diversity (H') and equitability (J'). Where: epifauna (E) and infauna (I). (CD)	145

Resumo

Neste estudo uma visão *multi-proxy* foi aplicada na compreensão das mudanças nas condições oceanográficas em que a plataforma continental S/SE Brasileira foi submetida ao longo do Holoceno Médio e Tardio. Para isso *proxies* sedimentológicos, geoquímicos e microfaunísticos foram estudados em três testemunhos marinhos de alta resolução coletados ao longo da plataforma S/SE do Brasil e discutidos sob uma perspectiva oceanográfica e climática regional e global. No Holoceno Médio e Tardio, os processos deposicionais da plataforma S/SE Brasileira foram influenciados por dois processos hidrodinâmicos distintos: (i) a presença da Pluma do Rio La Plata, trazendo sedimentos oriundos da Bacia de drenagem do Rio La Plata, e (ii) os movimentos *onshore/offshore* da Corrente do Brasil, no Holoceno Médio, trazendo sedimentos oriundos da margem SE Brasileira para porção norte da Bacia de Santos (25°S). A zona de influência do Rio La Plata estendeu-se a latitudes mais ao norte atingindo 25°S, no Holoceno Tardio, especialmente nos últimos 3000 anos, como resultado do aumento nos regimes de precipitação sobre a Bacia de drenagem desse rio. As águas superficiais da plataforma S/SE Brasileira foram fertilizadas pelas águas mais frias e menos salinas da Pluma do Rio La Plata, disponibilizando mais matéria orgânica para o sistema bentônico. Nas proximidades de 25°S, a penetração na plataforma da Água Central do Atlântico Sul (ACAS) também promoveu aumento na produtividade primária das águas superficiais. Ao longo do Holoceno Médio e Tardio, uma tendência geral de diminuição da temperatura e salinidade das águas superficiais corrobora com uma maior influência da Pluma do Rio La Plata sobre a plataforma S/SE Brasileira como consequência de um aumento na precipitação no SE da América do Sul. Essa tendência segue a tendência da insolação de verão em 30°S, e concorda com outros registros *proxy* e modelos numéricos. Na porção norte da área de estudo, sobreposta à tendência geral, duas grandes incursões negativas temperatura e salinidade, com contatos abruptos, centradas em 5500 anos cal. BP e depois de 2800 anos cal. BP sugerem a ocorrência de mudanças de escala multi-centenárias, possivelmente relacionadas a penetração da ACAS na plataforma em decorrência de ventos de NE persistentes. Estas mudanças ocorreram simultaneamente a eventos rápidos climáticos em escala regional e global. Eventos de desaceleração da AMOC, mediada por mecanismos de amplificação, são propostos como o mecanismo responsável por desencadear estas mudanças (*triggering mechanism*). Os mecanismos amplificadores podem ter mudado ao longo do tempo e dado o não total entendimento das teleconexões atmosféricas do sistema climático, colocamos como hipótese que, no Holoceno Médio e Tardio, diferentes modos de variabilidade climática tais como, ENSO e dipolo do Atlântico Sul, podem ter atuado.

Palavras-chave: Holoceno Médio e Tardio; Atlântico SW; Rio La Plata; Corrente do Brasil; *multi-proxies*; sedimentação.

Abstract

Mid- and Late Holocene paleoceanographic changes over the S/SE Brazilian continental shelf have been accessed through a multi-proxy approach. Sedimentological, geochemical and microfaunal proxies were investigated in three high resolution marine sedimentary cores collected along the S/SE Brazilian shelf and discussed under a regional and global oceanographic and climatic perspective. The depositional processes of the S/SE Brazilian margin were submitted to two different hydrodynamic controls during Mid- and Late Holocene: (i) the northward penetration of the La Plata River Plume, bringing La Plata River derived sediments, and (ii) the high energetic Brazil Current onshore/offshore movements transporting SE Brazilian derived sediments for the northernmost part of the Santos Basin (25°S) during the Mid-Holocene. In the Late Holocene, especially after 3000 yr cal. BP, La Plata River derived sediments reached up to 25°S, highlighting a stronger influence of the La Plata River over the S/SE Brazilian shelf as a result of increase in precipitation over the La Plata River drainage basin. As the La Plata River colder and less saline waters influence over the S/SE Brazilian shelf increased, the oligotrophic waters of the shelf were fertilized, promoting enhancement of surface waters primary productivity and seafloor exportation. In the vicinity of 25°S, surface waters primary productivity was also enhanced by increase in colder and less saline South Atlantic Central Waters (SACW) shelf penetration. An overall a background trend of lower water temperature and salinities corroborates to a stronger influence of the La Plata River Plume waters during the Late Holocene as a result of higher precipitation over SE South America. This trend followed the summer insolation at 30°S, in accordance to other proxy records and numerical models. In the northernmost part of study area, superimposed to the general background trend, two major temperature and salinity negative incursions with abrupt contacts centered at 5500 yr cal. BP and after 2800 yr cal. BP highlight multi-centennial scale changes, possibly related to SACW shelf penetrations due to persistent NE winds. These changes occurred simultaneously to rapid climatic events at regional and global spatial scale. AMOC slowdown events, mediated by amplifying mechanisms, are the proposed triggering mechanism for the changes observed in the SE Brazilian shelf records. The amplifying mechanisms may have changed throughout time and as atmospheric teleconnections are not yet fully understood we hypothesize that different modes of climatic variability, such as ENSO and the South Atlantic dipole, may have acted as mediators during Mid- and Late Holocene.

Keywords: Mid- and Late Holocene; SW Atlantic; La Plata River; Brazil Current; multi-proxies, sedimentation.

1. Introduction

Marine sediments provide valuable information about environmental conditions at the time of sediment deposition both in modern and past timescales. These archives are of most importance in the comprehension of environmental changes as they also reflect changes in processes at different spatial scales (*i.e.*, local, regional and/or global). As the spatial and temporal reconstruction of marine sediments distribution plays a major role in the understanding of oceanic circulation and climatic processes, marine sedimentary records have been widely applied in paleoceanographic and paleoenvironmental reconstructions (*e.g.*, Haug et al., 2001; Leduc et al., 2010 *amongst others*). The complexity of the sedimentary signature of past oceanographic and environmental conditions requires the use of high resolution records with a multidisciplinary integration - a multi-proxy¹ approach (*e.g.*, Martins et al., 2007; Vénec-Peyré and Caulet, 2000 *amongst others*).

In the context of global change, the comprehension of the mechanisms that influence and control the Earth's present and past variability are in the spotlight. Paleoceanographic and paleoclimatic reconstructions based on environmental proxies from high resolution records are fundamental tools in the understanding of climatic response to natural and anthropogenic forcing (Villalba et al., 2009). The presence of regional proxy records with good temporal resolution and the fact that the boundary conditions of the Earth system did not change drastically (compared with glacial-interglacial changes) make the Holocene Epoch (~11 650 yr BP until the pre-industrial times) of particular interest (Wanner et al., 2008).

1.1. Primary productivity: the link between ocean and climate

Through primary productivity – the uptake of dissolved inorganic carbon and its sequestration into organic compounds by marine primary producers – oceans act as regulators in the carbon biochemical cycle, which affects the balance between the ocean and the atmosphere. The distribution of carbon in the ocean is linked to biological productivity, sinking

¹ In the parlance of paleoenvironmental reconstruction, proxies (or “proxy variables”) are measurable descriptors which stand for the desired (but unobservable) variables such as temperature, salinity, nutrient content amongst others, also known as *target parameters* (Wefer et al., 1999).

and degradation of organic matter and calcium carbonate and ocean circulation (Mix, 1989). Thus, besides contributing to the understanding of the carbon cycle, studies related to paleoproductivity provide insights in fields such as oceanic circulation, biogeography, wind patterns, and climate (e.g., Boltovskoy, 1959; Vénec-Peyré and Caulet, 2000; Martins et al., 2006; Paytan, 2008).

The concept of changing oceanic productivity and its relation to climate stands at the beginning of paleoceanographic research (Paytan, 2008). Over the past 50 years, a large array of proxies (qualitative and quantitative) has been applied to reconstruct productivity, confirming the importance of this field (see Jorissen and Rohling, 2000; Paytan, 2008). Paleoproductivity studies may use different complementary approaches by applying micropaleontological and/or geochemical proxies. The first involves the application of microfossils such as foraminifera, whether for its test chemical composition or community structure, as proxies in paleoproductivity studies, providing also information about surface and bottom seawater hydrographic conditions (temperature and salinity), benthic trophic state (organic carbon supply and quality) and redox conditions, and bottom current energy (e.g., Mackensen et al., 1995; Fontanier et al., 2002; Martins et al., 2007). While, the later focuses on detangling the chemical organic and/or inorganic composition of marine sediments, providing also information about sediment provenance, continental influence (sedimentary terrigenous supply), organic matter supply to the bottom floor, as well as origin and quality (lability) of this organic matter (e.g., Paytan, 2008).

Continental margins (shelves and slopes) play a key role in the marine biogeochemical cycling of carbon and associated elements (Walsh, 1991). The large input of nutrients of both continental and oceanic sources (e.g., rivers and upwelling processes, respectively) characterizes these regions as high primary productivity areas (Martinez et al., 1999), providing sedimentary records that can reflect changes in oceanic and in the adjacent continent climatic conditions.

1.2. Mid- and Late Holocene

Various chronostratigraphic terms have been used to subdivide the Holocene; these, however, have not been consistently applied and generally refer to climatic stratigraphy that are, at best, regional in validity (Wanner et al., *op cit.*). Generally the Holocene can be subdivided in

three phases: the Early Holocene, lasting from approximately 11,600 to 9000 years BP; the second phase, the Mid-Holocene, covers the period from approximately 9000 to 5000–6000 years BP; and the Late Holocene, the third phase, lasting from approximately 5000–6000 years BP to pre-industrial time. It was during the Holocene that human civilization development took place. In this period humans were able to develop agriculture and domesticate animals; new civilizations and population centers appeared and disappeared (Hetherington and Reid, 2010). In the last 7000 years, in particular, the restructuring and collapse of numerous societies were driven by local and/or regional climatic changes (Hodell et al., 1995; deMenocal, 2001; Araujo et al., 2005; Bracco et al., 2010).

Over the last 30 years, the understanding of the Holocene Earth's evolution has been increasingly addressed in paleoceanographic and paleoclimatic reconstructions. However, despite the advances in Holocene climate evolution the vast majority of these studies are concentrated in the Northern Hemisphere. In South America most of the studies are focused over the eastern Pacific coast and still little is known about the Southwestern Atlantic oceanographic and South Eastern South America (SESA) climatic evolution. Even though this portion of South America represents one the main economic force given its high demographic density and well developed industries and agricultural production.

The climatic conditions over SESA in the Early Holocene are still under debate. Some studies assume persistently dry conditions over SESA since the Last Glacial Maximum (LGM) until the mid-Holocene (Ledru et al., 1998; Behling, 2002); others suggest relatively wet conditions prevailing during the same period (Cruz et al., 2005, 2007); and others characterize it as a period in which climate changed towards warmer and moister conditions (see Leonhart and Lorscheitter, 2010 and references therein). During Mid- and Late Holocene SESA was submitted to significant climatic fluctuations mainly characterized by the interchange between dry and humid periods, controlled by changes in atmospheric circulation.

The hydrodynamic control, together with the relative tectonic stability and the absence of post-glacial rebound, makes the S/SE Brazilian continental margin a favorable site for investigations of the Late Quaternary climatic changes of the southwestern Atlantic (Mahiques et al., 2011). Yet little is known about the Southwestern Atlantic continental margin Quaternary

history and evolution. For the Holocene Epoch pioneer works such as Mahiques et al. (2004, 2009) and Nagai et al. (2009) recognized, through a multi-proxy approach, oceanic productivity changes linked to oceanic circulation in the S/SE Brazilian continental shelf. During Mid- and Late Holocene SESA precipitation regime fluctuations also influenced depositional processes over S/SE Brazilian shelf mainly concerning sediments source (Mahiques et al., 2009; Gyllencreutz et al., 2010). These authors, through time-series analysis, recognized the occurrence of Sub-Milankovitch cycles, Mahiques et al. (2009) related this cycles to temperature cycles reported in the Northern Hemisphere; while Gyllencreutz et al. (2010) related the approximately 1000 year cycles to changes in solar forcing.

In this scenario, this study primary hypothesis is that during the Mid- and Late Holocene the S/SE Brazilian continental shelf experienced environmental changes influenced by the Southwestern Atlantic oceanographic and SESA environmental conditions linked to changes in oceanic circulation and climatic conditions at regional and/or global scale.

Thus, this study aims to understand the evolution of the S/SE Brazilian continental margin during Mid- and Late Holocene. Through a multi-proxy approach in three high resolution marine sedimentary cores collected along the S/SE Brazilian continental shelf, between 27° and 25°S, submitted to different oceanographic processes, in an attempt to better understand the oceanographic and climatic mechanisms related to paleoenvironmental and paleoproductivity changes. The Early Holocene was intentionally excluded from this study in order to dismiss the influence of large sea-level fluctuations on the shelf.

2. Objectives

This study aims to understand the evolution of the S/SE Brazilian continental margin during Mid- and Late Holocene through a multi-proxy approach . In order to achieve the main goal of this study we propose the following specific objectives:

- a) to evaluate changes in the depositional processes through sedimentological (grain size) and geochemical (sedimentary inorganic constituents and ϵNd) proxies;
- b) to evaluate paleoproductivity changes through geochemical (sedimentary organic matter and inorganic constituents, and chemical composition of planktonic foraminifera tests) and microfaunal (benthic foraminifera assemblages) proxies;
- c) to interpret and discuss Mid- and Late Holocene S/SE Brazilian shelf oceanographic settings through an oceanographic and climatic fluctuations regional and global perspective.

3. Study area

The northernmost part of the Southern Brazilian upper continental margin is known as the São Paulo Bight, an arc-shaped embayment extending from Cabo de Santa Marta (28°30'S–49°00'W) to Cabo Frio (23°00'S–42°00'W) (Figure 1, Zembruski 1979). In this area the shelf break is located between the isobaths of 120 and 180 meters and presents latitudinal variation in width. In the northernmost and southernmost part of the study area the shelf is narrower (*i.e.* approximately 70 km width off shore Cabo Frio) reaching its maximum width of 230 km at 25°S, with declivities ranging from 1:600 to 1:1300 (Zembruski, 1979).

3.1. Sedimentology

The adjacent SE Brazil continental region is characterized by the presence of narrow coastal plains bordered, landward, by a high plateau (approximately 1000 m height) and the Serra do Mar mountain range (over 1500 m height) forcing most of the drainage systems to run inland, nourishing the La Plata River Basin to the southwest of the study area (Gyllencreutz et al., 2010), or the Paraíba do Sul River Basin, to the northeast (Figure 1).

In general, inner shelf sediments are composed mainly of sand, which usually constitutes more than 50% of the sediments; silts and clays are predominant on the middle shelf, between the 50 and 100 m isobaths; on the outer shelf sand and gravel contents increase, sometimes accounting for more than 75% of the sediment distribution (Mahiques et al., 2004). The calcium carbonate content presents a northward trend of increasing values, especially on the outer shelf (Rocha et al., 1975; Nagai et al., *submitted*). (Figure 1)

Along the inner and middle shelves the sedimentation rate values are not higher than 70 cm.kyr⁻¹, the highest values are found on zones where primary productivity and allochthonous sources of terrigenous sediments (*i.e.* the Paraíba do Sul and La Plata rivers) play an important role in the sedimentation processes (Mahiques et al., 2011). Meanwhile the outer shelf and upper slope present negligible sedimentation rate values, reinforcing the relict character of the sediments in these sectors (Mahiques et al., 2011).

Figure 1– Location map, showing studied cores (7605, 7610 and 7616) site collection locations with an (a) schematic drawing of the main oceanic currents influencing the S/SE Brazilian shelf the Brazil Coastal Current (BCC) and the Brazil Current (BC), following the works of Souza and Robinson (2004) and Silveira et al. (2000); and (b) Distribution of the mean diameter (Φ) of the surface sediments, modified after Mahiques et al. (2004) and Gyllencreutz et al. (2010).

The S/SE Brazilian shelf has been studied since the 1970's (see Kowsmann and Costa, 1974 and Rocha et al., 1975). The absence of important adjacent fluvial sources has misled Late Quaternary depositional processes on the São Paulo Bight to be considered for decades as relict and palimpsest facies resulting of the reworking of sediments previously deposited at sea level lowstands during the Late Pleistocene (Mahiques et al., 2008; 2011). In the last decade, a series of papers has reassessed the modern sedimentary processes on the continental shelf and upper slope in terms of hydrodynamic controlling factors and the input of terrigenous sediments (Campos et al., 2008a, b; Figueira et al., 2006; Mahiques et al., 2004; 2008; Nagai et al., *submitted*). The latter is especially related to the transport of allochthonous sediments from the La Plata River to the S/SE Brazilian margin (Campos et al., 2008b; Mahiques et al., 2008; Nagai et al., *submitted*).

The La Plata River is the fifth largest river in volume of water in the world; its drainage basin is the second largest in South America and covers approximately 20% of the South American continent (an area of about 3 200000 km²), encompassing substantial portions of Argentina, Bolivia, Brazil, Uruguay, and Paraguay. A mean of 23000 m³·s⁻¹ of water and 57000000 m³·yr⁻¹ of silt are discharged by the La Plata River into the Atlantic Ocean (Campos et al., 2008b). The La Plata River drainage basin is composed by two main basins; the Uruguay and the Paraná (composed by the Paraguay and the Upper Paraná sub-basins). The Uruguay basin, the smallest in area (corresponding to 8% of the total drainage area, 22% of the mean water discharge) corresponds mainly to terrains of tholeitic basalts, sedimentary rocks and alluvial sediments; the Paraguay sub-basin (35% of the area and 16% of the water discharge) drains several types of rocks, from pre-Cambrian metamorphic to Quaternary sediments, including Paleozoic and Mesozoic sedimentary rocks; the Paraná sub-basin (27% of the area and 56% of the river discharge), drains Paleozoic–Mesozoic sedimentary rocks, with intercalated basalts, and supported by crystalline rocks on the boundaries of the Paraná Sedimentary Basin (Figure 2). According to Mahiques et al. (2008) the basalts from the South Paraná Magmatic Province may be identified as potential partial source rocks for the sediments from the La Plata River as well as from the Southern Brazil sector located southward to 28°S.

S/SE Brazilian continental margin sedimentation processes are strongly dominated by oceanic water mass dynamics and shelf circulation. On the inner and middle shelf, between 38°

to 27°S, the sedimentation is mainly determined by the seasonal input of sediments from the La Plata River and, to a lesser extent, from the southern Brazilian coastal lagoons (Campos et al., 2008a; Mahiques et al., 2008; Möller et al., 2008; Nagai et al., *submitted*) transported by the Brazilian Coastal Current - BCC (Souza and Robinson 2004). Northward of 27°S, on the middle and outer shelves and upper slope, the sedimentary processes are mainly influenced by the southward flow of the Brazil Current (BC) along the continental margin (Mahiques et al., 2002; 2004; Nagai et al., *submitted*).

3.2. Modern oceanographic settings

The S/SE Brazilian continental margin is influenced by distinct hydrodynamic controls which are reflected in the sedimentary processes and patterns found in the different sectors of the shelf. The inner shelf is mainly influenced by the BCC transporting the low-salinity waters derived from the La Plata River (Möller et al, 2008; Souza and Robinson, 2004). Meanwhile on the middle and outer shelves, as well as on the upper slope, circulation is dominated by the BC flowing southward and meandering around the 200 m isobaths (Souza and Robinson, 2004 , Figure 1).

Despite its economic and environmental impact, until recently, relatively little was known about the La Plata River waters (Plata Plume Water – PPW) and its effect over the physical and biological characteristics on the S/SE Brazilian shelf (Campos et al., 2008b). The PPW affects circulation, water column stratification, and nutrient and species distribution over an extensive portion of the inner continental shelf (Möller et al, 2008). Northward to the La Plata River estuary the low salinity waters of the PPW are associated with high nutrient and *chl-a* concentrations (Piola et al., 2008), phytoplankton (Ciotti et al., 1995), benthic foraminifera (Eichler et al., 2008) and commercially important fisheries species (Muelbert and Sinque, 1996; Sunyé and Servain, 1998).

Figure 2– (a) Geological framework of the South American continent (modified from Clapperton, 1993 by Mahiques et al., 2008). In a zoom, (b) the schematic geological map of the Parana River basin (from Depetris and Pasquini, 2007) and (c) a schematic diagram of the relative contribution of major tributaries to La Plata River's mean total discharge (from Pasquini and Depetris, 2007).

The freshwater outflow of the La Plata River northward displacement over the inner S/SE Brazilian continental shelf is modulated by climatic variations over its drainage basin (river discharge) and wind pattern (Gonzalez-Silvera et al., 2006; Piola et al., 2008). The PPW reaches northern latitudes during winter season, when S/SW winds prevail, extending as far as 25°S north, being restricted to 32°S during summer when prevailing winds are from N/NE (Piola et al., 2000, 2008). The precipitation regime over the La Plata River drainage basin impacts the river discharge. Although mean annual rainfall is unevenly distributed, it is largely influenced by the South American Monsoon System (SAMS) and its atmospheric features (Pasquini and Depetris, 2007).

Hydrological records also show that global climate variability modes such as the El Niño Southern Oscillation (ENSO) have a substantial effect on the magnitude of the Plata discharge, stream flow increases during ENSO warm events (El Niño) and normal to low discharges occur during cold events (La Niña) (Pasquini and Depetris, 2007 and *references therein*). However, observations point to a northernmost extension of the PPW during La Niña events due to the dominance of southerly winds forcing on the path of the plume (Piola et al., 2005). During El Niño years the tendency of the plume to extend farther north as a consequence of higher discharges is compensated by a reversal of the direction of the alongshore winds, which causes offshore displacement of low-salinity water and the plume's southwestward retreat (Piola et al., 2005; Möller et al., 2008).

Wind pattern (direction and intensity) also influences other oceanographic processes, such as the occurrence of coastal upwelling or seasonal differences in current strength (Palma and Matano, 2009). The former involves changes in sea surface temperature (SST) distributions due to shelf penetration of the Brazil Current (BC). During summer currents flow southwestward at an mean speed of $40 \text{ cm}\cdot\text{s}^{-1}$, while in winter surface currents are less organized, being southwestward at the 90 m isobath and towards the coast in the inner shelf (Palma and Matano, 2009).

The BC, the most important oceanographic current system of the S/SE Brazilian continental margin, is a western boundary current, adjacent to the Brazilian coastline, that closes the wind-driven Subtropical Gyre in the South Atlantic (Stramma and England, 1999).

This current transports Tropical Water (TW, Temperature > 20°C and Salinity > 36.40), at the upper levels and South Atlantic Central Water (SACW, T < 20°C and S < 36.40) at the pycnocline levels (Silveira et al., 2000; Rodrigues and Lorenzzetti, 2001). Therefore surface waters are typically nutrient-poor, dominated by warm and salty TW. However, the existence of subsurface peaks in chlorophyll values ($> 1.5 \text{ mg} \cdot \text{m}^{-3}$) at 30 to 40 m water depth, highlight bottom intrusions of the cold, less saline and nutrient-rich SACW (Brandini, 1990; Castro et al., 2008).

The penetration of SACW into the shelf has been attributed to be a result of persistent N/NE winds forcing (Castelão et al., 2004). More recently Palma and Matano (2009), through numerical modeling have shown that the penetration of the colder and less saline SACW slope waters into the shelf during the summer months is modulated by both wind pattern and onshore intrusions of the BC. And, even though, the band of upwelling favorable winds extends throughout the São Paulo Bight (south of 25.5°S) relatively warm SSTs occur in this region (as far as 28°S), suggesting that this process is not controlled only by winds (Palma and Matano, 2009).

The interaction between the poleward flow of the BC and the bottom topography also influences the near shore circulation, particularly in the bottom boundary layer. Changes in shelf width modulate the alongshore pressure gradient and the magnitude of the shelf-break upwelling and/or downwelling (Palma and Matano, 2009). The shelf-break upwelling processes are associated with the BC cyclonic meanders that generate vertical velocities over the shelf break and slope (Campos et al., 2000; Castelão et al., 2004). The cooling effect of this process in the northern region of the Bight promotes a SST gradient between northern (colder) and southern (warmer) parts of the São Paulo Bight during summer (Palma and Matano, 2009).

3.3. Modern climatic conditions

The latitudinal extension and diverse morphology of South America (SA) favor the development of different atmospheric systems which contribute to a climatic heterogeneity of the continent (Reboita et al. 2010). The SA continent also presents significant east-west asymmetries due to the presence of the Andean chain, the variable width of the continent

(larger in low latitudes) and by the boundary conditions imposed by the cold waters of the Pacific Ocean and the warm waters of the Southwestern Atlantic Ocean (Garreaud et al. 2009).

The regional low level atmospheric circulation is characterized by the presence of atmospheric systems such as the Intertropical Convergence Zone (ITCZ), the South America Low Level Jet (SALLJ), the South Atlantic High (SAH) and the South Atlantic Convergence Zone (SACZ) (Figure 3). Over subtropical oceans low level circulation is characterized by subtropical anticyclones, the so called subtropical highs that occupy 40% of Earth's surface (Rodwell and Hoskins, 2001). The SAH is a semi-permanent high pressure cell at about 20° to 35°S over the Atlantic Ocean maintained by subsidence and divergent winds, which originates trade and West winds (Grimm, 1999; Garreaud et al. 2009), bringing NE winds to the Southeastern Brazilian coastline between 15° and 25°S (Wainer and Taschetto, 2006).

SA precipitation regime is related to interactions between regional atmospheric circulation and the adjacent oceanic basins (Garreaud et al. 2009; Reboita et al. 2010). In Southeastern South America - SESA (S/SE Brazil, S Paraguay and Uruguay) the precipitation patterns are associated with the passage of frontal systems; cyclone and cold fronts; meso-scale convective complexes; cyclonic systems; and atmospheric blockages. Cold front systems can also promote precipitation over SESA directly or favoring the development of instability lines (Reboita et al., 2010). SESA precipitation regimes are also influenced by local circulation patterns (*i.e.*, sea breeze) and the indirect action of the SACZ (Reboita et al., *op cit.*) modulated by the SALLJ variability (Garreaud et al., 2009).

The pronounced seasonal cycle of the SESA precipitation regimes (more than 50% of total annual precipitation during summer) sustains that the climate in the central part of the continent be described as monsoonal (Zhou and Lau, 1998; Gan et al., 2004; Garreaud et al., 2009). The main characteristics of the South America Monsoon System (SAMS) are well described in the literature (*i.e.* Zhou e Lau, 1998; Gan et al., 2004; Vera et al., 2006a). Meanwhile, during winter, regional precipitation is linked to mid latitude cyclones and humidity from the SAH (Vera et al., 2002).

During austral summer, the southward displacement of the ITCZ and stronger trade winds, efficiently transport humidity from the Tropical Atlantic into SA reaching the Amazon

Basin, where intense convective activity takes place (Drumond et al. 2008). The ITCZ, a region with minimum pressure and intense trade winds low level convergence, is characterized by intense convective precipitation (Garreaud et al., 2009; Reboita et al., 2010), and presents seasonal displacement between 5° and 15°N – from July to October, and between 5° and 15°S – from January to April (Aquino and Setzer, 2006).

Figure 3 – South America main atmospheric features the (annual mean 850 hPa geopotential height NCEP-NCAR reanalysis (Kalnay et al. (1996). Where SALLJ stands for the South America Low Level Jet and H for the South Atlantic High.

The humidity produced in the Amazon Basin convective zone reaches subtropical latitudes transported by the SALLJ (Marengo et al., 2004; Vera et al., 2006b). The SAJLL is characterized as a straight current channelizing the near surface air flux (atmosphere's first 2 km) between the tropics and mid-latitudes east of the Andes (Marengo et al., 2004). This low level jet is responsible for the humidity transport from the Amazon region to S Brazil / N

Argentina during summer; and for the transport of tropical maritime air (less humid than the tropical air masses from the SAH) during winter (Marengo et al., *op cit.*). In this sense, the SALLJ modulates the precipitation regimes over Southern Brazil (Drumond et al. 2008).

The convergence of the northwestern flow of the SALLJ with the northeastern air flow induced by the SAH forms a NW-SE oriented nebulosity band that extends from the South of the Amazon to the Subtropical Atlantic, denominated SACZ, characterized by intense precipitation (Drumond and Ambrizzi 2005 and *references therein*). During austral summer, the SALLJ intensification promotes SACZ intensification and the penetration of cold frontal systems in Southern end of the SALLJ (S Brazil and Argentina), increasing convective processes along S/SE Brazil coast and lower humidity in Paraguay, Uruguay and N Argentina (Garreaud et al., 2009; Marengo et al., 2004). There is apparently a relationship between SACZ and Southwestern Atlantic Ocean sea surface temperatures (SST): positive (negative) anomalies of SST in South Atlantic subtropical latitudes are associated with a southward (northward) displacement of the SACZ which contributes to increase (decrease) in precipitation in SESA (Diaz et al., 1998; Barros et al., 2000).

SESA climatic variability results from the superimposition of different large-scale phenomenon's such as: the El-Niño Southern Oscillation (ENSO), influencing a vast region of South America both directly and indirectly (through atmospheric teleconnections); the Tropical Atlantic SST meridional gradient, strongly impacting both weather and climate in SA; the Pacific Decadal Oscillation (PDO); the Atlantic Multidecadal Oscillation (AMO); and high latitude forcings such as the Antarctic Oscillation - AAO (see Garreaud et al., 2009 and references therein).

ENSO events act as the main mode of variability in SA in the interannual timescale (Garreaud et al., 2009), affecting SESA precipitation regimes (Grimm et al., 2000) and promoting changes in wind pattern (Martin et al., 1993). In SESA El-Niño events are related to positive anomalies in precipitation and temperature, this scenario is inverted during La-Niña events (Garreaud et al., *op cit.*). The inter-hemispheric SST gradient is also affected by the SST variations that accompany ENSO events, with significant impacts on the position and intensity

of the ITCZ which follows the displacement of the positive SST anomalies in the Tropical Atlantic (Wainer and Taschetto, 2006).

In the decadal and inter-decadal timescales the PDO has similar spatial structure and impacts over SESA temperature and precipitation regimes as ENSO events, however, with smaller amplitudes (Garreaud et al., 2009). The AMO also influences SESA precipitation regimes in decadal and inter-decadal timescales associated with changes in the intensity of the Atlantic Meridional Overturning Circulation (AMOC). During AMO positive (negative) phase the weakening (strengthening) of the AMOC promotes warmer (colder) Southwestern Atlantic SST, increasing (decreasing) SACZ activity and precipitation over SESA (Chiessi et al., 2009). The ITCZ position is also influenced by AMOC variability since it promotes positive SST anomalies in the Southwestern Atlantic. During periods of strong (weak) AMOC the ITCZ occupies a southernmost (northernmost) position, creating positive (negative) anomalies in humidity transport into the Amazon Basin, resulting in an intensification (weakening) in SAMS/SACZ activity (Zhang and Delworth, 2005).

4. Materials and methods

Three piston cores, #7605, #7610 and #7616, were collected from the SE Brazilian shelf, on board R.V. Prof. W. Besnard, in 2005. The coring locations are presented in Figure 1 and Table 1. Surface sediments were lost during coring (probably splashed away on impact by the piston corer). Following opening, cores were subsampled in the laboratory at 2 cm intervals, for the sedimentological and geochemical analyses subsamples were immediately frozen and subsequently freeze-dried, and for microfaunal analyses subsamples were oven dried ($T < 60^{\circ}\text{C}$).

Table 1– Cores locations coordinates (latitude and longitude) and water depth, and sedimentary column recovery.

Core number	Latitude (°S)	Longitude (°W)	Water depth (m)	Recovery (cm)
7605	-27,104	-47,804	93	250
7610	-25,508	-46,635	89	410
7616	-25,098	-45,644	100	470

4.1. Chronology

Organic matter was used for radiocarbon dating owing to the lack of suitable carbonate material such as mono-specific foraminifers or well preserved mollusks. Approximately 7 g of bulk sediment were sampled at every 50 cm down cores, and subsequently separated for AMS radiocarbon dating at Beta Analytics Inc. (Miami/USA). Calibration of radiocarbon ages was performed using Calib 5.0.2 (Stuiver et al., 2005) with the Marine04 Calibration Dataset (Hughen et al., 2004). Correction for a regional reservoir effect of $\Delta R = 82.0 \pm 46$ was applied, based on the mean value of three samples reported by Angulo et al. (2005).

The age–depth relationship was established using the mixed-effect model regression calculated with the Cagedepth and Cagenew functions described by Heegard et al. (2005), available at <http://www.uib.no/bot/qeprg/Age-depth.htm> (last accessed January 3, 2007). This model was chosen owing to the possibility of better error estimation in sedimentation rates according to Mahiques et al. (2009). Sedimentation rates ($\text{cm} \cdot \text{kyr}^{-1}$) were obtained from the age model.

4.2. Sedimentological analysis

The size of the particles that compose sediments is the most relevant physical propriety in sedimentary studies, providing information about diverse environments including those where particles were formed and deposited, taking into account transport and/or remobilization processes (Dias, 2004). Hence, grain size analysis is an important and widely applied tool in paleoceanography studies (e.g. McCave et al., 1995, 2005; Gyllencreutz et al., 2010).

Sortable silt size has been applied as a proxy for past bottom current speed in deep ocean basins (Bianchi and McCave, 1999; McCave et al., 1995; 2005) and in shallow marine areas as a proxy for bottom current variability (Andrews et al., 2003; Chang et al., 2007; Gyllencreutz, 2005; Gyllencreutz et al., 2010). In these areas, grain size distribution in its totality (representing whole grain size distributions or the several populations involved in a grain size spectrum) should be considered for a better interpretation of paleoclimatic and paleoceanographic processes (Gyllencreutz et al., 2010 *and references therein*).

Grain size analyses were performed on the non-carbonate fraction of the sediment samples after dissolution with 1 M HCl and thorough rinsing with de-ionized water until pH was neutral. Grain size distributions of the samples were measured using a *Malvern Mastersizer 2000* and recorded using standard phi (ϕ) notation (Eq. 1):

$$\phi = \frac{(-\log_2 d)}{1 \text{ mm}} \quad (\text{Eq. 1})$$

where d is grain diameter in mm, and ϕ is dimensionless). Percentages of 53 intervals (0.25 ϕ -subclasses) were determined between 12 and -1 ϕ . The results are presented using a Particle Size Distribution (PSD) format with similar interpolation procedures used by Gyllencreutz et al. (2010).

Following the procedure adopted by Gyllencreutz et al. (2010), for each core a Correspondence Analysis (CA) of the grain size distributions (Teil, 1975) was performed using PAST version 2.16 available at <http://folk.uio.no/ohammer/past> (last accessed July, 2012). The first two factors, which corresponded to more than 70% of the total explained variance in all of

the cores, were plotted against depth and used to identify the grain size classes with the greatest influence on the distribution variability.

4.3. Geochemical analyses

4.3.1. Sedimentary organic matter

The organic matter preserved in sedimentary records provides a variety of proxies that can be used to reconstruct paleoenvironments and paleoclimates, since both production and preservation of organic matter are affected by environmental change (e.g., Meyers, 1997). Bulk properties (*i.e.* elemental composition - total organic carbon - TOC, total nitrogen - N_{tot} , and C/N ratio; carbon and nitrogen stable isotope ratios - $\delta^{13}C$ and $\delta^{15}N$) can be applied to infer general sources of the organic matter. These parameters register past availability of nutrients and, therefore, can be applied as proxies of ocean surface mixing and continental runoff.

In marine environments C/N ratios have been widely applied to distinguish between algal (marine) and land-plant (continental) origins of the organic matter (e.g. Prahl et al., 1980, 1994; Ishiwatari and Uzaki, 1987; Jasper and Gagosian, 1990; Silliman et al., 1996). In general, algae derived organic matter presents C/N ratios between 4 and 10, whereas vascular land plants have C/N ratios higher than 20 (Meyers, 1994). The abundance of cellulose in vascular plants, and the protein richness of algal organic matter (higher amounts of nitrogen) can be accounted for the differences in C/N ratios in the organic matter derived from these sources (Meyers, 1997). The main consideration to be taken into account while interpreting C/N ratios of organic matter in sediments, relies on the fact that this proxy is influenced by hydrodynamic sorting of sediments, *i.e.* sediment size (Thompson and Eglinton, 1978; Keil et al., 1994; Prahl et al., 1994; Meyers, 1997). Thus, it is important to associate other proxies in the reconstruction of past sources of organic matter in changing depositional conditions settings (Figure 4), such as carbon stable isotope ratios ($\delta^{13}C$), which are not affected by sediment size (Meyers, 1997).

The $\delta^{13}C$ of organic matter reflects mainly the dynamics of carbon assimilation during photosynthesis and the isotopic composition of the carbon source (Hayes, 1993). In terms of characteristic values, marine organic matter in tropical to sub-tropical areas typically presents $\delta^{13}C$ values between -18 and -22‰ and continental organic matter presents values of -27‰

from C₃ plants (most of the superior plants) and -14‰ from C₄ plants (grass) (Meyers, 1997). For the Brazilian continental shelf, Mahiques et al. (1999) estimated as markers of continental organic matter C/N ratio values of 24 and $\delta^{13}\text{C}$ values of -26.00‰.

Figure 4 – Cross plot between C/N ratio and $\delta^{13}\text{C}$ values, highlighting distinguish sources of organic matter in sediments and in settling particles, redrawn from Meyers (1994).

Similar to the $\delta^{13}\text{C}$, $\delta^{15}\text{N}$ values can be applied in the recognition of sources of nutrients based in the fact that when organisms assimilate N to produce biomass, the $\delta^{15}\text{N}$ content of their N source is imprinted in the organic matter eventually deposited in sediments (Robinson et al., 2012). The $\delta^{15}\text{N}$ value of dissolved nitrate ranges between +7‰ to +10‰, whereas the $\delta^{15}\text{N}$ of atmospheric N₂ is about 0‰ (Meyers, 1997). Dissolved nitrate derived from terrestrial vascular plants present a wide range of $\delta^{15}\text{N}$ values from -5‰ to +18‰, with mean value close to 3‰, whereas marine $\delta^{15}\text{N}$ values range from 3‰ to 12‰ with a mean value of 6‰ (Hu et al., 2006). For the SE Brazilian coastal shelf zone, Matsuura and Wada (1994) determined $\delta^{15}\text{N}$ values between 6.9 and 9.0‰ as representative of marine (phyto- and microzooplankton) end members.

The elemental and isotopic analysis of carbon and nitrogen measurements were performed in samples representative of Mid- and Late Holocene, distributed along the cores at every 2 cm intervals. Analyses were performed using a *Costech elemental analyzer* in line with a *Finnigan IRMS Delta V Plus* stable isotope ratio mass spectrometer at IOUSP. For the TOC contents samples were previously decarbonated by acidification using HCl 1M. The carbon and

nitrogen isotopes were measured simultaneously from the same sample by peak jumping with mean standard deviation of 0.19‰ and 0.28‰ for $\delta^{13}\text{C}_{\text{org}}$ and $\delta^{15}\text{N}_{\text{org}}$, respectively. All results are reported relative to vPDB for $\delta^{13}\text{C}_{\text{org}}$ and relative to air for $\delta^{15}\text{N}_{\text{org}}$. In addition, an internal standard of lignin was used every 6 to 8 samples to ensure stable measurement without drifts.

4.3.2. Calcium carbonate (CaCO_3)

The calcium carbonate (CaCO_3) present in marine sediments is predominantly composed by marine organisms shells (*i.e.* foraminifera and coccolithophores), has been applied as a paleoproductivity proxy in past reconstructions (Moreno et al., 2004), since its accumulation rates indirectly reflect organic carbon flux to the seafloor (Rühleman et al., 1999). In this study, CaCO_3 contents were obtained by weight difference before and after sample acidification with HCl 1M.

4.3.3. Sedimentary inorganic constituents

Many elements are present in seawater either in soluble form or adsorbed onto particles, the removal of dissolved elements from the water column to the sediments results from either biotic (uptake of trace elements that serve as minor or micronutrients for plankton) or abiotic processes (related to redox conditions) (Tribouillard et al., 2006). Hence, the analyses of the inorganic constituents of marine sediments have been widely applied in paleoceanographic studies since they reflect the environmental conditions at the time of deposition (Moreno et al., 2004).

Several studies in marine sedimentary records have applied iron/calcium (Fe/Ca) and titanium/ calcium (Ti/Ca) ratios as proxies of terrigenous sediment supply (*e.g.*, Arz et al., 1998; Haug et al., 2001; Mahiques et al., 2009). This is based on the premise that as a component of calcite and aragonite, calcium (Ca) mainly reflects the marine carbonate content in the sediment, whereas, titanium (Ti) and iron (Fe) are related to siliciclastic components and especially clay minerals (Arz et al., 1998). Thus, Fe and Ti variations would represent a simple chemical proxy for the input of land-derived materials, providing a direct measure of rainfall and continental runoff into the oceans (Haug et al., 2001).

In order to verify if the Fe and Ti data obtained from our cores had detrital provenance, we performed a cross plot of these elements versus aluminum (Al), which is considered to be of detrital origin and is usually immobile during diagenesis (Tribovillard et al., 2006 *and references therein*).

Barium (Ba) is one of the most widely used proxies in paleoproductivity estimates, because of the relationship between marine barite (BaSO_4), the major carrier of particulate Ba in the water column, and carbon export flux to the sea floor (Dymond et al., 1992; Paytan, 2008). In marine systems, Ba can be found associated to terrigenous material or associated with organic material, denominated as excess-Ba (the Ba fraction not carried by terrigenous material – $\text{Ba}_{\text{excess}}$) (Paytan, 2008). The applicability of Ba as a productivity proxy, however, is still under discussion (see Mahiques et al., 2009), presenting as major limitations the impossibility of calculating $\text{Ba}_{\text{excess}}$ values from the Ba/Al ratios and possible diagenetic remobilization (Moreno et al., 2004) and the absence of regional Ba/Al background values (Mahiques et al., 2009).

In order to apply Ba as a paleoproductivity proxy, the $\text{Ba}_{\text{excess}}$ portion in the sediments must be distinguished from the Ba associated with the terrigenous material. According to Pfeifer et al. (2001) $\text{Ba}_{\text{excess}}$ can be determined from the total Ba (Ba_{tot}) concentration in the sediment after subtracting the Ba associated with terrigenous material ($\text{Ba}/\text{Al}_{\text{terr}}$), which is calculated from total Al or Ti, and normalization to a constant detrital Ba/Al or Ba/Ti ratio (Eq. 2). For the Southwestern South Atlantic these authors estimated values of 0.004 for the $\text{Ba}/\text{Al}_{\text{terr}}$ ratio.

$$\text{Ba}_{\text{excess}} = \text{Ba}_{\text{tot}} - (\text{Al} * \text{Ba}/\text{Al}_{\text{terr}}) \quad (\text{Eq. 2})$$

Major and trace element contents (Al, Ba, Ca, Fe and Ti) of bulk sediment were analyzed at a sample spacing of 2 cm by means of total digestion. Samples (approximately 0.2g of sediment) were subsequently attacked with nitric acid (HNO_3), hydrofluoric acid (HF) and hydrogen peroxide (H_2O_2) under microwave action following the procedures tested by Sun et al. (2001). Element contents were determined by optical emission spectrometry with inductively coupled plasma (ICP-OES/*Varian 710ES*) at the Oceanographic Institute of the University of São Paulo (Brazil). The analysis method was validated using a reference material, Estuarine Sediment - SRM 1646a, with results that presented good precision and accuracy.

4.3.4. Mineralogy

The mineralogy of sediments reflects the cumulative effects of sediment source in terms of composition and chemical weathering (Nesbitt et al., 1997). Hence, clay mineralogy is useful in determining the distribution, sources, and dispersal routes of fine-grained sediments (e.g.; Griggs and Hein, 1980; Karlin, 1980; Park and Khim, 1990; Hein et al., 2003) and to determine the dispersal pattern or transport pathways of the bulk sediment (Petschick et al., 1996; Oliveira et al., 2002). However, generally, the presence of multiple sources and transport processes hampers the assessment of the main source area to a given clay mineral assemblage (Fagel, 2007). Thus, combining clay mineralogy and other proxies provides further constraints on the identification of the source area.

The vast majority of clay mineral is derived from continents since their formation is mainly controlled by climatic conditions (*i.e.* weathering) (Biscaye, 1965; Petschick et al., 1996). In marine environments the mineralogy of sediments is widely applied as a tool for comprehending interactions between oceans and climatic conditions in the adjacent continents (e.g., Robert et al., 2005 and Martins et al., 2007).

Mineralogical analyses were carried out on the <63 μm (silt) fraction of the sediments through X-ray diffraction (XRD) at the Geosciences Department of Aveiro University, under the supervision of Prof. Dr. Fernando Tavares Rocha and Dra. Maria Virginia Alves Martins. XRD measurements were performed using Philips PW1130/90 and X'Pert PW3040/60 equipment using Cu K α radiation. Scans were run between 2° and 60° 2 θ (non-oriented powder mounts) in the air-dry state after a previous glycerol saturation and heat treatment (300 and 500 °C). Qualitative and semi-quantitative mineralogical analyses followed the criteria recommended by Schultz (1964), Thorez (1976) and Mellinger (1979). For the semi-quantification of the identified principal minerals, peak areas of the specific reflections were calculated and weighted by empirically estimated factors (Table 2), according to Galhano et al. (1999) and Oliveira et al. (2002).

Table 2– Diagnostic peaks and weighting factors applied for the identified minerals.

Mineral	Peak (Å)	Normalizing factor
Analcime	2.925	0.8
Anatase	3.52	1
Anidrite	3.49	1.5
Bassanite	3.00	3
Calcite	3.03	1
Clorite	7.2-7.1	0.75
Dolomite	2.88	1
K-feldspars	3.21	1
Phyllosilicates	4.45	0.2
Halite	2.82	2
Hematite	2.69	1.3
Magnetite/Maghemite	2.68	1.3
Mica-ilite	10.06	0.5
Opal C/CT	4.03-4.02	0.5
Plagioclase	3.19-3.16	1
Pyrite	3.18	1
Quartz	2.71	2
Rodrocrosite	3.34	1
Siderite	2.79-2.75	1
Zeolites	2.79	0.8

Two mineralogical indexes were calculated in the fraction <63 µm: Detrital Minerals (DM, quartz+feldspars+phyllosilicates), Fine Detrital Minerals/Coarse Detrital Minerals [FDM/CDM, phyllosilicates / (quartz +K-feldspars + plagioclases)] (Vidinha et al., 1998; Fradique et al., 2006). These indexes demonstrate the relative importance of the terrigenous supply and hydrodynamic sorting intensity, respectively (Martins et al., 2007). According to these authors the XRD provides a minimum estimative for the occurrence of pyrite, thus it is possible that this mineral is under estimated.

4.3.5. Neodymium (Nd) isotopes

The Nd isotopic composition has been applied in several studies as a reliable tracer for modern sedimentary dynamics and sediment provenance, and past reconstruction (Vroon et al., 1995; Revel et al., 1996; Parra et al., 1997; Rutberg et al., 2000; Staubwasser and Sirocko, 2001; Ingram and Lin, 2002; Bayon et al., 2002; Kessarkar et al., 2003; Weldeab et al., 2002, 2003; Mahiques et al., 2008) due to the rapid incorporation of the river-originated neodymium in the marine sediments (DePaolo, 1988). Also, according to Grousset et al. (1988) the Nd isotope composition is little affected by grain-size differences of the sediment fractions.

Studies involving the application of this isotope in the comprehension of continental margin sedimentation processes are recent (Staubwasser and Sirocko, 2001; Fagel et al., 2002; Farmer et al., 2003). In a pioneer study for the Southwestern Atlantic continental shelf, Mahiques et al. (2008) applied neodymium and lead isotope signatures as a tool for the characterization of the modern sediment transport and their source rocks along the SE South American upper margin, between the latitudes 55° and 20°S. These authors found latitudinal variations in the ϵNd isotopic signatures related to changes in sediment provenance and hydrodynamic transport agents, allowing them to divide the area into four distinct sectors (Figure 5).

According to the findings of Mahiques et al. (2008) the sediments from the Argentinian shelf presented ϵNd values ranging from -0.1 to -4.0 (mean=-1.9, σ =1.2, n=11), these sediments were considered to be originated from the Andean rocks. The Basalts from the Paraná Magmatic Province were found as potential source rocks for the Rio de La Plata estuarine sediments with ϵNd values ranging from -8.2 to -10.3 (mean=-9.6, σ =0.7, n=12) as for the sediments from S Brazil (mean=-9.3, σ =0.9, n=18) up to 28°S. The sediments from SE Brazil presented a large variation in ϵNd values, ranging from -9.9 to -17.1 (mean=-13.0, σ =2.1, n=18) and were possibly originated in the erosion of the Brazilian Shield and are carried by the Brazil Current.

Figure 5- Latitudinal changes of the ϵNd values found by Mahiques et al. (2008) in SE South America upper margin.

The Nd and Pb isotopic analyses of the bulk lithogenic fraction were carried out at the School of Earth Sciences of the University of Bristol, United Kingdom, by Dr. Derek Vance in collaboration with Dr. Till Hanebuth (MARUM Institute, Germany). The Nd analyses, referred to as ϵNd , were prepared by standard methods in accordance with the analytical procedures described by Vance and Thirlwall (2002), on a Thermo-Finnigan Neptune MC-ICP-MS. Sample preparation involved calcium carbonate, Fe-Mn oxides and organic compounds removal. A concentrated HF-HNO₃ mixture (ratio 4:1) was added, and allowed to react for 3 days at a temperature of 140°C in order to digest the silicate fraction. Samples were then dissolved in 7M HCl, dried, and dissolved in 1M HCl for elemental separation. $^{143}\text{Nd}/^{144}\text{Nd}$ ratios were normalized to $^{146}\text{Nd}/^{144}\text{Nd} = 0.07219$, whilst residual instrument induced mass discrimination was corrected using correlations between $^{146}\text{Nd}/^{144}\text{Nd}$ -normalised, $^{143}\text{Nd}/^{144}\text{Nd}$ and $^{142}\text{Nd}/^{144}\text{Nd}$. Within run reproducibility is based on multiple measurements of the La Jolla standard before and during sample runs, with mean values 0.511853 ± 0.000010 . Analytical uncertainty is quoted as the internal error (2 standard errors).

4.4. Microfaunal analyses

Foraminifera are widely applied in paleoceanographic studies, especially in those which focus on paleoproductivity changes (Martinez et al., 1999; Herguera, 2000; Vénec-Peyré e

Caulet, 2000; Martins et al., 2006, 2007; Nagai et al., 2009). The planktonic foraminifera can provide information about past oceanic water column conditions in terms of water mass distributions, sea surface temperature and productivity (Marchant et al., 1999). Whereas benthic foraminifera provide a wide spectrum of information about environmental conditions, since these organisms present changes in their community structure (Murray, 1991), vertical distribution in the sedimentary column (Jorissen et al., 1995, Fontanier et al., 2003) and in size and morphological aspects (Bernhard, 1986; Boltovskoy et al., 1991) as a response to changes in environmental conditions.

4.4.1. Chemical composition of planktonic foraminifera tests

The chemical composition of the calcite from planktonic foraminifera tests is one of the most important tools in paleoceanographic and paleoclimatic reconstructions. Since, determining past temperature and salinity of ocean surface waters is essential for understanding past changes in climate (Elderfield and Ganssen, 2000). The oxygen isotope composition ($\delta^{18}\text{O}_c$) of calcite from planktonic foraminifera, for example, has been shown to reflect both sea surface temperature and seawater isotopic composition ($\delta^{18}\text{O}_w$) and magnesium/calcium (Mg/Ca) ratios in foraminiferal calcite also show temperature dependence (Elderfield and Ganssen, 2000). The approach of measuring Mg/Ca and $\delta^{18}\text{O}$ in single species of foraminiferal calcite has gain importance in the past few years, mainly due to its potential of estimating both temperature and $\delta^{18}\text{O}_w$ from the same sample and associated with the same parcel of seawater (Anand et al., 2003). The advantage of this approach is that synchronous estimates of sea surface temperature (SST) and global ice volume can be determined and used to calculate $\delta^{18}\text{O}_w$, a proxy for salinity, avoiding the bias of seasonality and/or habitat differences that occur when proxy data from different faunal groups are used (Groeneveld et al., 2008; Leduc et al., 2010).

There is a consensus over the importance of knowing the ecology of the foraminifera species chosen as a proxy (*i.e.* foraminiferal depth habitat, seasonal flux variations amongst others). In this study we picked the planktonic foraminifera *Globigerinoides ruber* pink variety - *G.ruber* (pink) – for chemical composition analyses because: (i) it is widely applied in

paleoceanographic studies; (ii) it is present throughout the cores; (iii) it would be able to best register shallow water changes over the S/SE Brazilian continental shelf (Chiessi et al., 2007).

G. ruber (pink) is one of the most commonly used planktonic foraminifera species in paleoceanographic reconstructions. This tropical to subtropical species (Hemleben et al., 1989) is considered to be a shallow dweller inhabiting the first 25 m of the water column (Anand et al., 2003; Tedesco et al., 2007; Steph et al., 2009), with maximum development at an optimum temperature range between 22.9 and 29.5°C (Záric et al., 2005). For the SE Brazilian margin Sousa et al. (*submitted*) found *G. ruber* (pink) with occupying the first 50 m of the water column and with an optimum temperature range between 22.9 and 26.8°C (Figure 6). It represents an excellent species to be applied in near surface temperature reconstructions.

For paired isotopic composition and trace elemental measurements *G. ruber* (pink) tests were picked in the 250–350 µm size fraction, approximately 10 and 15–30 specimens were used for isotopic composition and trace element ratio measurements, respectively. For core 7605, due to the lack of sufficient number of tests, only the stable isotopic composition in *G. ruber* (pink) was measured. Thus, to decouple temperature and salinity effects in the $\delta^{18}\text{O}$ values we used an alkenone based sea surface temperature record, the only available for the region, obtained in core 7606 (26°59.28'S, 48°4.56'W) located close to core 7605, by Bicego (2008).

4.4.1.1. Elemental ratios in planktonic foraminifera tests - Mg/Ca ratios

The Mg/Ca ratio in foraminiferal calcite is mainly dependent on the temperature of the water in which the foraminifera calcifies (Elderfield and Ganssen, 2000; Dekens et al., 2002). This categorizes it as an independent paleotemperature proxy and hence allows it to become a widely applied tool in paleoceanography for the reconstruction of SSTs. The advantage of Mg/Ca paleothermometry lies primarily in the potential to record changes in calcification temperature (e.g., McConnell and Thunell, 2005) and to distinguish the temperature component of the $\delta^{18}\text{O}$ signal recorded in calcite from salinity and ice-volume effects through paired

measurements of Mg/Ca and $\delta^{18}\text{O}$ (e.g., Elderfield and Ganssen, 2000; Lear et al., 2000, 2004; Weldeab et al., 2006).

Figure 6 – (a) vertical distribution of various planktonic foraminifera species in the Southwest Atlantic, highlighting *G. ruber* (pink) occurrence in the upper part of the water column (modified from Chiessi et al., 2007); and (b) the relationship between *G. ruber* (pink) abundance (%) and seawater temperature (°C), black dots represent global sediment trap data obtained by Záric et al. (2005), with the optimum temperature range of this species delimited by the gray bar, and red dots represent SE Brazilian continental margin plankton net data from Sousa et al. (submitted).

Magnesium is one out of several divalent cations which may substitute calcium (Ca) during the formation of biogenic calcite. Its incorporation into foraminiferal calcite is mainly temperature-dependent (Lea et al., 1999; Elderfield and Ganssen, 2000). Nevertheless, it may also be affected by other secondary factors, such as, salinity and pH (Lea et al., 2000; Nürnberg et al., 2000). Additionally, as the incorporation of Mg^{2+} is biologically mediated, a temperature calibration of Mg/Ca ratios based on foraminiferal calcite is required (Lea et al., 2000; Anand et al., 2003; Regenberg et al., 2009). These calibrations are based on laboratory experiments (e.g., Nürnberg et al., 1996), coretop calibrations (e.g., Elderfield and Ganssen, 2000; Cléroux et al., 2007; Groeneveld and Chiessi, 2011) or sediment trap studies (Anand et al., 2003; McConnell and Thunell, 2005).

Correlations between Mg/Ca and calcification temperature shows that an increase in temperature is likely associated with an exponential increase in Mg/Ca ratios (e.g., Elderfield and Ganssen, 2000; Anand et al., 2003; McConnell and Thunell, 2005). Hence, temperature estimates based in Mg/Ca ratios in foraminiferal calcite follow the exponential calibration equation (Eq. 3):

$$\frac{Mg}{Ca} = b \exp(aT)$$

(Eq. 3)

The regression curve is defined by the slope α , which is the temperature sensitive component, and the y-axis intercept b in mmol/mol. According to Anand et al. (2003) for *G. ruber* (pink) correlations are poorer than for the multispecies calibration and reveal no size fraction dependence, which is in agreement with the findings of Regenberget al. (2009). Thus, in this study we applied the coefficients values derived from Anand et al. (2003): $b = 0.38$ and $\alpha = 0.09$, for the Mg/Ca based paleotemperature estimates.

For trace element analyses *G. ruber* (pink) tests, picked from cores 7610 and 7616 (at every 2 cm intervals), were gently crushed between two glass plates to open the chambers and placed into leached vials. Prior to elemental analyses samples were submitted to a cleaning procedure following Martin and Lea (2002) methodology, excluding steps 4 (alkaline chelation) and 5 (final heat rinse). In general terms, the cleaning procedure of foraminiferal samples prior to analysis involves a number of discrete sequential steps aimed to remove various contaminating phases: (1) clay materials; (2) organic matter; (3) Mn-Fe-oxide coatings, and, if needed; (4) barite, with (5) a final “polishing” of the sample prior to analysis (Barker et al., 2003). After cleaning, the tests were dissolved in a diluted acid (0.001M). The solution was then analyzed for trace elements using a *Thermo Finnigan Element 2* sector field inductively coupled plasma mass spectrometry (ICP-MS) at the Geosciences Department of Bremen University (Germany), under the supervision of Dr. Stefan Mulitza and Dr. Henning Kunhert. The ^{25}Mg , ^{43}Ca , ^{55}Mn , ^{56}Fe and ^{137}Ba isotopes were measured. In order to correct instrumental sensibility yttrium (Y) was used as an internal standard within samples. Manganese (Mn) and iron (Fe) were measured at medium resolution, while the other elements were measured in low

resolution. A known uniformity standard was measured at every three (3) samples allowing *offline* corrections due to instrumental deviation and differences in readings done in different days. As indicators of contaminants manganese (Mn), present in clay minerals and iron-manganese crusts, and iron (Fe), due to the presence of pyrite precipitates inside the chambers of some specimens (observed in tests crushing) were measured. In order to check for contamination cross plots between Mg/Ca and Ba/Ca ratios and Mn/Ca and Fe/Ca ratios were performed.

4.3.4.3. Stable oxygen ($\delta^{18}\text{O}_c$) and carbon ($\delta^{13}\text{C}$) isotopic composition

$\delta^{18}\text{O}$ in marine carbonates is one of the main tools in paleoceanography and is presently widely applied in assessing past variability in ocean circulation (e.g. Vidal et al., 1997; Matsumoto and Lynch-Stieglitz, 2003), upper water column structure (e.g. Mulitza et al., 1997; Ruhlemann et al., 2001), continental ice volume (e.g. Waelbroeck et al., 2002; Sidall et al., 2003), freshwater input into the oceans (e.g. Duplessy et al., 1991; Maslin et al., 2000), seawater density (e.g. Lynch-Stieglitz et al., 1999), sea surface salinity (e.g. Lea et al., 2000; Schmidt et al., 2004; Weldeab et al., 2006), deep-sea salinity (e.g. Adkins et al., 2002; Schrag et al., 2002) as well as for stratigraphic purposes (e.g. Shackleton and Opdyke, 1973).

Isotopes are variants of an element containing different numbers of neutrons. There are three stable isotopes of oxygen: ^{16}O (99.76%), ^{17}O (0.04%) and ^{18}O (0.2%). The isotopic composition of a measured sample is expressed as $\delta^{18}\text{O}$ (Eq. 4), which represents the difference in the $^{18}\text{O}/^{16}\text{O}$ ratios between the sample and the standard, expressed as parts per thousand - ‰ (Mulitza et al., 2003).

$$\delta^{18}\text{O} = \left[\frac{(^{18}\text{O}/^{16}\text{O})_{\text{sample}} - (^{18}\text{O}/^{16}\text{O})_{\text{standard}}}{(^{18}\text{O}/^{16}\text{O})_{\text{standard}}} \right] \cdot 1000 \quad (\text{Eq. 4})$$

The oxygen isotopic composition in marine carbonates varies both with temperature and $\delta^{18}\text{O}_w$. The first is a function of temperature-dependent fractionation processes (i) kinetic in which stable isotopes are separated from each other by their mass through an unidirectional

process (e.g., evaporation, precipitation) and (ii) equilibrium fractionation, related to two or more substances in chemical equilibrium (e.g. in the system $\text{CO}_2\text{-H}_2\text{O-CaCO}_3$). The latter, in turn, depends on local precipitation-evaporation balance and global continental ice volume. For a more detailed description of the fractionation processes and interferences in the application of $\delta^{18}\text{O}_\text{c}$ as proxy see Mulitza et al. (2003). Carbonate samples are generally measured relative to the VPDB-standard (*Belemnitella americana* from the Pee Dee Formation, Cretaceous, South Carolina, USA - VPDB), whereas water samples refer to the Standard Mean Ocean Water (VSMOW). Hence, on account of the different preparation techniques for carbonate and water samples, a correction of -0.27 ‰ is necessary to convert the VSMOW scale into the VPDB scale (Hut 1987).

Foraminifera also use marine total dissolved inorganic carbon (ΣCO_2) to precipitate their calcite shells, thereby recording $\delta^{13}\text{C}$ of seawater ΣCO_2 during calcification. And despite its complexity (a wide variety of factors affecting seawater composition and foraminiferal calcite incorporation), $\delta^{13}\text{C}$ of foraminiferal calcite has been used as a proxy for past oceanic circulation, variations of biological productivity, changes in nutrient cycling in surface waters and variations in the global carbon cycle (Chiessi et al., 2007).

There are three major carbon isotopes: ^{12}C (99%), ^{13}C (1%) and ^{14}C ($10^{-10}\%$). Due to the different atomic weight, fractionation during the geochemical transfer of carbon produces variations in the distribution of the isotopes of carbon (Mulitza et al., 1999). The isotopic composition of the sample being measured is expressed as delta $\delta^{13}\text{C}$ (Eq. 5) which represents the difference in the $^{13}\text{C}/^{12}\text{C}$ ratios between the sample and the standard, expressed as parts per thousand (‰, Mulitza et al., 1999):

$$\delta^{13}\text{C} = \left[\frac{(^{13}\text{C}/^{12}\text{C})_{\text{sample}} - (^{13}\text{C}/^{12}\text{C})_{\text{standard}}}{(^{13}\text{C}/^{12}\text{C})_{\text{standard}}} \right] \cdot 1000 \quad (\text{Eq. 5})$$

The ΣCO_2 comprises the sum of the concentrations of CO_2 (aqueous carbon dioxide), HCO_3^- (bicarbonate), and CO_3^{2-} (carbonate ion), and seawater pH controls the relative proportion of these components. Biological primary production (photosynthesis) in the euphotic

zone strongly fractionates stable carbon isotopes concentrating the light isotope ^{12}C in organic matter, thus after photosynthesis, the isotope ^{13}C is depleted by 1.8‰ in comparison to its natural ratios in the atmosphere (Harkness 1979 *apud* Mulitza et al., 1999). Planktonic foraminifera dwelling in the euphotic layer thus record the resulting relative increase in seawater $\delta^{13}\text{C}$. For a more detailed description of the fractionation processes and interferences in the application of $\delta^{13}\text{C}$ as proxy see Mulitza et al. (1999).

Stable isotopic composition analyses were performed in 10 to 15 *G.ruber* (pink) tests picked from cores 7605, 7610 and 7616 at every 2 cm, using a FinniganMAT 252 mass spectrometer equipped with an automatic carbonate preparation device. The standard deviation of the laboratory standard was 0.01 and 0.02‰ for $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$, respectively, for the measuring period at the University of Bremen.

With the oxygen isotopic composition of foraminiferal calcite and the temperature of calcification data (via Mg/Ca paleothermometry for cores 7610 and 7616 and alkenone based for core 7605) $\delta^{18}\text{O}_w$ was determined based on Mulitza et al. (2003) empirical paleotemperature equation (Eq.6):

$$T = -4.44 (\delta^{18}\text{O}_c - \delta^{18}\text{O}_w) + 14.20 \quad (\text{Eq. 6})$$

where T stands for the in-situ temperature during calcite precipitation ($^{\circ}\text{C}$), $\delta^{18}\text{O}_c$ represents the oxygen isotopic composition of the calcite (‰, VPDB), and $\delta^{18}\text{O}_w$ stands for the oxygen isotopic composition (‰, VPDB) of the seawater from which the calcite has been precipitated. The $\delta^{18}\text{O}_w$ values were transformed from VPDB to SMOW following Hut (1987) and corrected taking into account global ice volume, subtracting a $D\delta^{18}\text{O}_w$ after Lambeck and Chappell (2001) and Schrag et al. (2002), thus, obtaining the oxygen composition of the seawater corrected for global ice volume ($\delta^{18}\text{O}_{w-\text{ivc}}$). The observed $\delta^{18}\text{O}_{w-\text{ivc}}$ variations were interpreted as salinity changes, as there is a linear relationship between salinity and $\delta^{18}\text{O}_w$, since both are affected by freshwater fluxes and evaporation and precipitation (LeGrande and Schmidt, 2006).

4.4.2. Benthic foraminifera community

Foraminifera constitute a substantial part of the benthic biomass in the ocean. Benthic foraminifera are widely used as microfossil proxies due to their relatively low position in oceanic food webs (most of them are primary consumers), high abundance and diversity in numerous marine environments, and excellent potential of fossilization (Jorissen and Rohling, 2000). In the last two decades, benthic foraminifera have been increasingly used as proxies for oceanic environmental changes, either related to circulation (e.g., Schmiedl and Mackensen, 1997; Schönfeld, 2002), productivity (e.g., Lutze and Coulbourn, 1984; Mackensen et al., 1985; Corliss and Chen, 1988; Loubere, 1996; Jorissen et al., 1998; Martinez et al., 1999; Wollenburg et al., 2004; Martins et al., 2007) or climate (e.g., Hill et al., 2003; Gupta et al., 2006; Zariess and Mackensen, 2011).

In general, abundance, distribution pattern and habitat depth of benthic foraminifera are controlled by dissolved oxygen concentrations of bottom and pore waters, and quality, quantity, and seasonality of organic matter supply (e.g., Herguera and Berger, 1991; Loubere, 1998; Loubere and Fariduddin, 1999; Schmiedl et al., 2000; Fontanier et al., 2002; Gooday, 2003; Jorissen et al., 2007). These factors, allied with substrate type and the energetic state at the benthic boundary layer, also control their distinct microhabitat distribution within the sediment (Mackensen et al., 1995; Schmiedl et al., 1997).

The benthic foraminifera assemblage has been applied in a paleoproductivity reconstruction for the Brazilian continental shelf (Nagai et al., 2009), with good correlations between the benthic foraminifera based inferences and geochemical productivity proxies (e.g., organic carbon contents and elemental ratios). More recently, in an assessment to study the southeastern Brazilian margin using modern vertical benthic foraminifera distribution, Burone et al. (2010), found that the living benthic foraminifera distribution was able to reflect different productivity and oceanographic conditions on the southeastern Brazilian shelf, presenting high potential for reconstructions regarding not only the quantity but also the quality of the organic input.

Samples for microfaunal analyses were selected along cores 7605 and 7616, in time intervals of approximately 100 years and 200 to 1000 years, respectively. Aliquots of 10 cc were

sieve washed (meshes >250µm and >63µm) and oven dried in temperatures below 60°C. Picking benthic foraminifera was done in two steps: first all the benthic foraminifera tests were picked from the >250 µm fraction (generally very poor in benthic foraminifera) and transferred to the 63-250 µm fraction, from now on denominated as the >63 µm fraction. Secondly the >63 µm fraction was thinly spread on a gridded picking tray, and random grids were fully investigated until a minimum of 300 individual foraminifera were counted, following the modified methodology of Schröder et al. (1987) and Schmielid et al. (1997). Tests were identified based on specific literature, such as Van Morkhoven et al. (1986), Loeblich and Tappan (1988), Jones (1994), and Barbosa (1998).

Foraminiferal parameters, such as density (D), species richness (R), equitability (J') and diversity (H') were calculated using the PAST program (Hammer et al., 2008). The species richness (R) was determined as the total number of species; equitability was calculated according to Pielou (1975); and diversity was calculated according to Shannon and Weaver (1999). These parameters may synthesize the population response to changes in environmental trophic conditions (Burone, 2002; Burone and Pires-Vanin, 2006). Benthic foraminifera species were also classified according to their micro-habitat (infaunal or epifaunal) based on Corliss (1985, 1991), Corliss and Chen (1988), Murray (1991), Fontanier et al. (2002) *amongst others*.

Cluster analyses were performed using the PAST program (Hammer et al., 2008). A matrix of data was constructed using species with abundance >3% in at least 10% of the analyzed samples (Nagai et al., 2009). R-mode cluster analyses were used to group species using the correlation method, and clusters were joined using the unweighted pair-group average (UPGMA). In this method, clusters are joined based on the average distance between all members in the two groups.

In order to observe variations in organic matter fluxes to seafloor, two benthic foraminifera based productivity indexes were determined: the Benthic Foraminifera Accumulation Rates index - BFAR (Herguera and Berger, 1991) and the Benthic Foraminifera High Productivity index - BFHP (Martins et al., 2007). Benthic foraminifera productivity based indexes, such as BFAR and BFHP can provide a useful proxy of the flux of organic matter to the ocean floor resulting from surface productivity (e.g., Herguera and Berger, 1991; Martins et al., 2007; Nagai et al., 2009). Although their use in a quantitative way has not been fully

investigated (Jorissen et al., 2007), qualitatively they have been successfully applied in paleoproductivity studies in other continental margins (e.g., Martinez et al., 1999; Martins et al., 2007) and in the SW Atlantic (Nagai et al., 2009).

The BFAR (tests in $10 \text{ cm}^2 \cdot \text{kyr}^{-1}$), commonly applied in deep-sea sites where it is correlated to the exported organic carbon flux to the sea floor, and thus correlated to primary production, was calculated according to the modified methodology of Wollenburg and Kuhnt (2000). However, this index has limitations, such as the dependence on sedimentation rates and the assumption that lateral supply of organic carbon is low or absent. Hence, it was cautiously applied in this study only to identify paleoproductivity trends. Whereas, the BFHP is based on species-specific response of benthic foraminifera to changes in organic matter fluxes to the seafloor, allowing the identification of periods of increased organic carbon fluxes (Martins et al., 2007). This index was calculated according to the modified methodology of Martins et al. (2007), through the quantification of specimens of species considered to be indicators of high productivity, such as *Brizalina* spp., *Bulimina* spp., and *Uvigerina peregrina*, among others.

5. Results

5.1. Core 7605 (27°6.24'S, 47°48.24'W – Itajaí/SC)

5.1.1. Chronology

Core 7605 is 2.40 m long and consists of dark olive-gray mud, slightly fining upward, with dispersed bioclasts (primary mollusk fragments). Due to the lack of sufficient organic material in core base sediment samples, ages were only obtained for the uppermost 1.10 m of the core, which ranges a time span from 7682 to 515 yr cal. BP; sediments younger than ~500 yr cal. BP were not recovered (Table 3, Figure 7). The uncorrected sedimentation rates inferred from the age model range from close to 10 cm kyr⁻¹ at the base of the core to 70 cm kyr⁻¹ at the top, increase starting at ca. 3000 yr cal. BP (Figure 7).

Table 3 – ¹⁴C AMS radiocarbon dating results for core 7605 and 2σ calibrated age ranges, no age inversion in radiocarbon dates was observed.

Core depth (cm)	BETA Analytc Inc. ID	¹⁴ C age (anos A.P.) ± 1σ	¹³ C/ ¹² C (‰, PDB)	2σ cal. range
0 - 2	257051	1530 ± 40	-20.4	Cal BP 708 - 515
50 - 52	257052	2910 ± 40	-23,0	Cal BP 2263 - 1908
68 - 70	329078	4130 ± 40	-20,9	Cal BP 4260 - 3888
98 - 100	257053	6940 ± 50	-21.9	Cal BP 7140 - 6776
108-110	259339	7860 ± 50	-20.7	Cal BP 7962 - 7682

Figure 7 - Age model and uncorrected sedimentation rates (cm·kyr⁻¹) for core 7605. Age model was based on calibrated radiocarbon ages (red circles), interpolations were obtained through the mixed effect model described by Heegard et al. (2005) – solid line; and the 95% confidence interval - dashed lines.

5.1.2. Sedimentological analyses

The basal sediments present bimodal grain size distribution, lasting until ca. 1200 yr cal. BP, with a strong sand contribution ($\pm 68\%$ at ca. 4700 yr cal. BP) centered at approximately 1.5 ϕ (Figure 8, Appendix 1). The sand contribution decreases in importance towards the top being replaced by a second mode centered at approximately 5 ϕ after 3100 yr cal. BP. The second mode is represented by muddy sediments (mainly silt) and it is present throughout the whole core but with increasing in contribution from the base to coretop. This finning upward behavior is also seen in the mean grain size distributions.

The first two factors of the CA (Figure 8) account for 84.1% of the total variance of the grain size distribution. While factor 1 (69.5% of the total variance) opposes silt (5.00 to 6.25 ϕ) against sand (2.75 to 1.00 ϕ) contributions, factor 2 (14.6% of the total variance) shows the

contrasts between the sandy contribution and silts. The CA of core 7605 reveals the transition from a polymodal grain size distribution, which lasted until approximately 5600 yr cal. BP (Figure 8a), to a quasi-unimodal distribution (Figure 8c) starting at c. 2300 yr cal. BP.

Figure 8— Particle size distribution (PSD), frequency (%) in each size class (ϕ) are indicated by colour-filled contours (legend in bottom), ϵ Nd data, the results of the grain size variations Correspondence Analysis (CA) for core 7605, and representative grain size frequency distributions (size class % versus Φ) for the corresponding core age levels (dashed lines) and labels on the CA-plots.

5.1.3. Geochemical analysis

5.1.3.1. Sedimentary organic matter

Organic carbon and total nitrogen contents present an upward increase, with low values in the lowermost part of the core (<0.25% and <0.05%, for TOC and N_{tot} respectively) until ca. 3000 yr cal. BP, followed by increase in TOC and N_{tot} contents to 1.0% e 0.15%, respectively (Figure 9, Appendix 1). This period also represents a boundary for C/N ratios that present increase in values up to coretop, where values range between 4 and 8. Organic matter isotopic

composition, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$, present relatively stable behavior ranging between -21.5‰ and -20.5‰ for $\delta^{13}\text{C}$ and between 1 and 3‰ for $\delta^{15}\text{N}$ (Figure 9).

Figure 9 - Along core 7605 distribution of CaCO_3 contents and sedimentary organic matter (TOC and N_{tot} contents, isotopic composition of the organic matter $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and C/N ratio). Black circles represent data and solid gray curves a moving average for every 3 samples.

TOC and N_{tot} contents present significant correlation between each other, in the cross plot it is possible to distinguish three distinct groups of samples, namely: sediments samples found between 5300 and 3100 yr cal. BP, samples between 3100 and 1900 yr cal. BP, and samples younger than 1900 yr cal. BP (Figure 9). And in the cross plot between $\delta^{13}\text{C}$ and C/N ratios all samples fall into the marine algae interval defined by Meyers et al. (1994) (Figure 10, Appendix 1).

5.1.3.2. Calcium carbonate (CaCO_3)

CaCO_3 contents present progressive increase from core base (average 13%) towards coretop, when CaCO_3 contents reaches 17% (Figure 9, Appendix 1).

Figure 10 - (a) cross plot between TOC and N_{tot} , showing significant correlation between variables ($p < 0.05$) and highlighting three distinct groups of sediment samples; and (b) $\delta^{13}C$ vs. C/N plot, the different fields correspond to end member sources for organic matter preserved in sediments (modified from Meyers, 1994).

5.1.3.3. Sedimentary inorganic constituents

The cross plot between Fe and Ti versus Al highlight that the first two metals present significant correlation with the last one (Figure 11a, b). Thus, Al, Fe and Ti present a similar trend along core the with relatively lower values from core base until ca. 2800 yr cal. BP, followed by a significant progressive increase towards coretop (Figure 12, Appendix 1). Fe/Ca and Ti/Ca ratios present continuous increase from core base (0.10 and 0.01, respectively) until ca. 6000 yr cal. BP (0.75 and 0.10, for Fe/Ca and Ti/Ca respectively), followed by a moderate increase in values up to 2000 yr cal. BP. After 2000 yr cal. BP, significant increase in these ratios can be observed from approximately 1 to 2 for Fe/Ca, and from 0.01 to 0.02 for Ti/Ca ratios (Figure 12).

Meanwhile, Ca has relatively high concentrations at lowermost core sediments until 6000 yr cal. BP (approximately $80000 \text{ mg}\cdot\text{kg}^{-1}$), followed by a relative decrease in concentration towards the top of the core. Ba presents relatively higher values between 7700 and 2000 yr cal. BP (average $217 \text{ mg}\cdot\text{kg}^{-1}$) and slightly lower values after 2000 yr cal. BP (approximately $200 \text{ mg}\cdot\text{kg}^{-1}$).

Figure 11 - Cross plots of (a) Fe vs. Al; (b) Ti vs. Al; (c) Ba/Al vs. TOC; and (d) Ba/Ca vs. TOC. The first three plots (a, b and c) presented statistically significant values ($p < 0.05$) of the Correlation Coefficient.

The cross plot between Ba/Al, Ba/Ca and TOC do not present a clear relationship between these variables (Figure 11c, d), although a significant negative correlation is found between Ba/Al and TOC. Different distribution pattern is observed between Ba/Al and Ba/Ca ratios. The first presents an upward decreasing trend and, the later, a relatively stable distribution pattern with a slight increase in values upward (Figure 12).

Figure 12 - Along core distribution of (a) sedimentary inorganic constituents (Al, Fe, Ti, Ca and Ba) and (b) elemental ratios (Fe/Ca, Ti/Ca, Ba/Ca and Ba/Al) obtained for core 7605. Black circles represent data and solid black curves a moving average for every 3 samples.

5.1.3.4. Mineralogy

The X-ray diffraction results for core 7605 in the < 63 μm fraction show the presence of mainly siliciclastic minerals (Appendix 1). As main components were identified: phyllosilicates (9.8 - 53%) and quartz (18.1 – 44.8%), followed by feldspars (6.4-26% - K-feldspars (0-15.8%) and plagioclases (0.4-26%), calcite and opal representing 4.4-15.4% and 1.5-13.9%, respectively (Figure 13). Accessory minerals are also represented by traces of several other minerals such as analcime (0-4.2%), dolomite (0.5-5%), halite (0-4.2%), and pyrite (0-9%) (Appendix 1). Other minerals such as anhydrite, chlorite, magnetite/maghematite, siderite and zeolites are present in some samples of the core with percentages below 3%.

Sediments at the base of the core present relatively higher amounts of phyllosilicates (average 40%), followed by a continuous decrease in values until 4000 yr cal. BP representing approximately 9% of sediments mineralogy, with an increase upward in phyllosilicates percentages (Figure 13). Meanwhile, an opposite distribution pattern was observed for quartz, presenting relatively lower amounts at core base ($\pm$ 24%) reaching maximum values of approximately 40% at 4000 yr cal. BP, with decrease in quartz percentages after this period towards coretop, where quartz represents close to 30% of sediments mineralogy (Figure 13).

Feldspars and opal amounts present continuous upward increase, for the first; however, this increase lasts until approximately 2100 yr cal. BP followed by a decrease in their contents after this (Figure 13). A constant decrease in calcite amounts is observed in the last 7900 yr cal. BP from 10% to 8%. A relatively stable behavior was observed for the Detrital Mineral Index (DM) with percentages varying between 52-83%, minimum values were observed at ca. 2800 yr cal. BP, presenting an increase of about 5% after this period. A similar behavior was also observed for the Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) ranging between 0.15 and 1.65.

Figure 13 - Along core 7605 distribution of the main mineralogical components identified for the < 63 μm size fraction and the Detrital Mineral Index (DMI) and Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) indexes. Black circles represent data and solid black curves a moving average for every 3 samples.

5.1.3.5. Neodymium (ϵNd) isotopes

For core 7605 relatively higher values ($\epsilon\text{Nd} = -7.50 \pm 0.12$) of neodymium isotopic composition of sediments are found at 7700 yr cal. BP, at 5600 yr cal. BP ϵNd values of -8.71 ± 0.12 are observed, and at 2000 yr cal. BP ϵNd values of -8.02 ± 0.12 were found (Table 4, Figure 8).

Table 4 – ϵNd data obtained for core 7605.

Core depth (cm)	Estimated age (yr cal. BP)	ϵNd
48 - 50	1989	-8.02 ± 0.12
88 - 90	5579	-8.71 ± 0.12
106 - 108	7715	-7.51 ± 0.12

5.1.4. Microfaunal analyses

5.1.4.1. Chemical composition of planktonic foraminifera tests

5.1.4.1.2. Stable oxygen ($\delta^{18}\text{O}_c$) and carbon ($\delta^{13}\text{C}$) isotopic composition

The $\delta^{18}\text{O}_c$ composition of *G. ruber* (pink) from core 7605 presents relatively higher values (average 0.90‰) between 7700 and approximately 4000 yr cal. BP, followed by a slight decreasing trend in $\delta^{18}\text{O}$ after 3000 yr cal. BP towards the coretop with average values of -1.05‰ (Appendix 1, Figure 14). Meanwhile $\delta^{13}\text{C}$ in *G. ruber* (pink) present relatively lower values between 7700 and 2000 yr cal. BP (average value of 1.68‰); followed by a progressive increase in $\delta^{13}\text{C}$ values in the last 2000 yr cal. BP with average value of approximately 1.82‰ (Figure 14).

As previously stated we used an alkenone based SST curve from core 7606 (Bícego, 2008), collected close to core 7605 to calculate $\delta^{18}\text{O}_{w-ivc}$ estimates. SST distributions for core 7606 present increase of approximately 2.5°C between 7700 and 6000 yr cal. BP, followed by average values of 27°C until approximately 5000 yr cal. BP (Figure 14). In the last 5000 years a

decrease in SST occurs in two steps, the first, between 5000 and 2500 yr cal. BP with an average decrease of 1.5°C and, the second, after 2500 yr cal. BP towards the present, presents a progressive decrease from 25.5°C to 24°C.

$\delta^{18}\text{O}_{\text{w-ivc}}$ estimates present a similar distribution pattern as alkenone based temperature, between 7700 and 5200 cal yr BP values increase by approximately 0.60‰, and then show a general trend towards lighter $\delta^{18}\text{O}_{\text{w-ivc}}$ values (average decrease of approximately 0.70‰) until present time with two superimposed high frequency steps with decreases of 0.20‰ and 0.70‰ (Figure 14).

Figure 14 – *G. ruber* (pink) $\delta^{18}\text{O}_c$ and $\delta^{13}\text{C}$ composition; alkenone based SST curve from core 7606 (Bícego, 2008); and $\delta^{18}\text{O}_{\text{w-ivc}}$ estimates for core 7605. Black circles represent data and solid gray curves a moving average for every 3 samples.

5.1.4.2. Benthic foraminifera community

A total of 182 species belonging to 68 genera of benthic foraminifera were identified, mainly calcareous taxa (Appendix 2), tests presented good preservation and no apparent evidence of shattered chambers in the sediments were observed. Benthic foraminiferal

densities (number of specimens in 10 cc of sediment) varied between 5392 and 41847 tests·10cc⁻¹. In general, throughout the core foraminifera densities did not present large along core variations (Figure 15).

Figure 15 – Along core 7605 distribution of benthic foraminifera density (tests·10cc⁻¹), epifauna and infauna species percentages, and benthic foraminifera based indexes BFAR (tests·cm⁻²·kyr⁻¹) and BFHP (%). Black circles represent data and solid gray curves a moving average for every 3 samples.

Angulogerina angulosa, *Angulogerina* spp., *Bulimina marginata*, *Bulimina* spp., *Buliminella elegantissima*, *Cibicides ungerianus*, *Globocassidulina subglobosa*, *Globocassidulina* spp., *Gyroidina umbonata*, *Gyroidina* spp., *Epistominella* spp., and *Islandiella norcrossi* were considered as representative species (relative frequency >3% in at least 10% of samples) Plates 1 and 2. *G. subglobosa* was the most abundant and widespread species in the core, representing in average over 20% of the total population in 32/33 samples, followed by *A. angulosa* (average more than 18% of the total population in 32/33 samples). Representing in average >5% of the total assemblage *B. marginata*, *Globocassidulina* spp. and *G. umbonata*. As minor components of the benthic foraminifera fauna *Angulogerina* spp., *Bulimina* spp., *B.*

elegantissima, *C. ungerianus*, *Gyroidina* spp., *Epistominella* spp., *I. norcrossi* (average <5% of the total assemblage).

R-mode cluster analysis revealed four main assemblages, which were denominated according to the dominant species: *A. angulosa*, *B. marginata*, *G. subglobosa* and *G. umbonata* (Figure 16). The *A. angulosa* assemblage is composed of *A. angulosa* and *Bulimina* spp. (Figure 16), this assemblage is present throughout the core with a slight increase in relative frequencies from 3000 yr cal. BP towards core top (Figure 17).

Figure 16 –Dendrogram classification resulting from the R-mode cluster analysis (correlation method joined by UPGMA) based on the 12 species with relative abundances higher than 3% in at least 10% of the samples from core 7605.

The *B. marginata* assemblage is composed of *B. marginata*, *C. ungerianus* and *I. norcrossi* (Figure 16) this assemblage presents an overall increase trend in frequencies. *B. marginata* and *I. norcrossi* presents decrease in frequencies after 3000 yr cal. BP, from mean values of 9 to close to 0% and from mean values of 4% to close to 0, respectively (Figure 17).

Meanwhile *C. ungerianus* presents a sharp decrease in frequencies at approximately 4800 yr cal. BP, going from mean 3% to 0 (Figure 17).

The *G. subglobosa* assemblage is composed of *B. elegantissima*, *G. subglobosa*, *Globocassidulina* spp., *Gyroidina* spp. and *Epistominella* spp. (Figure 16). This assemblage is present throughout the core and comprises over 30% of total benthic foraminifera assemblage. As a general trend this assemblage presents an overall increase in relative frequencies from 3000 yr cal. B.P. towards core top particularly shown by *B. elegantissima*, *Gyroidina* spp. and *Epistominella* spp. (Figure 17).

The *G. umbonata* assemblage is composed of *Angulogerina* spp. and *G. umbonata* (Figure 16). *G. umbonata* presents increase in frequencies between 7000 and approximately 4800 yr cal. BP, reaching values close to 9%, with decrease in frequencies from this age towards core top (Figure 17). Meanwhile, *Angulogerina* spp. frequencies do not present large variations throughout the core (Figure 17).

The benthic foraminifera assemblage from core 7605 is mainly composed by species with infaunal (~67%, of shallow/intermediate/deep infauna species) microhabitat, with epifaunal species representing approximately 10% of the total assemblage (Figure 15, Appendix 2). Slightly higher percentages of epifaunal species (~15%) are observed in older sediments with a decrease after approximately 6000 yr cal. BP (Figure 15). Approximately 12% of the identified species lacked microhabitat classification, this undetermined microhabitat species however accounted for less than 1% of the total benthic foraminifera assemblage.

Foraminiferal parameters are presented in Appendix 2. Sediment samples from core base presented relatively higher values for R (mean = 36) and H' (mean = 2.23), followed by a continuous decrease in values until approximately 3000 yr cal. BP when values of both R and H' parameters present mean values of approximately 29 and 2.10, respectively (Figure 18). J' presented along core mean values around 0.63 (Figure 18).

Figure 17 – Along core 7605 distribution of the relative frequencies of the 12 benthic foraminifera species considered as representative (>3% in at least 10% of samples), grouped according to the R-mode cluster analysis. Black circles represent data and solid gray curves a moving average for every 3 samples.

Cont. Figure 17

Benthic foraminifera productivity indexes BFAR and BFHP are presented in Appendix 2 and represented Figure 15. In general both indexes presented increase in values after approximately 2600 yr cal. BP (Figure 15). Relatively higher values of the BFAR index are observed between 7000 and approximately 3500 yr cal. BP ($\sim 2.2 \times 10^5$ tests $\cdot 10\text{cm}^{-2}\cdot\text{kyr}^{-1}$), followed by decrease in values to approximately 1.5×10^5 tests $\cdot 10\text{cm}^{-2}\cdot\text{kyr}^{-1}$ between 3500 and 2100 yr cal. BP. After approximately 2100 yr cal. BP BFAR values increases to mean values of 4.5×10^5 tests $\cdot 10\text{cm}^{-2}\cdot\text{kyr}^{-1}$ reaching a maximum value of 10.0×10^5 tests $\cdot 10\text{cm}^{-2}\cdot\text{kyr}^{-1}$ at core top (611 yr cal. BP, Figure 15). BFHP index values range between 4 and 20% (mean values of 12%), after approximately 2600 yr cal. BP BFHP values present a slight increase towards core top reaching 16% at approximately 940 yr cal. BP (Figure 15).

Figure 18 - Benthic assemblage parameters along core 7605 distribution. Where: R – species richness; H' – diversity; and J' - equitability.

5.2. Core 7610 (25°30.48'S, 46°38.1'W – Cananéia/SP)

5.2.1. Chronology

The recovery for core 7610 was 4.04 m, however, in this study only the uppermost 2.3 m were analyzed, representing a time span of approximately 7000 yr cal. BP, sediments younger than approximately 700 yr cal. BP were not recovered (Table 5, Figure 19). The first 2.4 m of the sedimentary column consists of dark olive gray muddy sands (with very fine sand) with irregular lamination and the presence of disperse bioturbation. The uncorrected sedimentation rates inferred from the age model (Figure 19) range from close to 30 cm kyr⁻¹ at the base of the core to 40 cm kyr⁻¹ at the top, sedimentation rates start increasing after approximately 5000 cal. BP.

Table 5 - ^{14}C AMS radiocarbon dating results for core 7610 and 2σ calibrated age ranges, no age inversion in radiocarbon dates was observed.

Core depth (cm)	BETA Analytic Inc. ID	^{14}C age (anos A.P.) $\pm 1\sigma$	$^{13}\text{C}/^{12}\text{C}$ (‰, PDB)	2σ cal. range
0 -- 2	248113	1140 $\pm$ 40	-20.3	Cal BP 820 - 563
50 -- 52	248114	2390 $\pm$ 40	-19.9	Cal BP 2189 - 1855
100 -- 102	248115	3210 $\pm$ 40	-20.3	Cal BP 3220 - 2846
150 -- 152	248116	4550 $\pm$ 40	-20.5	Cal BP 4864 - 4541
198 -- 200	248117	5650 $\pm$ 40	-20.8	Cal BP 6184 - 5901
238 -- 240	248118	7030 $\pm$ 40	-21.4	Cal BP 7608 - 7404
308 -- 310	248119	8880 $\pm$ 50	-21.6	Cal BP 9695 - 9392

Figure 19 - Age models and uncorrected sedimentation rates (cm·kyr⁻¹) for core 7610. Age model was based on calibrated radiocarbon ages (red circles), interpolations were obtained through the mixed effect model described by Heegard et al. (2004) – solid line; and the 95% confidence interval - dashed lines

5.2.2. Sedimentological analyses

Grain size analyses point to a predominance of muddy sediments along the core (Appendix 3). The PSD of the basal part of this core, however, shows similar characteristics to core 7605, with a pronounced bimodal distribution from core base until approximately 5000 yr cal. BP (Figure 20). The sand contribution (centered at approximately 2ϕ) decreases in importance towards coretop being replaced by a second mode centered at approximately 5ϕ , represented by muddy sediments (mainly silt), after 5000 yr cal. BP.

Figure 20 - Particle size distribution (PSD), frequency (%) in each size class (ϕ) are indicated by colour-filled contours (legend in bottom), ϵ Nd data, the results of the grain size variations Correspondence Analysis (CA) for core 7610, and representative grain size frequency distributions (size class % versus Φ) for the corresponding core age levels (dashed lines) and labels on the CA-plots.

The two first factors of CFA in core 7610 depict the highest variability of the studied cores, explaining 95.6% of the total variance. Factor 1 (81.2% of the total variance) opposes the

sediments between 3.50 and 1.25 Φ (sands) against silts. Factor 2 (14.4% of the total variance) opposes the medium to fine sands against the fine silts and clays (Figure 20).

5.2.3. Geochemical analysis

5.2.3.1. Sedimentary organic matter

Sedimentary organic matter contents parameters namely TOC, N_{tot} and C/N ratios present similar distribution curves along core 7610 (Appendix 3, Figure 21). Throughout the core a progressive increase in these parameters can be observed, occurring in three steps: the first, between 7000 and 4800 yr cal. BP, with relatively lower values for TOC (0.29%), N_{tot} (0.09%) and C/N ratios (± 3); the second, between 4800 and 2300 yr cal. BP with average values of 0.53% for TOC, 0.11% for N_{tot} and 4.5 for C/N ratios; and the third step, after 2300 yr cal. BP, where average values of 0.75% for TOC, 0.12% for N_{tot} and 6 for C/N ratios are observed (Figure 21).

For the isotopic composition of the organic matter a shift in values occurs at ca. 3800 yr cal. BP in both $\delta^{13}C$ and $\delta^{15}N$ values (Figure 21). The first presents values close to -22‰, in younger than 3800 yr cal. BP sediments, after which $\delta^{13}C$ presents average values of -20.5‰. For $\delta^{15}N$ values centered at around 5‰ are observed between ~7500 and 3800 yr cal BP and towards coretop values oscillate between 0‰ and 2.5‰ (with average values around 2‰).

As for core 7605, TOC and N_{tot} contents also presented significant correlation between each other and three distinct groups can also be identified in the cross plot between TOC and N_{tot} , namely sediments samples found between 6300 and 4800 yr cal. BP, samples between 4800 and 2300 yr cal. BP, and samples younger than 2300 yr cal. BP. Also in the cross plot between $\delta^{13}C$ and C/N ratios all samples fall into the marine algae interval defined by Meyers et al. (1994) (Figure 21).

Figure 21 – Along core 7610 distribution of CaCO_3 contents and sedimentary organic matter (TOC and N_{tot} contents, isotopic composition of the organic matter $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and C/N ratio). Black circles represent data and solid gray curves a moving average for every 3 samples.

5.2.3.2. Calcium carbonate (CaCO_3)

Calcium carbonate contents present relatively lower values (15-20%) between 7000 and 4000 yr cal., from this time interval until 3000 yr cal. BP relatively higher values (>25%) are observed for CaCO_3 . After 3000 yr cal. BP towards coretop a slight decrease in CaCO_3 contents occur with values oscillating between average values of 22% (Appendix 3, Figure 21).

Figure 22 – (a) cross plot between TOC and N_{tot} , showing significant correlation between variables ($n-1=103$; $\alpha= 0.05$) and highlighting three distinct groups of sediment samples; and (b) $\delta^{13}C$ vs. C/N plot, the different fields correspond to end member sources for organic matter preserved in sediments (modified from Meyers, 1994).

5.2.3.3. Sedimentary inorganic constituents

The crossplot between Fe and Ti versus Al, with higher than 0.9 r^2 values, highlights correlation between the first half and the later (Figure 23a,b). Al, Fe and Ti present similar along core distribution pattern with relatively lower values at core base and a progressive increase towards coretop (Appendix 3, **Figure 24**).

An upward decreasing trend is observed for Ca concentrations, presenting relatively higher concentrations at lowermost core sediments (approximately $34000 \text{ mg}\cdot\text{kg}^{-1}$). As an exception, a peak in this constituent concentration occurs at ca. 1000 yr cal. BP. Meanwhile, Ba concentrations presents a relatively stable behavior between 7700 and approximately 2800 yr cal. BP (average $190 \text{ mg}\cdot\text{kg}^{-1}$), followed by a decrease until 2000 yr cal. BP, when Ba concentration values are close to $150 \text{ mg}\cdot\text{kg}^{-1}$ and another increase after this period reaching values of approximately $210 \text{ mg}\cdot\text{kg}^{-1}$ at coretop. (**Figure 24**)

Figure 23 – Cross plots of (a) Fe vs. Al; (b) Ti vs. Al; (c) Ba/Al vs. TOC; and (d) Ba/Ca vs. TOC. Statistically significant values ($p < 0.05$) of the Correlation Coefficient are shown.

The distribution of Fe/Ca and Ti/Ca ratios along core 7610 (**Figure 24**) have similar trends to those presented for core 7605 (Figure 12) with a progressive increase from core base towards coretop. This increase, however, occurs in three distinct steps: (1) between 6000 and 4200 yr cal. BP, with Fe/Ca ratios, for example, going from 0.5 to approximately 1.2; (2) from 4200 to 2200 yr cal. BP, Fe/Ca ratios reach values close to 1.7; and (3) after 2200 yr cal. BP towards coretop Fe/Ca ratios presents values close to 2 (Figure 24).

The cross plot between Ba/Al and TOC do not present a clear relationship between these variables (Figure 23c), while Ba/Ca and TOC present low, but positive and significant correlation (Figure 23d). Different distribution pattern is observed between Ba/Al and Ba/Ca ratios. The first presents an upward decreasing trend and, the later, a relatively stable distribution pattern with a slight increase in values upward (Figure 24).

Figure 24 – Along core distribution of (a) the sedimentary inorganic constituents (Al, Fe, Ti, Ca and Ba) and (b) the elemental ratios (Fe/Ca, Ti/Ca, Ba/Ca and Ba/Al) obtained for core 7610. Black circles represent data and solid gray curves a moving average for every 3 samples.

5.2.3.3. Mineralogy

The X-ray diffraction results for core 7610 in the < 63 μm fraction highlight the presence of mainly siliciclastic minerals (Figure 25). As main components were identified: phyllosilicates (28 – 66.5%) and quartz (11 – 28%), followed by feldspars (0-15% - K-feldspars (0-8%) and plagioclases (0-12%), calcite and opal representing 6-22% and 1.6-10%, respectively (Figure 25). Accessory minerals are also represented by traces of several other minerals such as analcime (0-4.6%), halite (0-6.7%), and pyrite (0-7%) (Appendix 3). Other minerals such as anatase, anhydrite, clorite, hematite, magnetite/maghematite and siderite are present in some samples of the core with percentages below 3% (Appendix 3).

Sediments at the base of the core present relatively lower amounts of phyllosilicates (average of 40%); followed by a continuous upward increase in values representing approximately 70% of sediments mineralogy in coretop sediments (Figure 25). Meanwhile, quartz amounts present relatively stable behavior until 2000 yr cal. BP with values oscillating around 18%, followed by a slight decrease in quartz amounts (average of approximately 15%). Feldspars contents range from 5 to 16% (average 10.9%) from core base until 3000 yr cal. BP and present relatively lower values in younger than 3000 years sediments with average percentages of 8 (Figure 25). Calcite amounts present a relatively stable behavior throughout the core oscillating between 6 and 22%.

The detrital mineral index (DM) presents percentages varying between 53-85%, with an upward increasing trend (Figure 25, Appendix 3). A similar behavior was also observed for the Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) ranging between 0.7 and 3.7.

Figure 25 - Along core 7610 distribution of the main mineralogical components identified for the < 63 μm size fraction and the Detrital Mineral Index (DM) and Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) indexes. Black circles represent data and solid gray curves a moving average for every 3 samples.

5.2.4. Microfaunal analyses

5.2.4.1. Chemical composition of planktonic foraminifera tests

5.2.4.1.1. Elemental ratios in planktonic foraminifera tests - Mg/Ca and Ba/Ca ratios

Crossplots between Mn/Ca and Fe/Ca against Mg/Ca ratios presented no significant correlation, attesting no contamination (Appendix 3, Figure 26). Mg/Ca ratios obtained in *G. ruber* (pink) tests for core 7610 present a relatively stable distribution pattern, ranging between 3.45 and 4.65 mmol/mol and oscillating around an average of 4.07 mmol/mol (Appendix 3, Figure 27). As a general pattern, periods with above average Mg/Ca ratio values are observed between 5800-5000 yr cal. BP; 4500-4000 yr cal. BP and 3000-2000 yr cal. BP intercalated with periods with below average. A clear exception to this pattern occurs after 1800 and 1400 yr cal. BP when the lowest values for Mg/Ca ratios are observed (average = 3.70 mmol/mol) (Figure 27).

A similar pattern is also observed for Mg/Ca based SST estimates, presenting an amplitude of about 3°C, ranging between minimum values of 24.5°C and maximum of 27.8°C and average values of 26.3°C (Figure 27). As for Mg/Ca ratios, the period between 1800 and 1400 yr cal. BP presents the lowest SST estimates (average 25°C), presenting an average of 2°C difference from its former and later periods

Figure 26 - Crossplot between Mg/Ca ratios against (a) Mn/Ca and (b) Fe/Ca ratios, for core 7610, low R^2 values highlight no contamination.

5.2.4.1.2. Stable oxygen ($\delta^{18}\text{O}$) and carbon ($\delta^{13}\text{C}$) isotopic composition

The $\delta^{18}\text{O}_c$ composition of *G. ruber* (pink) from core 7610 presents a progressive decrease of approximately 0.75‰ between 6000 and 4700 yr cal. BP, followed by a rapid increase with the same magnitude in a time span of 200 years (from 4700 to 4500 yr cal. BP) (Appendix 3). After this rapid increase in $\delta^{18}\text{O}_c$ values, a continuous decrease trend occurs ($\approx 0.50\text{‰}$) lasting until 2500 yr cal. BP. After 2500 yr cal. BP another increase of approximately 0.60‰ in $\delta^{18}\text{O}_c$ values is observed towards the coretop (Figure 27).

Meanwhile, $\delta^{13}\text{C}$ values present a different distribution pattern, between 6000 and 5500 yr cal. BP and between 3500 and 2800 yr cal. BP, $\delta^{13}\text{C}$ has average values of approximately 1.60‰ intercalated by a period with relatively higher values close to 1.75‰ (between 5500 and 3500 yr cal. BP). The highest values observed for *G. ruber* (pink) $\delta^{13}\text{C}$ (average 1.80‰) are located in the uppermost part of core 7610, after 2800 yr cal. BP (Figure 27).

$\delta^{18}\text{O}_{\text{w-ivc}}$ values present an overall decreasing trend from core base towards coretop (Figure 27). Between 6000 and 4700 yr cal. BP a progressive 1.00‰ magnitude decrease is observed. As for SST estimates, this decrease is followed by a rapid increase with the same magnitude (1.00‰) in $\delta^{18}\text{O}_{\text{w-ivc}}$ values within a time span of 300 years (from 4700 to 4300 yr cal. BP). From 4300 to approximately 1600 yr cal. BP a progressive decrease in $\delta^{18}\text{O}_{\text{w-ivc}}$ takes place, reaching values close to 0.71‰ at 1640 yr cal. BP. In the last 1400 years, $\delta^{18}\text{O}_{\text{w-ivc}}$ values increase oscillating around 1.45‰.

Figure 27 - Along core distribution of chemical composition of *G. ruber* (pink) (Mg/Ca ratios, $\delta^{18}\text{O}_c$ and $\delta^{13}\text{C}$ composition) and Mg/Ca based SST and $\delta^{18}\text{O}_{\text{w-ivc}}$ estimates obtained for core 7610.

5.3. Core 7616 (25°5.88'S, 45°38.64'W – Santos/SP)

5.3.1. Chronology

Core 7616 is 5.36 m long; however, in this study, only the uppermost 3 m were analyzed (Figure 28), since the lower part of the core shows a significant erosional contact at 3 m depth, below which the sediments yield radiocarbon ages of about 13000–15000 yr cal. BP (Table 6). The upper 3 m of the core consists of olive black (7.5GY 3/2) homogeneous mud with

sparse millimeter size mollusk fragments, and spans about 7000–900 cal. BP. The uncorrected sedimentation rate inferred from the age model varies from 40 to 60 cm kyr⁻¹ (Figure 28). The base of the core, below the unconformity at 3 m, consists of bioturbated dark olive-gray (2.5GY) mud with intercalations of sandy lenses and concentrations of centimeter-size mollusk fragments. Sediments younger than about 900 cal. BP in core 7616 were not recovered (Table 6).

Table 6 - ¹⁴C AMS radiocarbon dating results for core 7616 and 2σ calibrated age ranges, no age inversion in radiocarbon dates was observed.

Core depth (cm)	BETA Analytic Inc. ID	¹⁴ C age (anos A.P.) ± 1σ	¹³ C/ ¹² C (‰, PDB)	2σ cal. range
0 -- 2	224522	1460 ± 40	-21.1	Cal BP 1060 - 773
50 -- 52	224523	2420 ± 40	-21.2	Cal BP 2117 - 1813
100 -- 102	224524	3300 ± 40	-21.4	Cal BP 3211 - 2853
150 -- 152	224525	3470 ± 40	-21.7	Cal BP 3395 - 3075
200 -- 202	224526	4510 ± 40	-21.3	Cal BP 4786 - 4431
250 -- 252	224527	5320 ± 50	-21.6	Cal BP 5750 - 5444
300 -- 302	224528	6610 ± 60	-21.4	Cal BP 7225 - 6853
350 -- 352	224529	12170 ± 70	-23.3	Cal BP 13730 - 13349
400 -- 402	224530	13300 ± 80	-22.9	Cal BP 15494 - 14816
450 -- 452	224531	13340 ± 70	-23.1	Cal BP 15517 - 14909

Figure 28 - Age model and uncorrected sedimentation rates ($\text{cm}\cdot\text{kyr}^{-1}$) for core 7616. Age model was based on calibrated radiocarbon ages (red circles), interpolations were obtained through the mixed effect model described by Heegard et al. (2005) – solid line; and the 95% confidence interval - dashed lines

5.3.2. Sedimentological analyses

The lowermost sediments present a bimodal distribution with a sand contribution (centered at 2ϕ) lasting until approximately 5000 yr cal. BP, followed by an upward coarsening with very fine sand and coarse silts until 2000 yr cal. BP. At ca. 2000 yr cal. BP there is shift in sedimentation, expressed by a higher input of very fine silts and clays until 1700 yr cal. BP with a moderate coarsening upward (Appendix 4, Figure 29). Relatively constant values are observed for grain size median from the core base until c. 3500 yr cal. BP. A coarsening upward sequence follows this interval until coretop, with a minor fine-shift at 2000 yr cal. BP, followed by further coarsening from 1700 cal. BP towards the top.

The sum of factors 1 and 2 of the CFA represent 77.6% of the total variance (Figure 29). Factor 1 (52.5% of the total variance) contrasts the sandy contribution (from 1.00 to 3.50 Φ) to the clay contribution. Factor 1 indicates pronounced upward fining during two periods, from 7000 to c. 5000 cal. BP (resulting from a decreasing and eventually disappearing sand mode) and from 2000 to 1000 cal. BP (resulting from clay increase). Factor 2 (25.0% of the variance) contrasts the sandy content with respect to the fine and very fine silts. The variation of factors 1 and 2 represent the transition from the bimodal distribution, with a main mode centered at 2.5 Φ in the core base (Figure 29a), towards a unimodal distribution, centred at 5.0 Φ until approximately 2000 yr cal. BP (Figure 29b). From this age towards the top, there is a clear increase in very fine silts and clays.

Figure 29 – Particle size distribution (PSD), frequency (%) in each size class (Φ) are indicated by colour-filled contours (legend in bottom), ϵ Nd data, the results of the grain size variations Correspondence Analysis (CA) for core 7616, and representative grain size frequency distributions (size class % versus Φ) for the corresponding core age levels (dashed lines) and labels on the CA-plots.

5.3.3. Geochemical analysis

5.3.3.1. Sedimentary organic matter

As for the other two cores, core 7616 presents progressive increase in TOC contents in the last 7000 years, the lowermost sediments present lower than 0.5% TOC contents reaching up to 1.5% at coretop. Meanwhile, N_{tot} contents present a slight increase between 7000 and 2400 yr cal. BP from values close to 0.12% to 0.15%, respectively; followed by a shift in N_{tot} contents after 2400 yr cal. BP, when values reach approximately 0.22%. (Appendix 4, Figure 30)

C/N ratios present relatively lower values between 7000 and approximately 6000 yr cal. BP, with a mean of 3; followed by a slight increase (mean values of 5) until approximately 2400 yr cal. BP when values shift to 4, followed by another increase in C/N ratios towards coretop when values reach approximately 6. Meanwhile the isotopic composition of the organic matter, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ present a small increase in values in the last 7000 years, oscillating between -22‰ and -21.3‰ and around an average of 5‰, respectively (Figure 30).

Figure 30 – Along core 7616 distribution of CaCO_3 contents and sedimentary organic matter (TOC and N_{tot} contents, isotopic composition of the organic matter $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ and C/N ratio). Black circles represent data and solid gray curves a moving average for every 3 samples.

In the cross plot between TOC and N_{tot} contents it is possible to distinguish three distinct groups of samples, namely: sediments samples younger than 2400 yr cal. BP, these are samples with higher TOC and N_{tot} contents, sediment samples between 5800 and 2400 yr cal. BP, and between 7000 and 5800 yr cal. BP (Figure 31). In the cross plot between $\delta^{13}C$ and C/N ratios all samples fall into the marine algae interval defined by Meyers et al. (1994) (Figure 31).

Figure 31 - (a) cross plot between TOC and N_{tot} , showing significant correlation between variables ($n=103$; $\alpha= 0.05$) and highlighting three distinct groups of sediment samples; and (b) $\delta^{13}C$ vs. C/N plot, the different fields correspond to end member sources for organic matter preserved in sediments (modified from Meyers, 1994).

5.3.3.2. Calcium carbonate ($CaCO_3$)

Calcium carbonate contents present relatively higher values (average 25%) between 7000 and 2700 yr cal., between 2700 and 2200 yr cal. BP values range from 23 to 21%, and after 2200 yr cal. BP a decrease in $CaCO_3$ contents occur reaching values close to 17% in coretop sediments (Appendix 4, Figure 30).

5.3.3.3. Sedimentary inorganic constituents

The crossplot between Fe and Ti versus Al, with higher than 0.7 r^2 values, highlights correlation between the first and the later (Figure 32a,b). Al, Fe and Ti present similar along core distribution patterns, with relatively lower values at core base and a progressive increase

towards coretop (Appendix 4, Figure 33). V also presents a similar distribution pattern as described for Al, Fe and Ti.

Figure 32 - Cross plots of (a) Fe vs. Al; (b) Ti vs. Al; (c) Ba/Al vs. TOC; and (d) Ba/Ca vs. TOC. Statistically significant values ($p < 0.05$) of the Correlation Coefficient are shown.

An upward decreasing trend is observed for Ca concentrations, presenting relatively higher concentrations at lowermost core sediments (approximately $64000 \text{ mg} \cdot \text{kg}^{-1}$) and relatively lower concentrations (average values of $40000 \text{ mg} \cdot \text{kg}^{-1}$), especially after 2000 yr cal. BP (Figure 33). In the meantime, Ba concentrations presents a relatively stable behavior throughout the core (average values of $185 \text{ mg} \cdot \text{kg}^{-1}$), with two periods with higher and lower than average values between 3400 and 3200 yr cal. BP (average $220 \text{ mg} \cdot \text{kg}^{-1}$) and between 2000 and 1500 yr cal. BP (average $160 \text{ mg} \cdot \text{kg}^{-1}$), respectively (Figure 33).

Figure 33 - Along core distribution of (a) the sedimentary inorganic constituents (Al, Fe, Ti, Ca, and Ba) and (b) the elemental ratios (Fe/Ca, Ti/Ca, Ba/Ca and Ba/Al) obtained for core 7616. Black circles represent data and solid gray curves a moving average for every 3 samples.

The distribution of Fe/Ca and Ti/Ca ratios along core 7616 (Figure 33) have similar trends to those presented for core 7610 presenting progressive increase from core base towards coretop in three distinct steps. The first, between 7000 and approximately 6000 yr cal. BP, with Fe/Ca ratios, for example, going from 0.4 to approximately 0.6; in the second step, from approximately 6000 to 2000 yr cal. BP, Fe/Ca ratios present stable behavior; and after 2000 yr cal. BP towards coretop, the third increase step, Fe/Ca ratios presents values close to 1 (Figure 33). The same pattern is observed for Ti/Al ratios.

The cross plot between Ba/Al and TOC do not present a clear relationship between these variables (Figure 32c), while Ba/Ca and TOC present low, but positive and significant correlation (Figure 32d). Different distribution pattern is observed between Ba/Al and Ba/Ca ratios. The first presents an upward decreasing trend and, the later, a relatively stable distribution pattern with a slight increase in values upward (Figure 33)

5.3.3.4. Mineralogy

The X-ray diffraction results for core 7616 in the < 63 μm fraction highlight the presence of mainly siliciclastic minerals (Appendix 4, Figure 34). As main components were identified: phyllosilicates (27 -64.6%) and calcite (10 – 30%), followed by quartz (9 – 25%), feldspars (4-16% - K-feldpars (0-5%) and plagioclases (1-16%)) and opal representing 0-9% (Figure 34). Accessory minerals are also represented by traces of several other minerals such as analcime (0-3.3%), halite (0-7%), and pyrite (0-3%) (Appendix 4). Other minerals such as anatase, anhydrite, clorite, hematite, magnetite/maghematite and siderite are present in some samples of the core with percentages below 3% (Appendix 4).

Sediments at the base of the core present relatively lower amounts of phyllosilicates (average 40%); followed by a continuous upward increase in values representing approximately 50% in coretop sediments (Figure 34). Meanwhile, calcite presents an opposite trend, with a progressive decrease in contents from older than 7000 yr cal. BP sediments (approximately 30%) towards coretop when calcite represents 10% of the minerals. Quartz amounts present a relatively stable behavior throughout the core oscillating around 17% (Figure 34). Feldspars contents range from 4 to 16% (average 9%) from core base until approximately 1500 yr cal. BP,

with decrease in values towards younger sediments with average percentages of about 6% (Figure 34).

The detrital mineral index (DM) presents percentages varying between 45-76%, with an upward increasing trend (Appendix 4, Figure 34). A similar behavior was also observed for the Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) ranging between 0.7 and 4.0.

5.3.3.5. Neodymium (ϵNd) isotopes

For core 7616 relatively lower values ($\epsilon\text{Nd} = -12.22 \pm 0.12$) of neodymium isotopic composition of sediments were found at older than 8000 yr cal. BP, at approximately 3600 yr cal. BP ϵNd values of -9.74 ± 0.12 are observed, and at around 1800 yr cal. BP ϵNd values of -9.97 ± 0.12 were found (Table 7, Figure 29).

Table 7 – ϵNd data obtained for core 7616.

Core depth (cm)	Estimated age (yr cal. BP)	ϵNd
46 -48	1817	-9.97 ± 0.12
154 -156	3579	-9.75 ± 0.12
306 - 308	8615	-12.22 ± 0.12

Figure 34 - Along core 7616 distribution of the main mineralogical components identified for the < 63 μm size fraction and the Detrital Mineral Index (DM) and Fine Detrital Minerals/Coarse Detrital Minerals (FDM/CDM) indexes. Black circles represent data and solid gray curves a moving average for every 3 samples.

5.3.4. Microfaunal analyses

5.3.4.1. Chemical composition of planktonic foraminifera tests

5.3.4.1.1. Elemental ratios in planktonic foraminifera tests - Mg/Ca and Ba/Ca ratios

Crossplots between Mn/Ca and Fe/Ca against Mg/Ca ratios presented no significant correlation, attesting no contamination (Figure 35). As a general pattern, Mg/Ca ratios obtained in *G. ruber* (pink) tests for core 7616, present periods with values above average (3.97 mmol/mol) between 7000-5800 yr cal. BP (4.07 mmol/mol) and 4600-2800 yr cal. BP (4.05 mmol/mol), and periods with below average values between 5800-4600 yr cal. BP (3.83 mmol/mol) and after 2800 yr cal. BP (3.92 mmol/mol) (Appendix 4, Figure 36).

As for core 7610, a similar pattern is also observed for Mg/Ca based SST estimates, presenting an approximately 3.5°C amplitude, ranging between minimum values of 24.0°C and maximum of 27.5°C and average values of 26.0°C (Figure 36). The period between 5800 and 4600 yr cal. BP presents the lowest SST estimates (average 25.6°C), presenting an average of 1°C difference from its former and later periods (Figure 36).

Figure 35 - Crossplot between Mg/Ca ratios against (a) Mn/Ca and (b) Fe/Ca ratios, for core 7616, low R^2 values highlight no contamination.

5.3.4.1.2. Stable oxygen ($\delta^{18}\text{O}$) and carbon ($\delta^{13}\text{C}$) isotopic composition

The $\delta^{18}\text{O}_c$ composition of *G. ruber* (pink) from core 7616 presents a relatively stable behavior between 7000 and approximately 3000 yr cal. BP, oscillating around the average - 0.79‰. After 3000 yr cal. BP a progressive decrease of approximately 0.80‰ takes place, with lowest values (-1.59‰) occurring between 2000 and 1000 yr cal. BP (Appendix 4, Figure 36).

Meanwhile, $\delta^{13}\text{C}$ values present a different distribution pattern, between 7000 and approximately 3000 yr cal. BP, $\delta^{13}\text{C}$ presents a progressive decrease of approximately 0.60‰, followed by an increase trend from 3000 to approximately 1000 yr cal. BP in the same magnitude (approximately 0.60‰) as the decrease from the previous period (Figure 36).

$\delta^{18}\text{O}_{w-ivc}$ values present an overall decreasing trend from core base towards coretop (Figure 36). Between 7000 and 4400 yr cal. BP $\delta^{18}\text{O}_{w-ivc}$ presents average values of approximately 2.10‰, from 4400 until 2800 yr cal. BP. $\delta^{18}\text{O}_{w-ivc}$ values increase reaching average values of 2.40‰, this increase is followed by a decrease in $\delta^{18}\text{O}_{w-ivc}$ values of approximately 0.60‰ magnitude (Figure 36).

Figure 36 - Along core distribution of chemical composition of *G. ruber* (pink) (Mg/Ca ratios, $\delta^{18}\text{O}_c$ and $\delta^{13}\text{C}$ composition) and Mg/Ca based SST and $\delta^{18}\text{O}_{w-ivc}$ estimates obtained for core 7616. Black circles represent data and solid gray curves a moving average for every 3 samples.

5.3.4.2. Benthic foraminifera community

A total of 127 species belonging to 59 genera of benthic foraminifera were identified in core 7616, mainly calcareous taxa (Appendix 5), tests presented good preservation and no apparent evidence of shattered chambers in the sediments was observed. Benthic foraminiferal densities (number of specimens in 10 cc of sediment) varied between 2.5 and 78×10^3 tests $\cdot 10\text{cc}^{-1}$ (Appendix 5). Between approximately 7000 and 4000 yr cal. BP benthic foraminifera densities presents mean values of approximately 36×10^3 tests $\cdot 10\text{cc}^{-1}$, followed by a significant increase in values from 4000 yr cal. BP until 3 600 yr cal. BP when densities reach 78×10^3 tests $\cdot 10\text{cc}^{-1}$ (Figure 37). After 3 600 yr cal. BP benthic foraminifera densities decrease again reaching a minimum values of approximately 2.5×10^3 tests $\cdot 10\text{cc}^{-1}$ approximately 1000 yr cal. BP (core top, Figure 37).

The following species were considered as representative species (relative frequency >3% in at least 10% of samples): *Angulogerina angulosa*, *Angulogerina* spp., *Bolivina subspiniensis*, *Brizalina* spp., *Bulimina marginata*, *Bulimina* spp., *Globocassidulina subglobosa*, *Globocassidulina* spp., *Gyroidina umbonata*, *Gyroidina* spp., *Epistominella* spp., *Islandiella norcrossi* and *Seabrookia earlandi* and are represented in Plates 1 and 2.

G. subglobosa was the most abundant and widespread species in the core, representing in average over 30% of the total population in 19/19 samples, followed by *A. angulosa* (average more than 10% of the total population in 19/19 samples) and *Epistominella* spp. (average more than 11% of the total population in 16/19 samples). The species *B. marginata*, *Globocassidulina* spp., *G. umbonata* and *I. norcrossi* represent in average >5% of the total assemblage. *Angulogerina* spp., *B. subspiniensis*, *Brizalina* spp., *Bulimina* spp., *Gyroidina* spp., and *S. earlandi* are minor components of the benthic foraminifera fauna (average <5% of the total assemblage).

R-mode cluster analysis revealed three main assemblages, which were denominated according to the dominant species: *A. angulosa*-*B. marginata*, *G. subglobosa* and *I. tumidula* (Figure 38). The *A. angulosa*-*B. marginata* assemblage is composed by *A. angulosa*, *Angulogerina* spp., *B. subspiniensis*, *B. marginata*, *Bulimina* spp., *G. umbonata*, *Gyroidina* spp. and *I. norcrossi* (Figure 38). This assemblage presents an overall decrease in relative frequencies from 7000 until 3000 yr cal. BP, followed by a period with a slight increase in

species relative frequencies and a clear trend of increase after 2800 yr cal. BP towards core top (Figure 39).

Figure 37 - Along core 7616 distribution of benthic foraminifera density (tests·10cc⁻¹), epifauna and infauna species percentages, and benthic foraminifera based indexes BFAR (tests·cm⁻²·kyr⁻¹) and BFHP (%). Black circles represent data and solid gray curves a moving average for every 3 samples.

The *G. subglobosa* assemblage is composed of *G. subglobosa* and *Globocassidulina* spp. (Figure 38) this assemblage is present throughout the core and comprises over 30% of total benthic foraminifera assemblage. As a general trend this assemblage presents an overall decrease in relative frequencies from 4000 yr cal. B.P. towards core top (Figure 39).

The *Epistominella* spp. assemblage is composed of *Brizalina* spp., *Epistominella* spp. and *S. earlandi* (Figure 38). This assemblage presents an overall decreasing trend in frequencies towards core top particularly shown by the *Brizalina* spp. and *S. earlandi* species (Figure 39). Meanwhile, *Epistominella* spp. presents relatively higher frequencies between 4500 and 2800 yr cal. BP (reaching relative frequency values of 40%), followed by a continuous decrease in frequencies, reaching 0% at core top (Figure 39).

Figure 38 - Dendrogram classification resulting from the R-mode cluster analysis (correlation method joined by UPGMA) based on the 13 species with relative abundances higher than 3% in at least 10% of the samples from core 7616.

Species with an infaunal microhabitat (shallow/intermediate/deep infauna) dominate the benthic foraminifera assemblage from core 7616 (~92%), epifaunal species represent approximately 6% of the total assemblage (Figure 37, Appendix 5). Relatively higher percentages of epifaunal species (~10%) are sediment samples between 7000 and 4500 yr cal. BP, with an abrupt decrease in epifaunal species percentages (~3%) after 4000 yr cal. BP towards core top (Figure 37). As in core 7605, some of the identified species in core 7616 lacked microhabitat classification (approximately 22%), this undetermined microhabitat species however accounted for less than 2% of the total benthic foraminifera assemblage.

Figure 39 - Along core 7616 distribution of the relative frequencies of the 13 benthic foraminifera species considered as representative (>3% in at least 10% of samples), grouped according to the R-mode cluster analysis. Black circles represent data and solid gray curves a moving average for every 3 samples.

Cont. Figure 39 -

Foraminiferal parameters are presented in Appendix 5 and represented in Figure 40. Between approximately 7000 and 4000 yr cal. BP higher values for R (mean = 43) and H' (mean = 2.59) are observed, followed by a decrease in values until approximately 2600 yr cal. BP when values of both R and H' parameters present values of approximately 20 and 1.90, respectively (Figure 40). J' presented along core mean values around 0.68 (Figure 40).

Benthic foraminifera productivity indexes BFAR and BFHP are presented in Appendix 5 and represented Figure 37. In general, BFAR index follows the same along core distribution as observed for benthic foraminifera densities (Figure 37), with a relatively higher value at approximately 3600 yr cal. BP (42×10^5 tests $\cdot 10^2 \text{cm}^{-2} \cdot \text{kyr}^{-1}$) and lower values in sediment samples older (mean values of 10×10^5 tests $\cdot 10^2 \text{cm}^{-2} \cdot \text{kyr}^{-1}$ approximately between 7000 and 4500 yr cal. BP) and younger (mean values of 8×10^4 tests $\cdot 10^2 \text{cm}^{-2} \cdot \text{kyr}^{-1}$ approximately between 3000 and 1000 yr cal. BP) than this period (Figure 37). Meanwhile the BFHP index values presented an opposite trend to BFAR, with relatively lower values at approximately 3600 yr cal. BP (~9%) and higher values in sediment samples older (mean values of 18% approximately

between 7000 and 4 500 yr cal. BP) and younger (mean values of 20% approximately between 3000 and 1000 yr cal. BP) than this period (Figure 37).

Figure 40 – Benthic assemblage parameters along core 7616 distribution. Where: R – species richness; H' – diversity; and J' - equitability.

6. Discussion

The good resolution of the three marine records chosen for this study allied to the application of a multi-proxy approach allowed the inference of significant paleoceanographic changes that took place over the S/SE Brazilian shelf during Mid- to Late Holocene.

In order to better explore the data and in an attempt to link the paleoceanographic changes observed to changes in environmental conditions over SE South America, during Mid- and Late Holocene, mainly related to precipitation and wind regimes, discussion was divided into 4 items. In the first item (6.1.) sedimentological and geochemical data is discussed in an effort to link changes observed in depositional processes and sediment provenance to hydrodynamic conditions over the S/SE Brazilian shelf, establishing a general scenario of the Mid- to Late Holocene oceanographic and environmental conditions; the second item (6.2.) seeks to link geochemical and microfaunal based productivity proxies to the oceanographic and environmental conditions scenario, also reinforcing the need of applying a multi-proxy approach when tackling productivity reconstructions. In the last two items the established oceanographic scenarios for Mid- and Late Holocene are discussed through a regional and global perspective taking into account climatic forcings; the third item (6.3.) views changes in the La Plata River influence over the S/SE Brazilian shelf as a result of SE South America precipitation regime changes driven insolation and the forth item (6.4.) presents an stacked record from cores 7610 and 7616 and discuss multi-centennial changes in water temperature and salinity at the northern portion of Santos Basin, as a result of It SACW shelf penetration, exploring possible triggering mechanisms.

6.1. Mid- to Late Holocene hydrodynamic changes in the S/SE Brazilian shelf - depositional processes and sediment provenance.

The analysis of the sedimentological and geochemical data of the three cores reveals that in the last 7000 years significant changes occurred in the depositional patterns of the S/SE Brazilian shelf. In general, all three cores show a pronounced bimodal distribution with a sand mode during Mid- Holocene, which experience a conspicuous decrease beginning at approximately 7000 yr cal. BP. The disappearance of the sand modes, however, took place at

different time intervals in each core: in the northernmost core (7616) the sand mode disappeared at approximately 5600 yr cal. BP; in core 7610, at approximately 5000 yr cal. BP; and in the southernmost core (7605) the sand mode enters into the Late Holocene, disappearing approximately at 1800 yr cal. BP. The second (and most important) grain size mode is represented by finer sediments centered at approximately 5 ϕ (medium to coarse silts) (Figure 41).

Grain size in marine records (including data from core 7616) have been previously applied to assess Mid- to Late Holocene paleoceanographic conditions over the S/SE Brazilian shelf by Gyllencreutz et al. (2010). These authors also found varying deposition of sands during the Mid-Holocene; and attributed these variations to changes in sediment provenance rather than in current speed. Taking into account relative sea-level oscillations and environmental variations Gyllencreutz et al. (2010) proposed that the Mid-Holocene sands found in cores south of 25°S were derived from the Argentinian shelf. According to these authors, Mid-Holocene coarser sediment deposition would be the result of the combination of higher sea-level conditions, inhibiting the La Plata River outflow hydraulic gradient and SW winds that enhanced the northward sediment transport along the SE South American coast. It is important to highlight that this hypothesis, however, was based solely in grain size data and in the fact that sand content and sortable silt size lacked correlation.

In fact, latitudinal (south to north) differences of the sand mode representativeness in grain size populations suggests a southern source of these coarser sediments. However, grain size data alone cannot assign the origin of the Mid-Holocene sands, since it is also possible that the Mid-Holocene sands represent reworked S Brazil shelf sediments made available by the Early to Mid-Holocene sea level rise (Figure 42). Likewise the ϵ Nd data obtained in our cores cannot confirm nor contradict Gyllencreutz et al. (2010) hypothesis. Since the modern ϵ Nd signatures found by Mahiques et al. (2008) were obtained in sediments mostly composed of silts; and, consequently, the inferences based in the ϵ Nd data, obtained for cores 7605 and 7616, most likely assess the provenance signature of the <63 μ m size fraction rather than of the quartzose sands.

Figure 41 -

Figure 41 - Upper panel - Left: Particle size distribution (PSD) for cores 7605, 7610, and 7616, where frequency % in each size class is indicated by colour-filled contours (legend in top). Right: Results of a Correspondence Analysis (CA) of grain size variations. Lower panel: Representative grain size frequency distributions (size class % versus Φ), for the cores. The corresponding core age levels are indicated with dashed red lines and labels on the CFA-plots

In the northernmost core (7616), ϵNd values show a clear change in sediment provenance from Mid- to Late Holocene; core base sediments presented similar ϵNd signatures to modern granitic SE Brazilian shelf sediments found by Mahiques et al. (2008). Whereas, Late Holocene sediments have similar ϵNd signatures to modern basaltic La Plata River derived sediments (Figure 43). Meanwhile, in the southernmost core (7605) sediments presented similar ϵNd signatures to modern La Plata River derived sediments and do not indicate changes in sediment provenance in the last 7000 yr cal. BP (Figure 43).

Figure 42 – Relative sea-level curves along the SE South American coast. (A) Southern Rio de la Plata, based on Cavalotto et al. (2004); (B) Salvador (Martin et al., 2003); and (C) envelope for the Brazilian coast north of 28°S (solid lines) and south of 28°S (dashed lines) from Angulo et al. (2006). (From: Gyllencreutz et al., 2010)

Therefore, during Mid-Holocene, the northernmost part of the study area received sediments derived from the SE Brazilian margin transported by southward currents, whereas in the southernmost part of the study area, sediments came from the La Plata River and, hence, were transported by northward currents. Whereas, during the Late Holocene, ϵNd data reveals that sediments deposited in the S/SE Brazilian shelf were derived from the La Plata River. In a similar situation to the present day conditions, when La Plata River sediments reach the S/SE Brazilian shelf transported by inner and mid- shelf northward flow of the BCC (Mahiques et al., 2008).

Figure 43 – Latitudinal changes of the ϵNd values obtained for sediment samples between 55 and 20°S by Mahiques et al. (2008) and the ϵNd values obtained for core 7605 (yellow hexagons) and core 7616 (purple cross) with sample estimated age (kyr cal. BP).

Following Gyllencreutz et al. (2010) rationale, if we consider that the inner- and mid-shelf currents in the São Paulo Bight (including the BCC) are strongly correlated to wind stress (Dottori and Castro, 2009), and while acknowledging that sedimentary properties alone cannot distinguish whether changes in grain size results from changes in current speed or in the variability of the speed (McCave et al., 1995), it is reasonable to assume that grain size variations in our study area reflect changes in wind pattern. However, owing to the lack of

provenance confirmation for the sand mode in our records and taking into account that Gyllencreutz et al. (2010) hypothesis implies that the changes in sand contents are related to variations in the La Plata River outflow rather than in currents strength. We chose to apply fine fraction grain size variations in order to assess changes in S/SE Brazilian inner and mid-shelf currents.

During the Mid-Holocene, SE Brazilian shelf derived sediments were probably transported to the northernmost part of the study area by the southward flow of the BC. In this part of the São Paulo Bight, cross-shelf circulation is characterized by onto the shelf intrusions of the BC, with substantial onshore bottom flow, extending from the slope to the middle shelf, during winter when downwelling favorable S/SW winds occur (Palma and Matano, 2009). Thus, coarser sortable silt might be related to onshore intrusions of the BC, occupying a position closer to the coast. Two main factors could have promoted the displacement of the BC towards the coast in the Mid-Holocene: (i) the sea-level highstand (Mahiques et al., 2007; Nagai et al., 2010) and/or (ii) the presence of persistent downwelling favorable S/SW winds (Palma and Matano, 2009). As Mid- and Late Holocene sea-level oscillations magnitude (Figure 42) may be considered negligible for general circulation pattern in the coring site depth (100 m isobath), we favor factor (ii) as the main driving mechanism of the onshore displacement of the BC during the Mid-Holocene. From Mid- to Late Holocene as the BC influence over the shelf decreased, finer sediments derived from the La Plata River were deposited, also leading to an increase in sedimentation rates.

In the southernmost part of the study area, from Mid- to Late Holocene, sortable silt size presents an oscillatory pattern leading to a general coarsening trend (Figure 44), suggesting increase in strength of the inner and mid-shelf northward flow of the BCC. Although no ϵNd data was obtained for core 7610 in terms of grain size distribution, namely in the fine fraction, during Mid and Late Holocene this core presents in between core 7605 and core 7616 values (Figure 44). Thus, it is reasonable to assume that this core, collected in the vicinity of 25.5°S (literally between the other two records), portrays a transitional limit between past hydrodynamic controlling features acting over the S/SE Brazilian shelf depositional processes. To the north, the high energetic conditions promoted by the BC onshore/offshore movements and to the

south the variations of the wind driven BCC, in accordance to the modern sedimentary distribution pattern proposed by Nagai et al. (*submitted*).

During the Late Holocene, no significant changes in sortable silt sizes were observed in all records until approximately 2000 yr cal. BP, when a coarsening shift in sortable silt size is observed in the northernmost core (Figure 44). This shift suggests more intense cross-shore circulation similar to the Mid-Holocene conditions. Simultaneously to the shift in sortable silt size, higher deposition of very fine sediments ($<10\text{ }\mu\text{m}$) is also observed (Figure 44). If we assume that there is a suspension sedimentary load (particles smaller than $10\text{ }\mu\text{m}$) associated with the La Plata River Plume, it seems reasonable to apply this fine sediment fraction as a proxy of the extension of the influence of this plume over the S/SE Brazilian shelf. Thus, this increase in the deposition of sediments smaller than $10\text{ }\mu\text{m}$ highlights that in the last 2000 yr cal. BP the La Plata River Plume influenced the S/SE Brazilian shelf sedimentation processes up to 25°S .

The input of terrigenous sediments derived from the La Plata River Estuary, into the S/SE Brazilian shelf during the Late Holocene is also supported by other geochemical proxies, such as Fe/Ca and Ti/Ca ratios and mineralogy. In all cores, Fe/Ca and Ti/Ca ratios presented a general trend of increase in values during the Late Holocene, with significant increase in values especially after 2000 yr cal. BP, suggesting higher input of terrigenous sediments (Haug et al., 2001). Although, Fe/Ca and Ti/Ca ratios do not provide information regarding provenance, the presence and progressive increase of predominantly siliciclastic sediments dominated by terrigenous particles, such as phyllosilicates and quartz, during the Late Holocene primarily derived from continental soils and the weathering of the rocks that cover the La Plata River drainage basin (Campos et al., 2008; Mahiques et al., 2008) reinforces this hypothesis.

Mahiques et al. (2009) also applied Fe/Ca and Ti/Ca ratios as proxies of terrigenous sediment input in the S Brazilian shelf; these authors found an increase in these ratios in Late Holocene sediments and associated it to an increase in terrigenous sediment input derived from the La Plata River. Due to the fact that the northward displacement of the La Plata River plume depends both on precipitation over its drainage basin and favorable south-southwesterly winds (Möller et al., 2008; Piola et al., 2008); Mahiques et al. (2009) attributed their results to climatic

oscillations, namely increased moisture conditions and intensification of southerly winds in the Late Holocene. Gyllencreutz et al. (2010) also proposed that, during the Late Holocene, changes in the depositional processes of the São Paulo Bight were a result of changes in precipitation regimes and wind patterns over SE South America. Moreover, increase in precipitation over SE South America has also been reported as a main factor influencing increase in terrigenous supply for the Uruguayan slope from Mid- to Late Holocene (Chiessi et al., 2010).

As discussed before, no significant changes in the northerly inner and mid-shelf currents strength were observed. Consequently, our data does not support the proposition of intensification but of persistent S/SW winds, during Late Holocene. On the other hand, the Fe/Ca and Ti/Ca ratios significant increase observed in the Late Holocene strongly suggests that the higher input of terrigenous sediments into the S/SE Brazilian shelf, especially after 2000 yr cal. BP (Figure 44), was a result of increased precipitation over the La Plata River drainage basin.

Figure 44 – Along core distribution of the below 10 μm fraction (%), sortable silt mean size (ϕ) and Fe/Ca ratios all three cores. Black line and dots represent core 7605; orange, 7610; and purple, 7616.

In accordance with the grain size variations, Fe/Ca and Ti/Ca ratios also highlight the decrease in the La Plata River influence over the S/SE Brazilian shelf with decreasing latitudes (*i.e.* distance to river mouth - Figure 44). In fact, core 7616 is located in the modern northern latitudinal limit (25°S) of the La Plata Plume influence (Piola et al., 2000; 2008). This scenario is in accordance to modern sediment distribution processes in the São Paulo Bight. Although La Plata River derived sediments reach the SE Brazilian shelf (up to 25°S) transported by inner and mid-shelf wind driven northward currents (Mahiques et al., 2008); northward of 27°S, mid- and outer shelves sediment distribution is mainly controlled by the BC (Mahiques et al., 2002; 2004; Nagai et al., *submitted*).

In summary, during Mid- and Late Holocene the depositional processes over the southernmost part of the S/SE Brazilian shelf were influence by the input of terrigenous sediments derived from La Plata River. Whereas, in the northernmost part of the study area only in the Late Holocene, especially in the last 2000 years, is this influence observed as a consequence of a positive change in the precipitation regime over the La Plata River discharge basin and more persistent winter S/SW winds.

6.2. Paleoproductivity changes in the S/SE Brazilian shelf during Mid- and Late Holocene

The S/SE Brazilian continental shelf also experienced productivity changes during the Mid- and Late Holocene as highlighted by the geochemical and microfaunal data. As a general trend, all three cores presented continuous increase in TOC contents from Mid- to Late Holocene. In addition, the $\delta^{13}\text{C}$ values and the cross-plot between $\delta^{13}\text{C}$ and C/N ratios, also point to the presence of marine derived organic matter throughout the cores; this allows us to state that from Mid- to Late Holocene the S/SE Brazilian shelf experienced increase in oceanic productivity, leading to higher flux of marine derived organic matter to the seafloor.

It is important to highlight that we are aware of the overlying problems of applying TOC contents as a paleoproductivity proxy, especially those related to organic matter preservation (*i.e.*, organic matter degradation and selection trough grain size variations). Higher amounts of nitrogen in younger sediment samples (Figure 10, Figure 22, Figure 31) underline the possibility

of the occurrence of organic matter degradation throughout the sedimentary column (*i.e.*, better preservation at core top); and, significant grain size variations between Mid- and Late Holocene sediments (coarser sediments at core base and a fining upward trend, respectively, Figure 41); might also represent a bias as organic matter is better retained in finer sediments (Meyers, 1997). Nevertheless, the significant increase (almost twice of the observed TOC content from Mid- to Late Holocene, even when TOC content are normalized by mud contents, and the fact that other proxies, such as, CaCO_3 contents and benthic foraminifera community structure support that the observed TOC content variations reflects changes in the flux of organic matter to the seafloor (*i.e.*, oceanic productivity) rather than being an artifact of organic matter preservation degree and/or grain size changes.

Interestingly, bulk sedimentary organic nitrogen isotopic signature ($\delta^{15}\text{N}$) reflects differences in nutrient source in the S/SE Brazilian shelf, northern and southern parts. In the northernmost part of the study area (25°S, core 7616) Mid- and Late Holocene sediments $\delta^{15}\text{N}$ values suggest a marine source for the dissolved nitrogen incorporated by the phytoplankton (Hu et al., 2006). Meanwhile, in the southernmost part of the study area (27°S, core 7605) Mid- and Late Holocene sediments $\delta^{15}\text{N}$ values suggest the presence of continental derived nutrients for this part of the S/SE Brazilian shelf (Hu et al., 2006). Whereas, $\delta^{15}\text{N}$ values observed for core 7610 point to changes in nutrient source from Mid- to Late Holocene, from marine to continental derived nutrients, respectively, in accordance with the previously established oceanographic and depositional scenario in item 6.1.

The benthic foraminifera community also responded to the environmental changes that occurred in the S/SE Brazilian shelf during Mid- and Late Holocene. In general, Mid- and Late Holocene S/SE Brazilian shelf benthic foraminifera community is dominated by infaunal species (Appendix 2, 5) with higher percentages of infaunal species observed during the Late Holocene (Figure 15Figure 37) which, considering the TROX model² (Jorissen et al., 1995, Figure 45) point to increase in food availability. In both cores benthic foraminifera assemblages were

² The TROX model is a conceptual model that considers the interplay between food availability and oxygen concentration. According to this model, proposed by Jorissen et al. (1995) in oligotrophic environments, a critical food level determines the penetration depth of most species, whereas in eutrophic settings, a critical oxygen level would determine this depth (Figure 45).

composed of individuals of very small size, reflecting a clear dominance of opportunistic, r-selected foraminiferal taxa (Gooday and Rathburn 1999; Duchemin et al. 2007). The dominance of very small sized individuals in the living benthic foraminifera assemblages of the S/SE Brazilian margin has been previously reported by Burone et al. (2010), whom attributed this to episodic deposition of phytodetritus related to phytoplankton blooms. This supports the increase in the flux of organic matter to the seafloor (*i.e.*, oceanic productivity) suggested by TOC and other sedimentary organic matter parameters.

In the southernmost part of the study area the *B. marginata* assemblage dominates Mid-Holocene (between approximately 7000 and 5000 yr cal. BP) benthic foraminifera total assemblage (Figure 17). The *B. marginata* assemblage is composed of epifaunal species commonly associated with high productivity waters (*B. marginata*, Murray et al., 2003; Martins et al., 2006; Burone et al., 2010) and with relatively high organic matter quality (*C. ungerianus*, Contreras-Rosales et al., 2012), having been previously linked to environments with high food supply and oxygen depletion (Lutze and Colbourn, 1984; Alve and Nagy, 1986; Jorissen et al., 2007). *I. norcrossi* has previously been associated with low bottom water temperatures in the N Atlantic (Saher et al., 2012). In the SW Atlantic *B. marginata* has been found composing living foraminiferal assemblages in latitudes from 22° to 30°S also related to input of organic material into the seafloor (Eichler et al., 2008; Burone et al., 2010). Taking into account that modern oxygen levels are above the critical values for hypoxia (Eichler et al., 2008) due to the high energetic oceanographic conditions in the study area and the presence of coarser sediments in this period. It is reasonable to assume that between 7000 and 5000 yr cal. BP, the *B. marginata* assemblage must be associated with food availability from cooler, fertile water masses, rather than with low oxygen levels.

After 5000 yr cal. BP the benthic foraminifera total assemblage is dominated by the *G. subglobosa* assemblage and higher frequencies of infaunal species (Figure 17, Figure 18). *G. subglobosa* is the main component of the *G. subglobosa* assemblage. This species has a cosmopolitan distribution in the oceans and its abundance has been linked to a number of variables including various water masses (e.g., Corliss, 1979; Schnitker, 1980; Mackensen et al., 1995) and pulsed phytodetrital input (e.g., Gooday, 1988, 1994; Gupta and Thomas, 2003; Eberwein and Mackensen, 2006; Smart et al., 2010). In the modern SE Atlantic, Schmiedl et al.

(1997) linked the distribution of *G. subglobosa* with vigorous bottom currents and sandy sediments in elevated and oligotrophic areas. In the S/SE Brazilian shelf *G. subglobosa* has been reported as a major component of the living benthic foraminifera assemblage, especially in areas influenced by upwelling systems or within the PPW influence zone, associated to episodic deposition of phytodetritus, as a consequence of phytoplankton blooms (Eichler et al., 2008; Burone et al., 2010). The presence of specimens of the genus *Epistominella* in this assemblage also reinforces that this assemblage reflect episodic deposition of phytodetritus. In the N Atlantic species of the genera *Epistominella* (e.g., *Epistominella exigua*) have been described as an opportunist species (r-strategist), able to grow and reproduce rapidly in the presence of phytodetritus (Goody, 1993; Smart et al., 1994), reflecting seasonal deposition of phytodetritus. Hence, the occurrence of this assemblage seems to be related to seasonal organic matter fluxes and relatively oxic bottom waters.

Figure 45 – Schematic drawing showing variation of benthic foraminifera microhabitat depth following the TROX model (Jorissen et al., 1995) and the depth critical levels of oxygen. Modified from: Jorissen (1999)

Between 5000 yr cal. BP and approximately 2500 yr cal. BP, the *G. subglobosa* assemblage occurs in association with the *G. umbonata* assemblage (Figure 17). This assemblage is composed by epifaunal to infaunal species (Murray, 1991; Fontanier et al., 2008) and commonly considered to inhabit oligotrophic environments (*G. umbonata*, De Rijk et al., 2000) with intense bottom currents (*Angulogerina* spp., Schönfeld, 2002).

Whereas, in younger than 2500 yr cal. BP sediments where higher frequencies of the species that compose the *G. subglobosa* assemblage are observed in association with the *A. angulosa* assemblage (Figure 17). *A. angulosa* is a cosmopolitan infaunal species, and occurs in low to moderate abundances from subtidal to middle bathyal depths (Schönfeld, 2001). High percentages of this species are recorded from current-swept passages (Hayward et al., 1994), coarse, biogenic sands on the inner shelf (McGann, 1996 *apud* Schönfeld, 2002), and deep, high-energy environments on the outer shelf and upper slope (Mackensen et al., 1985; Schönfeld, 2002). *A. angulosa* species is commonly considered to be indicators of well oxygenated bottom waters and low concentrations of organic carbon (e.g., Mackensen et al., 1995; Schönfeld, 2002). Due to the presence of the species of the *Bulimina* genus in this assemblage it is reasonable to assume that this assemblage mostly reflects intense bottom currents and moderate to low food availability, since, in general, the infaunal Buliminids are closely associated with high nutrient levels (Mackensen et al., 1990; Murray, 1991) and are also reported as markers of upwelling in other continental shelves (Debenay and Redois, 1997; Mendes et al., 2004).

In addition, after 2500 yr cal. BP, an increase of the *G. subglobosa* assemblage and especially in the frequencies of *B. elegantissima*, *Gyroidina* spp. and *Epistominella* spp. is also observed (Figure 17). *B. elegantissima* is an infaunal deposit-feeder (Murray, 2006) typical of shelf environments (Murray, 2006; Burone et al., 2007). This species composes the living benthic foraminifera assemblage from the shelf sector between the La Plata River mouth (Burone et al., *in press*) and Itajaí (Eichler et al., 2008), it inhabits sediments with high mud and carbon contents (Burone et al., *in press*) and environments with freshwater influence (Eichler et al., 2008). Thus, the increase of the *G. subglobosa* assemblage and the presence of the *A. angulosa* assemblage, after 2500 yr cal. BP, reinforces the hypothesis of occurrence of episodic inputs of organic matter to the seafloor, probably promoted by the input of continental derived

nutrients ($\delta^{15}\text{N}$ values) brought to the S Brazilian shelf by the La Plata River Plume during the Late Holocene.

Most of the representative species found in the southernmost core, with the exception of *B. elegantissima*, were also identified as main components of the benthic foraminifera community in the northernmost core. In addition, the northern core also presented as representative species other infaunal species as *B. subspinensis* (Murray, 1991), *Brizalina* spp. (Murray, 1991) and epifaunal/infauna *S. earlandi* (Heinz et al., 2001). The identified benthic foraminifera assemblages in the northernmost core have as component species that reflect high food availability, whether reaching the seafloor as high organic matter fluxes (e.g., *B. marginata* and *Brizalina* spp.) or as episodic pulses of phytodetritus (e.g., *G. subglobosa* and *Epistominella* spp.), and well oxygenated bottom waters (e.g., *A. angulosa* and *G. subglobosa*). These assemblages occur in association with one another throughout the core and most likely reflect changes in the intensity and frequency of organic matter input into the benthic system.

In the northernmost part of the study area, during Mid- Holocene (between 7000 yr cal. BP and approximately 4500 yr cal. BP) coarser sediments (Figure 29) inhabited by *A. angulosa*, *G. subglobosa* and *Epistominella* spp. assemblages (Figure 40) and relatively higher percentages of epifaunal species (Figure 37) reflect an environment with low food availability and well oxygenated bottom waters probably related to a relatively stronger influence of the BC onshore/offshore movements over the shelf promoting vigorous bottom currents, supporting the Mid-Holocene oceanographic scenario established by the sedimentological and geochemical data for this part of the SE Brazilian shelf.

The Late Holocene is marked by higher frequencies of infaunal species (>90%) suggesting increase in organic carbon flux to the seafloor (Figure 37). Between 4500 and 2800 yr cal. BP, the dominance of the benthic foraminifera total assemblage by phytodetritus species (e.g., *G. subglobosa* and *Epistominella* spp.) and relatively low percentages of taxa considered to be indicative of high productivity areas, such as *Bulimina* spp., *Bolivina* spp., *Cassidulina* spp amongst others characterizes this period as an overall low to moderate productivity period affected by episodic fluxes of phytodetritus to the seafloor (Smart et al., 2008). Also, during this period, relatively smaller equitability (J') and diversity (H') values suggest a less stable environment (Figure 40) (Burone and Vanin, 2006), supporting the occurrence of episodic food

supply. The decrease of *A. angulosa* assemblage importance, between 4500 and 2800 yr cal. BP also suggests a relative reduction in bottom current strength.

A conspicuous decrease in *Epistominella* spp. assemblage occurs at approximately 2800 yr cal. BP, after which relative frequencies of *G. subglobosa* also decrease (Figure 40) suggest decrease in episodic input of phytodetritus to the seafloor. Meanwhile, relative frequencies of species composing the *A. angulosa* assemblage increase, suggesting high food availability (e.g., *B. marginata*, Murray et al., 2003), relatively colder bottom water masses (e.g., *I. norcrossi*, Saher et al., 2012) and relatively stronger bottom currents (e.g., *A. angulosa*, Schönfeld, 2002) in this period. Two different oceanographic processes can be accounted for the increase in oceanic productivity and, hence, high food availability and cooler water masses after 2 800 yr cal. BP; the presence over the northernmost part of the SE Brazilian shelf of the cold and less saline waters of the (i) La Plata River Plume and/or (ii) South Atlantic Central Water.

As previously discussed, sedimentological and geochemical data (item 6.1) showed that during the Late Holocene, especially after 2000 yr cal. BP, the input of sediments derived from the La Plata River reached the northernmost part of the study area (up to 25°S). However, $\delta^{15}\text{N}$ values suggest marine derived N as a main nutrient source for the phytoplankton throughout core 7616. Thus it seems that although during the Late Holocene the La Plata River extended its influence over the northernmost part of the SE Brazilian continental shelf depositional processes, its waters did not significantly change the nutrient source signature. Conversely the penetration of SACW into the shelf would deliver marine nutrients to the euphotic zone increasing productivity. The presence of the SACW in the Brazilian shelf, especially in the last approximately 3000 years was also reported by Nagai et al. (2009), at Cabo Frio (23°S). That area is influenced by coastal upwelling events, in which persistent NE winds promote the colder and nutrient enriched SACW shelf penetration, promoting increase in oceanic productivity. However, both of the suggested processes are characteristic of seasonal occurrence (the La Plata River Plume, during winter and SACW shelf penetration, during summer) and the decrease in the phytodetritus assemblages suggests that in this period episodic organic matter fluxes decreased. Hence, it is possible to assume that in the last approximately 2800 yr cal. BP

both processes positively influenced oceanic productivity, resulting in an overall increase in oceanic productivity and organic matter flux to the seafloor.

The Benthic Foraminifera High Productivity index (BFHP) values observed for both cores are also in agreement with the general trend of increase in food availability from Mid- to Late Holocene (Figure 15, Figure 37) suggested by TOC contents. This index, however, does not include phytodetritus species indicative of episodic input of organic matter, which represents a disadvantage in applying this index as a reliable productivity proxy, as it might underestimate oceanic productivity in areas such as the S/SE Brazilian continental shelf affected by episodic fluxes of phytodetritus to the seafloor (as shown by the assemblage data).

Analogously, the use of the Benthic Foraminifera Accumulation Rate index (BFAR) should be interpreted with caution as its values are dependent on sedimentation rates. According to Smart et al. (2010), since relative foraminifera abundances are not dependent upon such estimates, the reliability of the BFAR data can be assessed through comparisons between environmental information from BFAR and relative abundance data. Both cores presented highly variable sedimentation rates (Figure 7, Figure 28) and along core distribution pattern of BFAR values (Figure 15, Figure 37) closely followed sedimentation rates changes. In the southernmost core environmental information provided by BFAR values from core 7605 are in agreement with assemblage relative frequencies data, whereas in the northernmost part of the study area BFAR values do not represent the increase in productivity shown by the benthic foraminifera assemblages.

In addition, the BFAR index was initially defined in the >150 μm size-fraction (Herguera and Berger, 1991), when calculated in the >63 μm size-fraction which is mainly made up of small-sized species that quickly proliferate and build up large populations in the presence of a seasonal, pulsed and unpredictable food supply (Smart et al., 2008). In areas with low to moderate productivity affected by episodic fluxes of phytodetritus to the seafloor, such as the S/SE Brazilian shelf, BFAR fluctuations may not be linear in the presence of abundant phytodetritus species (e.g., Schmiedl and Mackensen, 1997) and are probably not simply related to the flux of organic matter to the seafloor (Smart et al., 2008).

We also proposed to apply inorganic elemental ratios to access Mid- to Late Holocene productivity changes. There is still some debate over the use of sedimentary Ba contents as

productivity proxies, terrigenous background values are not so easy to determine (see Mahiques et al., 2009 and references therein). The vast majority of the Ba/Al values obtained for cores 7610 and 7616 were smaller than 0.0075, which may be considered as a terrigenous background value (Dymond et al., 1992), 0.0040, determined by Pfeifer et al. (2001) for the Southwest South Atlantic or even than 0.0028, determined by Klump et al. (2000) in the Chilean continental margin surface sediments. This gives negative values of Ba_{excess} , invalidating the determination of Ba_{excess} values. Thus, we followed Mahiques et al. (2009) and compared Ba content as well as Ba/Al, Ba/Ti, and Ba/Ca ratios with the TOC to evaluate if the data could be compared qualitatively to establish temporal changes in productivity.

However, Ba/Ca showed positive significant correlation with TOC in cores 7610 and 7616, and no significant correlation in core 7605. Additionally, in this core, Ba/Al and TOC content presented negative significant correlation. Insight of this it is possible to state that sedimentary Ba contents should be carefully applied in the northernmost part of the study area as a productivity proxy, whereas for the southernmost part of the study area it is closely related to the strong continental influence of the La Plata River. Although Ba/Ca ratios distribution along cores 7610 and 7616 presented a general trend of increasing values from Mid- to Late Holocene indicating increase in productivity, it is important to highlight that in order to properly apply Ba/element ratios as productivity proxies in the Brazilian continental margin further constraints and knowledge in order to determinate Ba_{excess} values are necessary to be exploited by future studies.

6.3. Tracing Mid- and Late Holocene La Plata River influence over the S Brazilian continental shelf – insolation driven changes

Mid- and Late Holocene depositional and productivity processes over the S Brazilian shelf were influenced by the northward penetration of shelf waters associated with the La Plata River Plume, as previously established by sedimentological, geochemical and microfaunal proxies obtained for core 7605 (27°S). In order to better address the influence of the La Plata River Plume waters over the S Brazilian shelf we applied the isotopic composition of the planktonic foraminifera *G. ruber* (pink) in core 7605. The Holocene variability of the La Plata

River discharge and its impact on the depositional processes over the southern Brazilian shelf have been recently discussed by Mahiques et al. (2009), pointing to an increase in the La Plata River influence from Mid- to Late Holocene. However, these authors applied sedimentological and geochemical proxies, not specific for paleotemperature and salinity changes, a more direct proxy for the presence of La Plata River Plume colder and less saline waters.

As stated earlier (see Material and Methods item 4.4.1.) the knowledge of the ecology of the foraminifera species chosen is of sum importance in paleoceanographic reconstruction studies. According to Anand et al. (2003), surface dwelling planktonic species, such as the *G. ruber* (pink), present strong intra-annual variability (seasonality) in the foraminiferal Mg/Ca and $\delta^{18}\text{O}_c$. At Cariaco Basin, for instance, a sediment trap study indicates that this species registers annual mean SST (Tedesco et al., 2007). Thus, in order to determine if *G. ruber* (pink) reflects mean annual, summer or winter conditions and since there are no sediment trap data for the S/SE Brazilian continental margin, we compared modern *G. ruber* (pink) $\delta^{18}\text{O}$ based temperature estimates with the mean temperature of the first 50m of the water column taken from the World Ocean Atlas 2009. For this, modern *G. ruber* (pink) calcification temperature estimates were obtained by applying the equation for *G. ruber* set by Mulitza et al. (2003) (Eq. 6) to coretop $\delta^{18}\text{O}_c$ values obtained, between 20.5° and 36.5°S and 53.4° to 37°W, for *G. ruber* (pink) by Chiessi et al. (2007). The $\delta^{18}\text{O}_w$ values were extracted from the global gridded data set of LeGrande and Schmidt (2006) and scaled to VPDB by subtracting 0.27‰ (Hut, 1987). As shown in Figure 46, it is possible to assume that in the S/SE Brazilian margin, *G. ruber* (pink) reflects mean annual to summer conditions.

As the oxygen isotopic composition of marine carbonates is a function of temperature and salinity (Mulitza et al., 2003) we chose to compare the *G. ruber* (pink) $\delta^{18}\text{O}_c$ data with an alkenone³ (U'_{37} index) based sea surface temperature curve from a core collected in the vicinity of our core (core 7606, 26°59' S/48°4' W/60 m water depth) from Bicego (2008), the only available for the region, in order to evaluate relative changes in salinity that might have

³ SST reconstructions can be obtained by measuring the unsaturation ratio of long-chain (C_{37} , C_{38} , C_{39}), methyl and ethyl ketones compounds found in marine sediments, known collectively as 'alkenones', are biomarkers of specific haptophyte algae, such as the coccolithophorid *Emiliania huxleyi* (Brassell, 1993).

occurred. According to Leduc et al. (2010) there is a strong contrast in the seasonal ecological responses of coccolithophores and planktonic foraminifera oceanographic conditions, which may lead to significant differences in the temperature signal provided by these organisms, especially in low latitudes. Thus, the comparison between our *G. ruber* (pink) $\delta^{18}\text{O}_c$ curve with the Bicego (2008) alkenone based SST curve was performed cautiously and only in a qualitative basis.

Figure 46 – Comparison between $\delta^{18}\text{O}$ temperature estimates from *G. ruber* (p) (black dots) with annual mean (dashed line), winter (blue line) and summer (red line) temperature of the first 50m of water column, highlighting that *G. ruber* (p) records mean annual to summer conditions between 25 and 27°S.

Between 7700 and 5200 cal yr BP *G. ruber* (pink) $\delta^{18}\text{O}_c$ values increase (approximately 0.60‰), this is followed by a general trend towards lighter $\delta^{18}\text{O}_c$ values (mean decrease of approximately 0.70‰) until the present (Figure 47). This decrease trend in $\delta^{18}\text{O}_c$ values from Mid- to Late Holocene is also accompanied by decrease in alkenone (U_{37}^k) based SST estimates (Figure 47). Hence, in general, our data suggests relative higher SST and salinities during the Mid-Holocene and lower SST and salinities during the Late Holocene, highlighting an increase of the La Plata River Plata Plume influence over the S Brazilian shelf. This corroborates with other geochemical proxies (e.g., Ti/Ca ratio and TOC contents – Figure 47)

previously discussed and with the established environmental scenario (item 6.1.) of increase in precipitation regimes from Mid- to Late Holocene.

Figure 47 – (a) *G. ruber* (pink) $\delta^{18}\text{O}$ values, (c) TOC contents and (d) Ti/Ca ratio values from core 7605 compared with (b) alkenone based SST estimates from core 7606 (Bícego, 2008), (e) from Al/Si ratio from a core collected at the Uruguay slope (Chiessi et al., 2010), (f) $\delta^{18}\text{O}$ values from Botuverá Cave speleothem record (Wang et al., 2007) and (g) summer insolation at 30°S.

The background trend of lower sea surface temperatures and salinities over the S Brazilian shelf is coincident to changes in February insolation in the Southern Hemisphere at 30°S (Figure 47). According to Biasutti et al. (2003), insolation determines the north-south displacement of continental convection over South America by favoring moisture convergence over the continent as land-sea temperature contrasts increases. In SE Brazil, speleothem $\delta^{18}\text{O}$ records (Botuverá Cave – 27°S,49°W) have shown that past fluctuations in the precipitation

regime over SE South America, related to the SASM and SACZ, were dominated by changes in insolation (Cruz et al., 2005; Wang et al., 2006, 2007).

Mid-Holocene paleoenvironmental and paleoclimatic records from the S/SE Brazil suggest the presence of relatively drier climatic conditions during this period (*e.g.*, Behling, 1995; Ledru et al., 2009; Pessenda et al., 2004, Figure 48) and portrait the Late Holocene as marked by the gradual increase of moisture until the establishment of the modern (*e.g.*, Ledru, 1993, Ledru et al., 1998, 2009; Behling et al., 2004, 2005) (Figure 48). The reported changes in precipitation or moisture conditions over S/SE Brazil were a consequence of the SH insolation increase through the Mid- and Late Holocene that lead to the southward displacement of the ITCZ and, consequently, to an overall increase in precipitation regimes due to the strengthening of the SASM and SACZ (Cruz et al., 2005; Wang et al., 2006, 2007; Melo and Marengo, 2008 *among others*).

Figure 48 - Spatial distribution of precipitation anomalies between HT and HM (HM-HT) based on 61 proxy-records from SE South America. Positive anomalies are represented as blue dots (HM wetter than HT) and negative anomalies as red (HM drier than HT), the orange dot indicating that the HT presented dry and wet episodes.

6.4. Surface waters temperature and salinity changes in the Santos Basin in the last 7000 years

Mid- to Late Holocene, changes in the surface water conditions, namely temperature, salinity and productivity, in the northern part of the São Paulo Bight (vicinity of 25°S to 25.5°S) were assessed through the chemical composition of the planktonic foraminifera *G. ruber* (pink) test. These variations were related to changes in oceanic hydrodynamic conditions over the SE Brazilian continental margin associated to environmental oscillations. In general, both records present a general long-term trend of decreasing temperature (Mg/Ca based) and salinity ($\delta^{18}\text{O}_{\text{w-ivc}}$ values) (Figure 49, linear regression) towards the Late Holocene. And, although both records present similarities, they also present differences, such as overall Mid- and Late Holocene lower temperatures in core 7616 (Figure 49). These differences reflect the complex hydrodynamic conditions over the SE Brazilian shelf, promoted by the BC with its meanders and eddies.

Figure 49 – Mid- and Late Holocene Mg/Ca based SST estimates (red) and seawater isotopic $\delta^{18}\text{O}$ (blue) and $\delta^{13}\text{C}$ (green) composition derived from the chemical analysis of the planktonic foraminifera *G. ruber* (pink) tests for cores 7610 and 7616. Where data

variation (shaded lines); 3 point moving average (bold lines); and significant linear regression (dashed lines).

As similarities, both cores presented two periods with relatively lower temperature (Mg/Ca based) and salinity ($\delta^{18}\text{O}_{\text{w-ivc}}$ values), and higher primary productivity ($\delta^{13}\text{C}$ values) approximately between 5500 and 4800 yr cal. BP and after ~2800 cal yrs BP, intercalated with a period of relatively warmer and more saline waters are predominant between 4800 and ~2600 cal yrs BP, relatively higher primary productivity is observed until 3500 cal yrs BP, with subsequent decrease in $\delta^{13}\text{C}$ values until ~2600 cal yrs BP (Figure 49). The warmer periods present a small lower temperature incursion between 3400 and 3200 yr cal. BP, however this is not clearly reflected in salinity or primary productivity (Figure 49). As the similarities between the records exceed the differences we chose to do evaluate the Mid- and Late Holocene changes through the stacked record of both cores, which also provides a broader picture (a regional signal) of the Mid- to Late Holocene environmental conditions over the SE Brazilian shelf (Figure 50). The stacked record was obtained by averaging the detrended records; interpolation was done using the largest time interval spacing found in the records (= 60 years).

G. ruber (pink) represents mean annual to summer conditions (Figure 46), hence during Mid-Holocene the presence of colder (low Mg/Ca based temperature) and fresher (lower $\delta^{18}\text{O}_{\text{w-ivc}}$ values) waters over the shelf reflects shelf penetration of the colder and less saline waters over the S/SE Brazilian shelf and SACW, also promoting higher primary productivity of surface waters (higher $\delta^{13}\text{C}$ values). Nowadays, SACW slope waters penetration into the SE Brazilian shelf occurs mainly during the summer months, modulated, primarily, by wind pattern (N/NE winds) and, secondarily, by the onshore intrusions of the BC (Castelão et al., 2004; Palma and Matano, 2009). As a common feature associated to the SACW penetration into the shelf enhancement of surface waters primary productivity is observed (Brandini, 1990), as shown by higher $\delta^{13}\text{C}$ values associated with lower temperatures. The fact that core 7616 presented overall colder temperatures than core 7610 also highlights the presence of SACW as, according to Palma and Matano (2009), the northernmost part of the São Paulo Bight is generally colder due to shelf-break upwelling.

Meanwhile, for the Late Holocene, previously discussed geochemical and microfaunal proxies have shown that the northernmost part of the SE Brazilian shelf has also been influenced by La Plata River Plume waters. The northward extension of the colder and less saline waters of the La Plata River over the S/SE Brazilian shelf is a predominantly winter phenomena (Möller et al., 2008; Piola et al., 2008) also leading to enhancement in surface waters primary productivity (Ciotti et al., 1995). Simultaneously, sedimentary organic matter parameters and microfaunal proxies point to the presence of labile organic matter production and availability derived from marine nutrient source. Additionally, Nagai et al. (2009) and Mahiques (*unpublished data*) also found increase in upwelling events in the Cabo Frio (23°S) area due to SACW shelf penetration as a consequence of stronger and more persistent NE winds during summer. Thus, during the Late Holocene, it is reasonable to assume that the presence of colder and less saline waters over the shelf reflects both the presence of the La Plata River Plume and the penetration of the SACW in the shelf.

The long-term trend of decreasing temperature and salinity towards the Late Holocene (Figure 49) follows the increase in austral summer insolation over the Southern Hemisphere promoting a southward shift of the ITCZ (see Figure 18 of Wanner et al., 2008). The southward displacement of the ITCZ lead to an overall increase in precipitation regimes due to the strengthening of the SASM and SACZ (Cruz et al., 2005; Wang et al., 2006; Chiessi et al., 2010 *among others*), also favoring predominantly NE winds in the study area, by promoting a westward enhancement of the South Atlantic High (Lenters and Cook, 1999), and, hence, resulting in an overall Late Holocene with higher La Plata River Plume and SACW shelf penetration in the SE Brazilian margin. Superimposed to this long-term trend, however, an alternation between periods with relatively higher SACW shelf penetration (*i.e.*, lower Mg/Ca based temperature, between 5500 and 4800 yr cal. BP and after ~2800 yr cal. BP) and smaller SACW shelf penetration (*i.e.*, higher Mg/Ca based temperature, 5500-4800 and ~2800 yr cal. BP) with abrupt contacts seems to reflect multicentennial-scale changes (Figure 50).

During the Holocene, other proxy based records have shown the occurrence of multicentennial-scale changes in oceanographic and climatic conditions fluctuating between

Figure 50 – Stacked Mg/Ca based temperature (°C), $\delta^{18}\text{O}_{\text{w-ivc}}$ and $\delta^{13}\text{C}$ records of the cores obtained by averaging the detrended records; interpolation was done using the largest time interval spacing found in the records (= 60 years). Periods with above mean values are painted in red and with below mean values in blue.

warm and cold, and humid and arid states (Wanner et al., 2011 *and references therein*). The transitions between these climatic fluctuations happened in a rapid fashion, also called as ‘rapid climate changes’⁴ (Mayewski et al., 2004). And have been mostly represented in records concentrated in the Northern Hemisphere - NH (e.g. Bond et al., 1997, 2001; Came et al., 2007;

⁴ Mayewski et al. (2004) applied the term ‘rapid climate change’ (RCC) for the intervals of climate change (9000–8000, 6000–5000, 4200–3800, 3500–2500, 1200–1000, and 600–150 yr cal. BP) sufficiently fast from the point of view of human civilization (*i.e.*, a few hundred years and shorter). This term, however, does not imply that these changes are comparable in magnitude or rapidity to the abrupt climate changes of the Last Glacial period.

DeMenocal et al., 2000; Lea et al., 2003; Oppo et al., 2003; Weldeab et al., 2011 *among others*). Nevertheless, Holocene multicentennial-scale changes have also been reported for the Southern Hemisphere - SH (*e.g.* Arz et al., 2001; Gyllencreutz et al., 2010; Mahiques et al., 2009; Strikis et al., 2011). The dynamical triggering mechanisms responsible for these events, however, are still under discussion. The most reported mechanisms are changes in solar activity, in the dynamics of deep-water flow, and in the Atlantic Meridional Oceanic Circulation (AMOC) or teleconnections with the Indo-Pacific sea surface temperatures (SST), ENSO and the Asian monsoon systems (for a more detailed review see Wanner et al., 2011).

The NH experienced four major cold periods, during Mid- and Late Holocene, with peaks at 1400, 2800, 4200 and 5900 yr cal. BP denominated Bond events⁵, sequentially numbered, after the works of Bond et al. (1997; 2001). These events are consistent with glacier fluctuations and overall colder conditions in the NH extra-tropical area (Wanner et al., 2011), in the SH, however, a high spatiotemporal variability of temperature and humidity/precipitation exists, mainly due to differences in the sensitivity of different proxies (Mayewski et al., 2004; Wanner et al., 2011). Our records, for example, present different responses for Bond events 4 and 2, in the first, SACW shelf penetration is highlighted by colder SST, lower salinity and higher surface waters primary productivity; whereas for Bond event 2 proxies point to opposite conditions. Mayweski et al (2004) also observed diverging conditions between RCC that occurred between 6000–5000 and 3500– 2500 yr cal. BP, especially in the SH. And Wanner et al. (2011) found a variable and complex global pattern for the cool event that occurred between 3300 and 2500 yr BP which corresponds with Bond event 2. A different response to Bond events has also been observed by Strikis et al. (2011) in a speleothem record over central Brazil (Lapa Grande, 14°25'S; 44°21'W), these authors found increased precipitation coherent with Bond events 4 and 2, but no precipitation response for Bond events 1 and 3. Interestingly, following the end of Bond events our record shows similar responses, to shifts in the environmental conditions.

⁵ Based on studies of ice rafted debris (IRD) in the North Atlantic Ocean Bond et al. (1997, 2001) postulated the existence of a 1500 years cycle characterized as series of shifts in ocean surface hydrography during which drift ice and cooler surface waters in the Nordic and Labrador Seas were repeatedly advected southward and eastward, promoting overall cold conditions over the Northern Hemisphere. In total nine Bond cycles were detected during the Holocene, with peaks at about 1400, 2800, 4200, 5900, 8100, 9400, 10300, and 11100 years ago (Bond et al., 1997; 2001).

According to Oppo et al. (2003) Holocene Bond event 4 was accompanied by significant reduction in the North Atlantic Deep Water (NADW) production. Numerical simulations show that an AMOC slowdown would promote an anomalous southward ITCZ displacement, increasing northeasterly trades (Zhang and Delworth, 2005; Chiang et al., 2008). As a result of the reorganization of the ocean-atmospheric system, negative (positive) SST anomalies would be observed in the North (Tropical) Atlantic (subpolar North Atlantic - Came et al., 2007 and Farmer et al., 2008; Cariaco Basin - Lea et al., 2003; NE Brazil - Weldeab et al., 2006; and NW Africa Weldeab et al., 2011) (Figure 51) While there is still some debate over the magnitude of the AMOC changes during the Holocene (e.g. Lynch-Stieglitz et al., 2009) the overall scenario observed in Figure 51 appears to be consistent with AMOC slowdown during Bond event 4. In addition, $^{231}\text{Pa}/^{231}\text{Th}$ in the subtropical North Atlantic (McManus et al., 2004) and a decrease of northern sourced water mass over the Southern portion of the Brazilian margin (27°S, 1200 m - Came et al., 2008) point to decrease in AMOC.

In the SH, this colder period also corresponds to higher precipitation (SASM increase) over central Brazil found by Strikis et al. (2011, Figure 51). These authors reported differences in inter-hemispheric monsoonal systems responses during the Holocene, proposing that the abrupt events observed would be a result of a slowdown of the AMOC associated with freshwater pulses in the North Atlantic, potentially influenced by feedback processes such as El-Niño like events. In a more recent work Cheng et al. (2012) taking into account that during the Holocene rather small in amplitude solar radiation variability occurred hypothesized that an amplifying mechanism would be necessary to trigger worldwide climate change, such as ENSO events. The presence of an amplifying mechanism and/or a feedback process would explain the different responses recorded as a consequence of Mid- and Late Holocene AMOC changes.

Even though the teleconnection dynamics between ENSO and SW Atlantic SSTs is not fully understood, we might consider ENSO as a possible amplifying mechanism. As this feature plays a major role in the climate variability over South America (see Garreaud et al., 2009). Furthermore, El-Niño events promote positive anomalies in the precipitation over South America with associated negative SST anomalies in SE Brazil coast during summer (Grimm, 2003). Higher occurrence and intensification of ENSO events simultaneously to both of our colder periods has been observed in proxy based records from S Ecuador (Moy et al., 2002) and from

the East Equatorial Pacific (Marchitto et al., 2010). However, recent works point only to increase in ENSO variability in the last 3000 years, emphasizing a 'damped ENSO' state for the Mid-Holocene (e.g., Koutavas and Joanides, 2012). Nevertheless, we propose that ENSO might have been the acting amplifying mechanism in the colder period observed in our record after 2800 yr cal. BP; however, insight of the new information it cannot be considered as a possible mechanism for the colder period centered at 5500 yr cal. BP and alternative mechanisms have to be explored.

The comparison between the SST obtained from our record and SST obtained in marine records from NE Brazil (Weldeab et al., 2006) and NW African (Weldeab et al., 2011) (Figure 51), highlights the presence of the South Atlantic dipole⁶ in its positive phase, during Mid-Holocene colder periods. According to Haarsma et al. (2003), during the positive phase of the South Atlantic dipole the ITCZ experiences a southward displacement. Hence, this feature may be an alternative positive feedback mechanism for the Mid-Holocene colder period observed in our records, as it that would also enhance ITCZ southward displacement during AMOC slowdown periods.

Other triggering and amplifying mechanisms have been proposed to explain the abrupt environmental shifts observed during the Holocene, such as the desertification of the Sahara (e.g., deMenocal et al., 2000; Muschitiello et al., 2013) and sea-ice expansion over the circum-Antarctic (e.g., Kim et al., 2003). Still, we are far from fully understanding the causes of past climate events, to accomplish this knowledge of the spatial and phase relationships between different paleoenvironmental records is required. As the climatic system presents a single resulting response to innumerable variables, detangling forcing changes and the modes of variability is neither simple nor easy.

⁶ The South Atlantic dipole is the dominant mode of atmosphere– ocean coupled variability over the South Atlantic, acting over the tropical and extratropical South Atlantic (e.g. Venegas et al., 1997; Sterl and Hazeleger, 2003). This dipole pattern is related to the variability of the South Atlantic Subtropical High (Haarsma et al., 2003), which influences low level atmospheric circulation and forces SST fluctuations in a north–south dipole structure (Venegas et al. 1997). When the equatorward pole has positive SST anomalies the dipole is called positive (Haarsma et al., 2003)

Figure 51 – Comparison between our (g) stacked record of Mg/Ca based SST (°C) for the SW Atlantic and (f) South America Summer Monsoon precipitation changes recorded by a $\delta^{18}\text{O}$ from a speleothem from Central Brazil (Stríks et al., 2012); (e) Mg/Ca based SST (°C) for the E Equatorial Atlantic (Weldeab et al., 2005); (d) Mg/Ca based SST (°C) for the W Equatorial Atlantic (Lea et al., 2003); (c) frequency of El-Niño events per 100 years (Moy et al., 2002); (b) North Atlantic Deep Water – NADW - variations recorded by $\delta^{13}\text{C}$ in *C. wuellerstorfi* tests (Oppo et al., 2004); and (a) percentages of HSG in the N Atlantic marking Bonds events also marked in blue numbered (Bond et al., 2001).

7. Summary and conclusions

In this study a multi-proxy approach was applied in three high resolution marine sedimentary cores collected along the S/SE Brazilian continental shelf, between 27° and 25°S, in order to better understand the Mid- and Late Holocene evolution of this part of the Brazilian margin and the oceanographic and climatic mechanisms that promoted these paleoenvironmental and paleoproductivity changes.

The depositional processes of the S/SE Brazilian margin were submitted to two different oceanographic controls during Mid-Holocene. In the vicinity of 27°S La Plata River derived sediments were brought by the northward penetration of the La Plata River Plume. Meanwhile, in the northernmost part of the Santos Basin the high energetic Brazil Current onshore/offshore movements brought SE Brazilian derived sediments. In the Late Holocene, especially after 3000 yr cal. BP, La Plata River derived sediments reached up to 25°S, highlighting a stronger influence of the La Plata River over the S/SE Brazilian shelf due to increase in precipitation over the La Plata River drainage basin.

As the La Plata River influence over the S/SE Brazilian shelf increased, bringing its colder and less saline waters during the Late Holocene, the oligotrophic waters of the shelf were fertilized by the La Plata River Plume waters, promoting enhancement of surface waters primary productivity and, consequently, organic carbon flux to the seafloor. The benthic foraminifera assemblages responded to the seasonal input increase of organic matter, as shown by the increase in opportunistic species. In the vicinity of 25°S, surface waters primary productivity was also enhanced by increase in colder and less saline SACW shelf penetration.

A general trend of lower temperature and salinities observed in the geochemical composition of planktonic foraminifera tests corroborates to a stronger influence of the La Plata River Plume waters followed the summer insolation at 30°S, in accordance to other proxy records and numerical models for SE South America. As insolation increased through Mid- and Late Holocene the southward displacement of the ITCZ promoted enhancement of the SASM/SACZ and, consequently, precipitation increase over the La Plata River drainage basin and intensification of the NE winds derived from the SAH. In the northernmost part of Santos Basin, superimposed to the general background trend, two major temperature and salinity

negative incursions with abrupt contacts centered at 5500 yr cal. BP and after 2800 yr cal. BP highlight multi-centennial scale changes, possibly related to SACW shelf penetrations due to persistent NE winds. These changes occurred simultaneously to rapid climatic events at regional and global spatial scale. AMOC slowdown events, mediated by amplifying mechanisms, is the proposed triggering mechanism for the changes observed in the SE Brazilian shelf records as it promotes southward shifts of the ITCZ. As amplifying mechanisms may have changed throughout time and as atmospheric teleconnections are not yet fully understood we hypothesize that different modes of climatic variability, such as ENSO and the South Atlantic dipole, may have acted as mediators.

Based on the data obtained we present the following conclusions:

- Mid- to Late Holocene S/SE Brazilian shelf environmental (depositional and oceanographic processes) conditions were influenced by two different hydrodynamic controls, the onshore/offshore movements of the BC and the La Plata River Plume northward penetration;
- the La Plata River has been the main source of fine sediments to the S/SE Brazilian shelf up to 27°S since the Mid-Holocene and to northern latitudes up to 25°S since the Late Holocene;
- after 3000 yr cal. BP, insolation driven precipitation increase over the La Plata River drainage basin promoted a northward extension of the La Plata River plume waters influence over the S/SE Brazilian shelf;
- a stronger La Plata River influence over S/SE Brazilian shelf and SACW shelf penetration, during the Late Holocene, promoted enhancement of surface waters productivity and its export to the seafloor, affecting benthic communities;
- in the vicinity of 25°S two major temperature and salinity negative incursions, centered at 5500 yr cal. BP and after 2800 yr cal. BP, occurred as a result of SACW shelf penetrations due to persistent NE winds;
- These multi-centennial scale changes occurred simultaneously to rapid climatic events in the NH and SH, as a result of a southward shift of the ITCZ in response to AMOC slowdown events mediated by amplifying mechanisms, such as ENSO and the South Atlantic dipole.

8. References

- ADKINS, J. F.; MCINTYRE, K.; SCHRAG, D. P. The salinity, temperature, and delta O-18 of the glacial deep ocean. **Science**, v. 298, n. 5599, p. 1769-1773 2002.
- ALVE, E.; NAGY, J. Estuarine Foraminiferal Distribution in Sandebukta, a Branch of the Oslo Fjord. **Journal of Foraminiferal Research**, v. 16, n. 4, p. 261-284 1986.
- ANAND, P.; ELDERFIELD, H.; CONTE, M. H. Calibration of Mg/Ca thermometry in planktonic foraminifera from a sediment trap time series. **Paleoceanography**, v. 18, n. 2, 2003.
- ANDREWS, J. T.; HARDADOTTIR, J.; STONER, J. S.; MANN, M. E.; KRISTJANSDDOTTIR, G. B.; KOC, N. Decadal to millennial-scale periodicities in North Iceland shelf sediments over the last 12000 cal yr: long-term North Atlantic oceanographic variability and solar forcing. **Earth and Planetary Science Letters**, v. 210, n. 3-4, p. 453-465 2003.
- ANGULO, R. A.; LESSA, G. C.; SOUZA, M. C. A critical review of mid- to late-Holocene sea-level fluctuations on the eastern Brazilian coastline. **Quaternary Science Reviews**, v. 25, p. 486-506 2006.
- ANGULO, R. A.; SOUZA, M. C.; REIMER, P. J.; SASAOKA, S. K. Reservoir effect of the southern and southeastern Brazilian coast. **Radiocarbon**, v. 47, p. 67-73 2005.
- AQUINO, F. E.; SETZER, A. O clima da Amazzônia Azul. In: SERAFIM, C. F. S. e CHAVES, P. T. (Ed.). **Geografia: ensino fundamental e ensino médio: o mar no espaço geográfico brasileiro**. Brasília: Ministério da Educação, v.8, 2006. cap. 226-230,
- ARAÚJO, A. G. M.; NEVES, W. A.; PILÓ, L. B.; ATUI, J. P. V. Holocene dryness and human occupation in Brazil during the "Archaic Gap". **Quaternary Research**, v. 64, p. 298-307 2005.
- ARZ, H. W.; GERHARDT, S.; PATZOLD, J.; ROHL, U. Millennial-scale changes of surface- and deep-water flow in the western tropical Atlantic linked to Northern Hemisphere high-latitude climate during the Holocene. **Geology**, v. 29, n. 3, p. 239-242 2001.
- ARZ, H. W.; PATZOLD, J.; WEFER, G. Correlated millennial-scale changes in surface hydrography and terrigenous sediment yield inferred from last-glacial marine deposits off northeastern Brazil. **Quaternary Research**, v. 50, n. 2, p. 157-166 1998.
- BARBOSA, V. P. **Foraminíferos Bentônicos Quaternários do Talude Continental da Baía de Santos: Sistemática, Paleobatimetria e Paleoecologia**. 1998. 427 (PhD thesis). Instituto de Geociências, Universidade Federal do Rio Grande do Sul, São Paulo.
- BARKER, S.; GREAVES, M.; ELDERFIELD, H. A study of cleaning procedures used for foraminiferal Mg/Ca paleothermometry. **Geochemistry Geophysics Geosystems**, v. 4, 2003.

BARROS, V.; GONZALEZ, M.; LIEBMANN, B.; CAMILLONI, I. A. Influence of the South Atlantic convergence zone and South Atlantic Sea surface temperature on interannual summer rainfall variability in Southeastern South America. **Theoretical and Applied Climatology**, v. 67, p. 123-133 2000.

BAYON, G.; BOELLA, G. R. M.; MILTON, J. A.; TAYLOR, R. N.; NESBITT, R. W. An improved method for extracting marine sediment fractions and its application to Sr and Nd isotopic analysis. **Chemical Geology**, v. 187, p. 179-199 2002.

BEHLING, H. A High-Resolution Holocene Pollen Record from Lago Do Pires, Se Brazil - Vegetation, Climate and Fire History. **Journal of Paleolimnology**, v. 14, n. 3, p. 253-268 1995.

_____. South and southeast Brazilian grasslands during Late Quaternary times: a synthesis. **Palaeogeography Palaeoclimatology Palaeoecology**, v. 177, n. 1-2, p. 19-27 2002.

BEHLING, H.; COHEN, M. C. L.; LARA, R. J. Late Holocene mangrove dynamics of Marajo Island in Amazonia, northern Brazil. **Vegetation History and Archaeobotany**, v. 13, n. 2, p. 73-80 2004.

BEHLING, H.; PILLAR, V. D.; BAUERMANN, S. G. Late Quaternary grassland (Campos), gallery forest, fire and climate dynamics, studied by pollen, charcoal and multivariate analysis of the Sao Francisco de Assis core in western Rio Grande do Sul (southern Brazil). **Review of Palaeobotany and Palynology**, v. 133, n. 3-4, p. 235-248 2005.

BERNHARD, J. M. Characteristic Assemblages and Morphologies of Benthic Foraminifera from Anoxic, Organic-Rich Deposits - Jurassic through Holocene. **Journal of Foraminiferal Research**, v. 16, n. 3, p. 207-215 1986.

BIANCHI, G. G.; MCCAVE, I. N. Holocene periodicity in North Atlantic climate and deep-ocean flow south of Iceland. **Nature**, v. 397, n. 6719, p. 515-517 1999.

BIASUTTI, M.; BATTISTI, D. S.; SARACHIK, E. S. The annual cycle over the tropical Atlantic, South America, and Africa. **Journal of Climate**, v. 16, n. 15, p. 2491-2508 2003.

BÍCEGO, M. C. **Reconstrução Paleoceanográfica dos últimos 7500 anos na Plataforma Continental do Atlântico Sudoeste Baseada em Marcadores Geoquímicos Orgânicos**. 2008. (Livre-docência thesis). Instituto Oceanográfico, Universidade de São Paulo, São Paulo.

BISCAYE, P. E. Mineralogy and Sedimentation of Recent Deep-Sea Clay in Atlantic Ocean and Adjacent Seas and Oceans. **Geological Society of America Bulletin**, v. 76, n. 7, p. 803-805 1965.

BOLTOVSKOY, E. **Foraminíferos recientes. Biología, métodos de estudio, aplicación oceanográfica.** Buenos Aires: Eudeba Editorial Universitaria de Buenos Aires, 1965. 510.

BOLTOVSKOY, E.; SCOTT, D. B.; MEDIOLI, F. S. Morphological variations of benthic foraminiferal tests in response to changes in ecological parameters: a review. **Journal of Paleontology**, v. 65, n. 2, p. 175-185 1991.

BOND, G.; KROMER, B.; BEER, J.; MUSCHELER, R.; EVANS, M. N.; SHOWERS, W.; HOFFMANN, S.; LOTTI-BOND, R.; HAJDAS, I.; BONANI, G. Persistent solar influence on north Atlantic climate during the Holocene. **Science**, v. 294, n. 5549, p. 2130-2136 2001.

BOND, G.; SHOWERS, W.; CHESEBY, M.; LOTTI, R.; ALMASI, P.; DEMENOCAL, P.; PRIORE, P.; CULLEN, H.; HAJDAS, I.; BONANI, G. A pervasive millennial-scale cycle in North Atlantic Holocene and glacial climates. **Science**, v. 278, n. 5341, p. 1257-1266 1997.

BRACCO, R.; DEL PUERTO, L.; INDA, H.; PANARIO, D.; CASTINEIRA, C.; GARCIA-RODRIGUEZ, F. The relationship between emergence of mound builders in SE Uruguay and climate change inferred from opal phytolith records. **Quaternary International**, v. 245, n. 1, p. 62-73 2011.

BRANDINI, F. P. Hydrography and Characteristics of the Phytoplankton in Shelf and Oceanic Waters Off Southeastern Brazil during Winter (July August 1982) and Summer (February March 1984). **Hydrobiologia**, v. 196, n. 2, p. 111-148 1990.

BRASSELL, S. C. Applications of biomarkers for delineating marine paleoclimate fluctuations during the Quaternary. In: ENGEL, M. H. e MACKO, S. A. (Ed.). **Organic Geochemistry**. New York: Plenum, 1993. p.699-738.

BURONE, L. **Foraminíferos bentônicos e parâmetros físico-químicos da Enseada de Ubatuba, São Paulo: estudo ecológico em uma área com poluição orgânica.** 2002. (PhD thesis). Instituto Oceanográfico, Universidade de São Paulo, São Paulo.

BURONE, L.; ORTEGA, L.; FRANCO-FRAGUAS, P.; MAHIQUES, M.; GARCÍA-RODRIGUEZ, F.; VENTURINI, N.; MARIN, Y.; BRUGNOLI, E.; NAGAI, R.; MUNIZ, P.; BÍCEGO, M.; FIGUEIRA, R.; SALAROLI, A. A multiproxy study between the Río de la Plata and the adjacent South-western Atlantic inner shelf to assess the sediment footprint of river vs. marine influence. **Continental Shelf Research**, in press.

BURONE, L.; PIRES-VANIN, A. M. S. Foraminiferal assemblages in Ubatuba Bay, south-eastern Brazilian coast. **Scientia Marina**, v. 70, n. 2, p. 203-217 2006.

BURONE, L.; SOUSA, S. H. M.; MAHIQUES, M. M.; VALENTE, P.; CIOTTI, A.; YAMASHITA, C. Benthic foraminiferal distribution on the southeastern Brazilian shelf and upper slope. **Marine Biology**, v. 158, n. 1, p. 159-179 2010.

BURONE, L.; VALENTE, P.; PIRES-VANIN, A. M. S.; SOUSA, S. H. D. E.; MAHIQUES, M. M.; BRAGA, E. Benthic foraminiferal variability on a monthly scale in a subtropical bay moderately affected by urban sewage. **Scientia Marina**, v. 71, n. 4, p. 775-792 2007.

CAME, R. E.; EILER, J. M.; VEIZER, J.; AZMY, K.; BRAND, U.; WEIDMAN, C. R. Coupling of surface temperatures and atmospheric CO₂ concentrations during the Palaeozoic era. **Nature**, v. 449, n. 7159, p. 198-U3 2007.

CAME, R. E.; OPPO, D. W.; CURRY, W. B.; LYNCH-STIEGLITZ, J. Deglacial variability in the surface return flow of the Atlantic meridional overturning circulation. **Paleoceanography**, v. 23, n. 1, 2008.

CAMPOS, E. J. D.; MULKHERJEE, S.; PIOLA, A. R.; DE CARVALHO, F. M. S. A note on a mineralogical analysis of the sediments associated with the Plata River and Patos Lagoon outflows. **Continental Shelf Research**, v. 28, n. 13, p. 1687-1691 2008.

CAMPOS, E. J. D.; PIOLA, A. R.; MATANO, R. P.; MILLER, J. L. PLATA: A synoptic characterization of the southwest Atlantic shelf under influence of the Plata River and Patos Lagoon outflows. **Continental Shelf Research**, v. 28, n. 13, p. 1551-1555 2008.

CAMPOS, E. J. D.; VELHOTE, D.; DA SILVEIRA, I. C. A. Shelf break upwelling driven by Brazil Current cyclonic meanders. **Geophysical Research Letters**, v. 27, n. 6, p. 751-754 2000.

CASTELAO, R. M.; CAMPOS, E. J. D.; MILLER, J. L. A modelling study of coastal upwelling driven by wind and meanders of the Brazil current. **Journal of Coastal Research**, v. 20, n. 3, p. 662-671 2004.

CASTRO, B. M.; BRANDINI, F. P.; PIRES-VANIN, A. M. S.; MIRANDA, L. B. Multidisciplinary oceanographic processes on the western Atlantic continental shelf between 4°N and 34°S. In: ROBINSON, A. R. e BRINK, K. H. (Ed.). **The Global Coastal Ocean: Interdisciplinary Regional Studies and Syntheses, Pan-Regional Syntheses and the Coasts of North and South America and Asia**. Cambridge: Harvard University Press, v.14A, 2008. cap. 8,

CAVALLOTTO, J.; VIOLANTE, R. A.; PARKER, G. Sea-level fluctuations during the last 8600 years in the de la Plata river (Argentina). **Quaternary International**, v. 114, p. 155-165 2004.

CHANG, T. S.; FLEMMING, B. W.; BARTHOLOMA, A. Distinction between sortable silts and aggregated particles in muddy intertidal sediments of the East Frisian Wadden Sea, southern North Sea. **Sedimentary Geology**, v. 202, n. 3, p. 453-463 2007.

CHENG, H.; SINHA, A.; WANG, X.; CRUZ, F. W.; EDWARDS, R. L. The Global Paleomonsoon as seen through speleothem records from Asia and the Americas. **Climate Dynamics**, v. 39, n. 5, p. 1045-1062 2012.

CHIANG, J. C. H.; CHENG, W.; BITZ, C. M. Fast teleconnections to the tropical Atlantic sector from Atlantic thermohaline adjustment. **Geophysical Research Letters**, v. 35, n. 7, 2008.

CHIESSI, C.; MULITZA, S.; PÄTZOLD, J.; WEFER, G. How different proxies record precipitation variability over southeastern South America. IOP Conference Series: **Earth and Environmental Sciences**, v. 9, n. 012007, p. 1-6 2010.

CHIESSI, C.; ULRICH, S.; MULITZA, S.; PATZOLD, J.; WEFER, G. SigNature of the Brazil-Malvinas Confluence (Argentine Basin) in the isotopic composition of planktonic foraminifera from surface sediments. **Marine Micropaleontology**, v. 64, n. 1-2, p. 52-66 2007.

CIOTTI, A. M.; ODEBRECHT, C.; FILLMANN, G.; MOLLER, O. O. Fresh-Water Outflow and Subtropical Convergence Influence on Phytoplankton Biomass on the Southern Brazilian Continental-Shelf. **Continental Shelf Research**, v. 15, n. 14, p. 1737-1756 1995.

CLAPPERTON, C. M. **Quaternary Geology and Geomorphology of South America**. Amsterdam: Elsevier, 1993.

CLEROUX, C.; CORTIJO, E.; DUPLESSY, J. C.; ZAHN, R. Deep-dwelling foraminifera as thermocline temperature recorders. **Geochemistry Geophysics Geosystems**, v. 8, 2007.

CONTRERAS-ROSALES, L. A.; KOHO, K. A.; DUIJNSTEE, I. A. P.; DE STIGTER, H. C.; GARCIA, R.; KONING, E.; EPPING, E. Living deep-sea benthic foraminifera from the Cap de Creus Canyon (western Mediterranean): Faunal-geochemical interactions. **Deep-Sea Research Part I**, v. 64, p. 22-42 2012.

CORLISS, B. H. Response of Deep-Sea Benthonic Foraminifera to Development of the Psychrosphere near the Eocene-Oligocene Boundary. **Nature**, v. 282, n. 5734, p. 63-65 1979.

_____. Microhabitats of Benthic Foraminifera within Deep-Sea Sediments. **Nature**, v. 314, n. 6010, p. 435-438 1985.

_____. Morphology and Microhabitat Preferences of Benthic Foraminifera from the Northwest Atlantic-Ocean. **Marine Micropaleontology**, v. 17, n. 3-4, p. 195-236 1991.

CORLISS, B. H.; CHEN, C. Morphotype Patterns of Norwegian Sea Deep-Sea Benthic Foraminifera and Ecological Implications. **Geology**, v. 16, n. 8, p. 716-719 1988.

CRUZ, F. W.; BURNS, S. J.; JERCINOVIC, M.; KARMANN, I.; SHARP, W. D.; VUILLE, M. Evidence of rainfall variations in Southern Brazil from trace element ratios (Mg/Ca and

Sr/Ca) in a Late Pleistocene stalagmite. **Geochimica Et Cosmochimica Acta**, v. 71, n. 9, p. 2250-2263 2007.

CRUZ, F. W.; BURNS, S. J.; KARMANN, I.; SHARP, W. D.; VUILLE, M.; CARDOSO, A. O.; FERRARI, J. A.; DIAS, P. L. S.; VIANA, O. Insolation-driven changes in atmospheric circulation over the past 116,000 years in subtropical Brazil. **Nature**, v. 434, n. 7029, p. 63-66 2005.

DEBENAY, J. P.; REDOIS, F. Distribution of the twenty seven dominant species of shelf benthic foraminifers on the continental shelf, north of Dakar (Senegal). **Marine Micropaleontology**, v. 29, n. 3-4, p. 237-255 1997.

DEKENS, P. S.; LEA, D. W.; PAK, D. K.; SPERO, H. J. Core top calibration of Mg/Ca in tropical foraminifera: Refining paleotemperature estimation. **Geochemistry Geophysics Geosystems**, v. 3, 2002.

DEMENOCAL, P. Cultural responses to climate change during the Late Holocene. **Science**, v. 292, n. 5517, p. 667-673 2001.

DEMENOCAL, P.; ORTIZ, J.; GUILDERSON, T.; ADKINS, J.; SARNTHEIN, M.; BAKER, L.; YARUSINSKY, M. Abrupt onset and termination of the African Humid Period: rapid climate responses to gradual insolation forcing. **Quaternary Science Reviews**, v. 19, n. 1-5, p. 347-361 2000.

DEPAOLO, D. J. **Neodymium Isotope Geochemistry. An Introduction**. Berlin: Springer-Verlag, 1988.

DERIJK, S.; JORISSEN, F.; ROHLING, E. J.; TROELSTRA, S. R. Organic flux control on bathymetric zonation of Mediterranean benthic foraminifera. **Marine Micropaleontology**, v. 40, p. 151-166 2000.

DIAS, J. M. A. **A análise sedimentar e o conhecimento dos sistemas marinhos (Uma introdução à Oceanografia Geológica)** 2004.

DIAZ, A.; STUDZINSKI, C. D.; MECHOSO, C. R. Relationship between precipitation anomalies in Uruguay and Southern Brazil and Sea Surface Temperature in the Pacific and Atlantic Ocean. **Journal of Climate**, v. 11, p. 251-271 1998.

DOTTORI, M.; CASTRO, B. M. The response of the Sao Paulo Continental Shelf, Brazil, to synoptic winds. **Ocean Dynamics**, v. 59, n. 4, p. 603-614 2009.

DRUMOND, A.; AMBRIZZI, T. The role of SST on the South American atmospheric circulation during January, February and March 2001. **Climate Dynamics**, v. 24, n. 7-8, p. 781-791 2005.

DRUMOND, A.; NIETO, R.; GIMENO, L.; AMBRIZZI, T. A Lagrangian identification of major sources of moisture over Central Brazil and La Plata Basin. **Journal of Geophysical Research**, v. 113, n. D14, 2008.

DUCHEMIN, G.; FONTANIER, C.; JORISSEN, F.; BARRAS, C.; GRIVEAUD, C. Living small-sized (63-150µm) foraminifera from mid-shelf to mid-slope environments in the Bay of Biscay. **Journal of Foraminiferal Research**, v. 37, n. 1, p. 12-32 2007.

DUPLESSY, J. C.; LABEYRIE, L.; JUILLETLECLERC, A.; MAITRE, F.; DUPRAT, J.; SARNTHEIN, M. Surface Salinity Reconstruction of the North-Atlantic Ocean during the Last Glacial Maximum. **Oceanologica Acta**, v. 14, n. 4, p. 311-324 1991.

DYMOND, J.; SUESS, E.; LYLE, M. Barium in Deep-Sea Sediment: A Geochemical Proxy for Paleoproductivity. **Paleoceanography**, v. 7, n. 2, p. 163-181 1992.

EBERWEIN, A.; MACKENSEN, A. Regional primary productivity differences off Morocco (NW-Africa) recorded by modern benthic foraminifera and their stable carbon isotopic composition. **Deep Sea Research Part I**, v. 53, n. 8, p. 1379-1405 2006.

EICHLER, P. P. B.; SEN GUPTA, B. K.; EICHLER, B. B.; BRAGA, E. S.; CAMPOS, E. J. Benthic foraminiferal assemblages of the South Brazil: Relationship to water masses and nutrient distributions. **Continental Shelf Research**, v. 28, n. 13, p. 1674-1686 2008.

ELDERFIELD, H.; GANSEN, G. Past temperature and δ¹⁸O of surface waters inferred from foraminiferal Mg/Ca ratios. **Nature**, v. 405, p. 442-445 2000.

FAGEL, N. Chapter Four Clay Minerals, Deep Circulation and Climate. In: (Ed.). **Developments in Marine Geology - Proxies in Late Cenozoic Paleoceanography**: Elsevier, v.1, 2007. cap. 4, p.139-184. ISBN 15725480.

FAGEL, N.; INNOCENT, C.; GARIEPY, C.; HILLAIRES-MARCEL, C. Sources of Labrador Sea sediments since the last glacial maximum from Nd-Pb isotopes. **Geochimica Et Cosmochimica Acta**, v. 66, n. 14, p. 2569-2581 2002.

FARMER, E. J.; CHAPMAN, M. R.; ANDREWS, J. E. Centennial-scale Holocene North Atlantic surface temperatures from Mg/Ca ratios in *Globigerina bulloides*. **Geochemistry, Geophysics, Geosystems**, v. 9, n. 12, p. n/a-n/a 2008.

FARMER, G. L.; BARBER, D.; ANDREWS, J. Provenance of Late Quaternary ice-proximal sediments in the North Atlantic: Nd, Sr and Pb isotopic evidence. **Earth and Planetary Science Letters**, v. 209, n. 1-2, p. 227-243 2003.

FIGUEIRA, R. C. L.; TESSLER, M. G.; MAHIQUES, M. M.; CUNHA, I. I. L. Distribution Of (CS)-C-137 Pu-238 and Pu239+240 in sediments of the southeastern Brazilian shelf-SW Atlantic margin. **Science of the Total Environment**, v. 357, n. 1-3, p. 146-159 2006.

FONTANIER, C.; JORISSEN, F.; LICARI, L.; ALEXANDRE, A.; ANSCHUTZ, P.; CARBONEL, P. Live benthic foraminiferal faunas from the Bay of Biscay: faunal density, composition and microhabitats. **Deep-Sea Research Part I**, v. 49, p. 751-785 2002.

FONTANIER, C.; JORISSEN, F. J.; CHAILLOU, G.; DAVID, C.; ANSCHUTZ, P.; LAFON, V. Seasonal and interannual variability of benthic foraminiferal faunas at 550m depth in the Bay of Biscay. **Deep Sea Research Part I**, v. 50, n. 4, p. 457-494 2003.

FONTANIER, C.; JORISSEN, F. J.; LANSARD, B.; MOURET, A.; BUSCAIL, R.; SCHMIDT, S.; KERHERVÉ, P.; BURON, F.; ZARAGOSI, S.; HUNAUT, G.; ERNOULT, E.; ARTERO, C.; ANSCHUTZ, P.; RABOUILLE, C. Live foraminifera from the open slope between Grand Rhône and Petit Rhône Canyons (Gulf of Lions, NW Mediterranean). **Deep Sea Research Part I**, v. 55, n. 11, p. 1532-1553 2008.

FRADIQUE, C.; CASCALHO, J.; DRAGO, T.; ROCHA, F.; SILVEIRA, T. The meaning of heavy minerals in the recent sedimentary record of the Douro estuary (Portugal). **Journal of Coastal Research**, v. 39, p. 165-169 2006.

GALHANO, C.; ROCHA, F.; GOMES, C. Geostatistical analysis of the influence of textural, mineralogical and geochemical parameters on the geotechnical behaviour of the 'Argilas de Aveiro' formation (Portugal). **Clay Minerals**, v. 34, n. 1, p. 109-116 1999.

GAN, M. A.; KOUSKY, V. E.; ROPELEWSKI, C. F. The South America Monsoon circulation and its relationship to rainfall over west-central Brazil. **Journal of Climate**, v. 17, p. 47-66 2004.

GARREAUD, R. D.; VUILLE, M.; COMPAGNUCCI, R.; MARENGO, J. Present-day South American climate. **Palaeogeography, Palaeoclimatology, Palaeoecology**, v. 281, n. 3-4, p. 180-195 2009.

GONZALEZ-SILVERA, A.; SANTAMARIA-DEL-ANGEL, E.; MILLAN-NUNEZ, R. Spatial and temporal variability of the Brazil-Malvinas Confluence and the La Plata Plume as seen by SeaWiFS and AVHRR imagery. **Journal of Geophysical Research-Oceans**, v. 111, n. C6, 2006.

GOODAY, A. J. A Response by Benthic Foraminifera to the Deposition of Phytodetritus in the Deep-Sea. **Nature**, v. 332, n. 6159, p. 70-73 1988.

_____. Deep-Sea Benthic Foraminiferal Species Which Exploit Phytodetritus - Characteristic Features and Controls on Distribution. **Marine Micropaleontology**, v. 22, n. 3, p. 187-205 1993.

_____. The Biology of Deep-Sea Foraminifera - a Review of Some Advances and Their Applications in Paleoceanography. **Palaaios**, v. 9, n. 1, p. 14-31 1994.

_____. Benthic foraminifera (protista) as tools in deep-water palaeoceanography: Environmental influences on faunal characteristics. **Advances in Marine Biology**, Vol 46, v. 46, p. 1-90 2003.

GOODAY, A. J.; RATHBURN, A. E. Temporal variability in living deep-sea benthic foraminifera: a review. **Earth-Science Reviews**, v. 46, n. 1-4, p. 187-212 1999.

GRIGGS, G. B.; HEIN, J. R. Sources, Dispersal, and Clay Mineral-Composition of Fine-Grained Sediment Off Central and Northern California. **Journal of Geology**, v. 88, n. 5, p. 541-566 1980.

GRIMM, A. M. Meteorologia básica - Notas de aula., 1999. Disponível em: <<http://fisica.ufpr.br/grimm/aposmeteo>>. Acesso em: 02/2009.

GRIMM, A. M. The El Nino impact on the summer monsoon in Brazil: Regional processes versus remote influences. **Journal of Climate**, v. 16, n. 2, p. 263-280 2003.

GRIMM, A. M.; BARROS, V. R.; DOYLE, M. E. Climate variability in southern South America associated with El Nino and La Nina events. **Journal of Climate**, v. 13, n. 1, p. 35-58 2000.

GROENEVELD, J.; CHIESSI, C. M. Mg/Ca of Globorotalia inflata as a recorder of permanent thermocline temperatures in the South Atlantic. **Paleoceanography**, v. 26, n. 2, 2011.

GROENEVELD, J.; NÜRNBERG, D.; TIEDEMANN, R.; REICHART, G.-J.; STEPH, S.; REUNING, L.; CRUDELI, D.; MASON, P. Foraminiferal Mg/Ca increase in the Caribbean during the Pliocene: Western Atlantic Warm Pool formation, salinity influence, or diagenetic overprint? **Geochemistry, Geophysics, Geosystems**, v. 9, n. 1, p. n/a-n/a 2008.

GROUSSET, F.; BISCAYE, P. E.; ZINDLER, A.; PROSPERO, J.; CHESTER, R. Neodymium isotopes as tracers in marine sediments and aerosols: North Atlantic. **Earth and Planetary Science Letters**, v. 87, p. 367-378 1988.

GUPTA, A. K.; SARKAR, S.; MUKHERJEE, B. Paleooceanographic changes during the past 1.9 Myr at DSDP Site 238, Central Indian Ocean Basin: Benthic foraminiferal proxies. **Marine Micropaleontology**, v. 60, n. 2, p. 157-166 2006.

GUPTA, A. K.; THOMAS, E. Initiation of Northern Hemisphere glaciation and strengthening of the northeast Indian monsoon: Ocean Drilling Program Site 758, eastern equatorial Indian Ocean. **Geology**, v. 31, n. 1, p. 47-50 2003.

GYLLENCREUTZ, R. Late Glacial and Holocene Paleooceanography in the Skagerrak from high-resolution grain size records. **Palaeogeography Palaeoclimatology Palaeoecology**, v. 222, n. 3-4, p. 344-369 2005.

GYLLENCREUTZ, R.; MAHIQUES, M. M.; ALVES, D. V. P.; WAINER, I. K. C. Mid- to late-Holocene paleoceanographic changes on the southeastern Brazilian shelf based on grain size records. **Holocene**, v. 20, n. 6, p. 863-875 2010.

HAARSMA, R. J.; CAMPOS, E. J. D.; MOLTENI, F. Atmospheric response to South Atlantic SST dipole. **Geophysical Research Letters**, v. 30, n. 16, 2003.

HAMMER, O.; HARPER, D. A. T.; RYAN, P. D. PAST: Paleontological Statistics software package for education and data analysis. **Paleontologia Electronica**, v. 4, n. 1, p. 9 2001.

HAUG, G. H.; HUGHEN, K. A.; SIGMAN, D. M.; PETERSON, L. C.; RÖHL, U. Southward migration of the Intertropical Convergence Zone through the Holocene. **Science**, v. 293, p. 1304-1308 2001.

HAYES, J. M. Factors Controlling C-13 Contents of Sedimentary Organic-Compounds - Principles and Evidence. **Marine Geology**, v. 113, n. 1-2, p. 111-125 1993.

HAYWARD, B. W.; HOLLIS, C. J.; GRENFELL, H. Foraminiferal Associations in Port Pegasus, Stewart-Island, New-Zealand. **New Zealand Journal of Marine and Freshwater Research**, v. 28, n. 1, p. 69-95 1994.

HEEGARD, E., BIRKS, H.J.B. AND TELFORD, R.J. Relationships between calibrated ages and depth in stratigraphical sequences: an estimation procedure by mixed-effect regression. **The Holocene**, v.15, p. 612–618 2005.

HEIN, J. R.; DOWLING, J. S.; SCHUETZE, A.; LEE, H. J. Clay-mineral suites, sources, and inferred dispersal routes: Southern California continental shelf. **Marine Environmental Research**, v. 56, n. 1-2, p. 79-102 2003.

HEINZ, P.; KITAZATO, H.; SCHMIEDL, G.; HEMLEBEN, C. Response of deep-sea benthic foraminifera from the Mediterranean Sea to simulated phytoplankton pulses under laboratory conditions. **Journal of Foraminiferal Research**, v. 31, n. 3, p. 210-227 2001.

HERGUERA, J. C. Last glacial paleoproductivity patterns in the eastern equatorial Pacific: benthic foraminifera records. **Marine Micropaleontology**, v. 40, p. 259-275 2000.

HERGUERA, J. C.; BERGER, W. H. Paleoproductivity from Benthic Foraminifera Abundance - Glacial to Postglacial Change in the West-Equatorial Pacific. **Geology**, v. 19, n. 12, p. 1173-1176 1991.

HETHERINGTON, R.; REID, R. G. B. **The Climate Connection: Climate change and Human evolution**. New York: Cambridge University Press, 2010.

HILL, T. M.; BROOKS, G. R.; DUNCAN, D. S.; MEDIOLI, F. S. Benthic foraminifera of the Holocene transgressive west-central Florida inner shelf: paleoenvironmental implications. **Marine Geology**, v. 200, n. 1-4, p. 263-272 2003.

HODELL, D. A.; CURTIS, J. H.; BRENNER, M. Possible Role of Climate in the Collapse of Classic Maya Civilization. **Nature**, v. 375, n. 6530, p. 391-394 1995.

HU, J.; PENG, P. A.; JIA, G.; MAI, B.; ZHANG, G. Distribution and sources of organic carbon, nitrogen and their isotopes in sediments of the subtropical Pearl River estuary and adjacent shelf, Southern China. **Marine Chemistry**, v. 98, n. 2-4, p. 274-285 2006.

HUGHEN, K. A.; BAILLIE, M. G. L.; BARD, E.; BECK, J. W.; BERTRAND, C. J. H.; BLACKWELL, P. G.; BUCK, C. E.; BURR, G. S.; CUTLER, K. B.; DAMON, P. E.; EDWARDS, R. L.; FAIRBANKS, R. G.; FRIEDRICH, M.; GUILDERSON, T. P.; KROMER, B.; MCCORMAC, G.; MANNING, S.; RAMSEY, C. B.; REIMER, P. J.; REIMER, R. W.; REMMELE, S.; SOUTHON, J. R.; STUIVER, M.; TALAMO, S.; TAYLOR, F. W.; VAN DER PLICHT, J.; WEYHENMEYER, C. E. Marine04 marine radiocarbon age calibration, 0-26 cal kyr BP. **Radiocarbon**, v. 46, n. 3, p. 1059-1086 2004.

HUT, G. **Consultants group meeting on stable isotope reference samples for geochemical and hydrological investigations**. Report to the Director General. International Atomic Energy Agency. Vienna, p.42. 1987

INGRAM, B. L.; LIN, J. C. Geochemical tracers of sediment sources to San Francisco Bay. **Geology**, v. 30, n. 6, p. 575-578 2002.

ISHIWATARI, R.; UZAKI, M. Diagenetic Changes of Lignin Compounds in a More Than 0.6 Million-Year-Old Lacustrine Sediment (Lake Biwa, Japan). **Geochimica Et Cosmochimica Acta**, v. 51, n. 2, p. 321-328 1987.

JASPER, J. P.; GAGOSIAN, R. B. The Sources and Deposition of Organic-Matter in the Late Quaternary Pygmy Basin, Gulf of Mexico. **Geochimica Et Cosmochimica Acta**, v. 54, n. 4, p. 1117-1132 1990.

JONES, R. W. **The Challenger foraminifera**. London: Oxford University Press, 1994.

JORISSEN, F. Benthic foraminiferal successions across Late Quaternary Mediterranean spropels. **Marine Micropaleontology**, v. 153, p. 91-101 1999.

JORISSEN, F.; FONTANIER, C.; THOMAS, E. Paleoceanographical proxies based on deep-sea benthic foraminiferal assemblage characteristics. In: HILLAIRES-MARCEL and C. VERNAL, A. (Ed.) **Proxies in Late Cenozoic Paleoceanography: Pt. 2: Biological tracers and biomarkers**, Elsevier, 2007. p. 263-326.

JORISSEN, F.; ROHLING, E. J. Faunal perspectives on paloproductivity. **Marine Micropaleontology**, v. 40, p. 131-134 2000.

JORISSEN, F.; STIGER, H. C.; WIDMARK, J. G. V. A conceptual model explaining benthic foraminiferal microhabitats. **Marine Micropaleontology**, v. 26, p. 3-15 1995.

JORISSEN, F.; WITTLING, I.; PEYPOUQUET, J. P.; RABOUILLE, C.; RELEXANS, J. C. Live benthic foraminiferal faunas off Cape Blanc, NW-Africa: community structure and microhabitats. **Deep-Sea Research Part I**, v. 45, p. 2157-2188 1998.

KALNAY, E.; KANAMITSU, M.; KISTLER, R.; COLLINS, W.; DEAVEN, D.; GANDIN, L.; IREDELL, M.; SAHA, S.; WHITE, G.; WOOLLEN, J.; ZHU, Y.; CHELLIAH, M.; EBISUZAKI, W.; HIGGINS, W.; JANOWIAK, J.; MO, K. C.; ROPELEWSKI, C.; WANG, J.; LEETMAA, A.; REYNOLDS, R.; JENNE, R.; JOSEPH, D. The NCEP/NCAR 40-year reanalysis project. **Bulletin of the American Meteorological Society**, v. 77, n. 3, p. 437-471 1996.

KARLIN, R. Sediment Sources and Clay Mineral Distributions Off the Oregon Coast. **Journal of Sedimentary Petrology**, v. 50, n. 2, p. 543-560 1980.

KEIL, R. G.; TSAMAKIS, E.; FUH, C. B.; GIDDINGS, J. C.; HEDGES, J. I. Mineralogical and Textural Controls on the Organic Composition of Coastal Marine-Sediments - Hydrodynamic Separation Using Splitt-Fractionation. **Geochimica Et Cosmochimica Acta**, v. 58, n. 2, p. 879-893 1994.

KESSARKAR, P. M.; RAO, V. P.; AHMAD, S. M.; BABU, G. A. Clay minerals and Sr-Nd isotopes of the sediments along the western margin of India and their implication for sediment provenance. **Marine Geology**, v. 202, n. 1-2, p. 55-69 2003.

KIM, J. H.; SCHNEIDER, R. R.; MULITZA, S.; MULLER, P. J. Reconstruction of SE trade-wind intensity based on sea-surface temperature gradients in the Southeast Atlantic over the last 25 kyr. **Geophysical Research Letters**, v. 30, n. 22, 2003.

KLUMP, J.; HEBBELN, D.; WEFER, G. The impact of sediment provenance on barium-based productivity estimates. **Marine Geology**, v. 169, p. 259-271 2000.

KOUTAVAS, A.; JOANIDES, S. El Niño–Southern Oscillation extrema in the Holocene and Last Glacial Maximum. **Paleoceanography**, v. 27, n. 4, 2012.

KOWSMANN, R. O.; COSTA, M. P. A. Paleolinhas de costa na plataforma continental das regiões sul e norte brasileiras. **Revista Brasileira de Geociências**, v. 4, p. 215-222 1974.

LAMBECK, K.; CHAPPELL, J. Sea level change through the last glacial cycle. **Science**, v. 292, n. 5517, p. 679-86 2001.

LEA, D. W.; MASHIOTTA, T. A.; SPERO, H. J. Controls on magnesium and strontium uptake in planktonic foraminifera determined by live culturing. **Geochimica Et Cosmochimica Acta**, v. 63, n. 16, p. 2369-2379 1999.

LEA, D. W.; PAK, D. K.; PETERSON, L. C.; HUGHEN, K. A. Synchronicity of tropical and high-latitude Atlantic temperatures over the last glacial termination. **Science**, v. 301, n. 5638, p. 1361-4 2003.

LEAR, C.; ELDERFIELD, H.; WILSON, P. Cenozoic Deep-Sea Temperatures and Global Ice Volumes from Mg/Ca in Benthic Foraminiferal Calcite. **Science of the Total Environment**, v. 287, n. 269-272, 2000.

LEAR, C.; ROSENTHAL, Y.; COXALL, H. K.; WILSON, P. A. Late Eocene to early Miocene ice sheet dynamics and the global carbon cycle. **Paleoceanography**, v. 19, n. 4, 2004.

LEDRU, M. P. Late Quaternary Environmental and Climatic Changes in Central Brazil. **Quaternary Research**, v. 39, n. 1, p. 90-98 1993.

LEDRU, M. P.; MOURGUIART, P.; RICCOMINI, C. Related changes in biodiversity, insolation and climate in the Atlantic rainforest since the last interglacial. **Palaeogeography Palaeoclimatology Palaeoecology**, v. 271, n. 1-2, p. 140-152 2009.

LEDRU, M. P.; SALGADO-LABOURIAU, M. L.; LORSCHTEITTE, M. L. Vegetation dynamics in southern and central Brazil during the last 10,000 yr BP. **Review of Palaeobotany and Palynology**, v. 99, n. 2, p. 131-142 1998.

LEDUC, G.; SCHNEIDER, R.; KIM, J. H.; LOHMANN, G. Holocene and Eemian sea surface temperature trends as revealed by alkenone and Mg/Ca paleothermometry. **Quaternary Science Reviews**, v. 29, n. 7-8, p. 989-1004 2010.

LEGRANDE, A. N.; SCHMIDT, G. A. Global gridded data set of the oxygen isotopic composition in seawater. **Geophysical Research Letters**, v. 33, n. 12, 2006.

LENTERS, J. D.; COOK, K. H. Summertime precipitation variability over South America: Role of the large-scale circulation. **Monthly Weather Review**, v. 127, n. 3, p. 409-431 1999.

LEONHARDT, A.; LORSCHTEITTE, M. L. The last 25,000 years in the Eastern Plateau of Southern Brazil according to Alpes de São Francisco record. **Journal of South American Earth Sciences**, v. 29, n. 2, p. 454-463 2010.

LOEBLICH, A. R.; TAPPAN, H. **Foraminiferal genera and their classification - PLATES**. New York: Van Nostrand Reinhold, 1988. 970.

LOUBERE, P. The surface ocean productivity and bottom water oxygen signals in deep water benthic foraminiferal assemblages. **Marine Micropaleontology**, v. 28, n. 3-4, p. 247-261 1996.

_____. The impact of seasonality on the benthos as reflected in the assemblages of deep-sea foraminifera. **Deep-Sea Research Part I**, v. 45, n. 2-3, p. 409-432 1998.

LOUBERE, P.; FARIDUDDIN, M. Quantitative estimation of global patterns of surface ocean biological productivity and its seasonal variation on timescales from centuries to millennia. **Global Biogeochemical Cycles**, v. 13, n. 1, p. 115-133 1999.

LUTZE, G. F.; COULBOURN, W. T. Recent Benthic Foraminifera from the Continental-Margin of Northwest Africa - Community Structure and Distribution. **Marine Micropaleontology**, v. 8, n. 5, p. 361-401 1984.

LYNCH-STIEGLITZ, J.; CURRY, W. B.; LUND, D. C. Florida Straits density structure and transport over the last 8000 years. **Paleoceanography**, v. 24, 2009.

LYNCH-STIEGLITZ, J.; CURRY, W. B.; SLOWEY, N. Weaker Gulf Stream in the Florida straits during the last glacial maximum. **Nature**, v. 402, n. 6762, p. 644-648 1999.

MACKENSEN, A.; GROBE, H.; KUHN, G.; FUTTERER, D. K. Benthic foraminiferal assemblages from the eastern Weddell Sea between 68 and 73°S: distribution, ecology and fossilization potential. **Marine Micropaleontology**, v. 16, p. 241-283 1990.

MACKENSEN, A.; SCHMIEDL, G.; HARLOFF, J.; GIESE, M. Deep-sea foraminifera in the South Atlantic ocean: Ecology and assemblage generation. **Micropaleontology**, v. 41, n. 4, p. 342-358 1995.

MACKENSEN, A.; SEJRUP, H. P.; JANSEN, E. The Distribution of Living Benthic Foraminifera on the Continental-Slope and Rise Off Southwest Norway. **Marine Micropaleontology**, v. 9, n. 4, p. 275-306 1985.

MAHIQUES, M. M.; DA SILVEIRA, I. C. A.; SOUSA, S. H. D. E.; RODRIGUES, M. Post-LGM sedimentation on the outer shelf-upper slope of the northernmost part of the Sao Paulo Bight, southeastern Brazil. **Marine Geology**, v. 181, n. 4, p. 387-400 2002.

MAHIQUES, M. M.; FUKUMOTO, M. M.; SILVEIRA, I. C. A.; FIGUEIRA, R. C. L.; BICEGO, M. C.; LOURENCO, R. A.; MELLO-E-SOUSA, S. H. Sedimentary changes on the Southeastern Brazilian upper slope during the last 35,000 years. **Anais Da Academia Brasileira De Ciencias**, v. 79, n. 1, p. 171-181 2007.

MAHIQUES, M. M.; MISHIMA, Y.; RODRIGUES, M. Characteristics of the sedimentary organic matter on the inner and middle continental shelf between Guanabara Bay and Sao

Francisco do Sul, southeastern Brazilian margin. **Continental Shelf Research**, v. 19, n. 6, p. 775-798 1999.

MAHIQUES, M. M.; SOUSA, S. H. M.; BURONE, L.; NAGAI, R. H.; SILVEIRA, I. C. A.; FIGUEIRA, R. C. L.; SOUTELINO, R. G.; PONSONI, L.; KLEIN, D. A. Radiocarbon geochronology of the sediments of the Sao Paulo Bight (southern Brazilian upper margin). **Anais Da Academia Brasileira De Ciencias**, v. 83, n. 3, p. 817-834 2011.

MAHIQUES, M. M.; TASSINARI, C. C. G.; MARCOLINI, S.; VIOLANTE, R. A.; FIGUEIRA, R. C. L.; SILVEIRA, I. C. A.; BURONE, L.; SOUSA, S. H. M. Nd and Pb isotope signatures on the Southeastern South American upper margin: Implications for sediment transport and source rocks. **Marine Geology**, v. 250, n. 1-2, p. 51-63 2008.

MAHIQUES, M. M.; TESSLER, M. G.; CIOTTI, A. M.; SILVEIRA, I. C. A.; SOUSA, S. H. D. E.; FIGUEIRA, R. C. L.; TASSINARI, C. C. G.; FURTADO, V. V.; PASSOS, R. F. Hydrodynamically driven patterns of recent sedimentation in the shelf and upper slope off Southeast Brazil. **Continental Shelf Research**, v. 24, n. 15, p. 1685-1697 2004.

MAHIQUES, M. M.; WAINER, I. K. C.; BURONE, L.; NAGAI, R.; SOUS, S. H. D. E.; FIGUEIRA, R. C. L.; SILVEIRA, I. C. A.; BICEGO, M. C.; ALVES, D. P. V.; HAMMER, O. A high-resolution Holocene record on the Southern Brazilian shelf: Paleoenvironmental implications. **Quaternary International**, v. 206, p. 52-61 2009.

MARCHANT, M.; HEBBLEN, D.; WEFER, G. High resolution planktonic foraminiferal record of the last 13,300 years from an upwelling area off Chile. **Marine Geology**, v. 161, p. 115-128 1999.

MARCHITTO, T. M.; MUSCHELER, R.; ORTIZ, J. D.; CARRIQUIRY, J. D.; VAN GEEN, A. Dynamical Response of the Tropical Pacific Ocean to Solar Forcing During the Early Holocene. **Science**, v. 330, n. 6009, p. 1378-1381 2010.

MARENGO, J. A.; SOARES, W. R.; SAULO, C.; NICOLINI, M. Climatology of the low-level jet east of the Andes as derived from the NCEP-NCAR reanalyses: Characteristics and temporal variability. **Journal of Climate**, v. 17, n. 12, p. 2261-2280 2004.

MARTIN, L.; DOMINGUEZ, J. M. L.; BITTENCOURT, A. C. S. P. Fluctuating Holocene sea levels in eastern and southeastern Brazil: evidence from multiple fossil and geometric indicators. **Journal of Coastal Research**, v. 19, n. 1, p. 101-124 2003.

MARTIN, L.; FOURNIER, M.; MOURGUIART, P.; SIFEDDINE, A.; TURCQ, B. Southern Oscillation signal in South American paleoclimatic data of the last 7000 years. **Quaternary Research**, v. 39, p. 338-346 1993.

MARTIN, P. A.; LEA, D. W. A simple evaluation of cleaning procedures on fossil benthic foraminiferal Mg/Ca. **Geochemistry Geophysics Geosystems**, v. 3, 2002.

MARTINEZ, P.; BERTRAND, P.; SHIMMIELD, G. B.; COCHRANE, K.; JORISSEN, F.; FOSTER, D.; DIGNAN, M. Upwelling intensity and ocean productivity changes off Cape Blanc (northwest Africa) during the last 70,000 years: geochemical and micropalaeontological evidence. **Marine Geology**, v. 158, p. 57-74 1999.

MARTINS, V.; DUBERT, J.; JOUANNEAU, J.-M.; WEBER, O.; DA SILVA, E. F.; PATINHA, C.; ALVEIRINHO DIAS, J. M.; ROCHA, F. A multiproxy approach of the Holocene evolution of shelf-slope circulation on the NW Iberian Continental Shelf. **Marine Geology**, v. 239, n. 1-2, p. 1-18 2007.

MARTINS, V.; JOUANNEAU, J.-M.; WEBER, O.; ROCHA, F. Tracing the late Holocene evolution of the NW Iberian upwelling system. **Marine Micropaleontology**, v. 59, n. 1, p. 35-55 2006.

MASLIN, M. A.; DURHAM, E.; BURNS, S. J.; PLATZMAN, E.; GROOTES, P.; GREIG, S. E. J.; NADEAU, M. J.; SCHLEICHER, M.; PFLAUMANN, U.; LOMAX, B.; RIMINGTON, N. Palaeoreconstruction of the Amazon River freshwater and sediment discharge using sediments recovered at Site 942 on the Amazon Fan. **Journal of Quaternary Science**, v. 15, n. 4, p. 419-434 2000.

MATSUMOTO, K.; LYNCH-STIEGLITZ, J. Persistence of Gulf Stream separation during the Last Glacial Period: Implications for current separation theories. **Journal of Geophysical Research-Oceans**, v. 108, n. C6, 2003.

MATSUURA, Y.; WADA, E. Carbon and nitrogen stable isotope ratios in marine organic matters of the coastal ecosystem in Ubatuba, southern Brazil. **Ciência e Cultura**, v. 46, p. 142-146 1994.

MAYEWSKI, P. A.; ROHLING, E. E.; STAGER, J. C.; KARLEN, W.; MAASCH, K. A.; MEEKER, L. D.; MEYERSON, E. A.; GASSE, F.; VAN KREVELD, S.; HOLMGREN, K.; LEE-THORP, J.; ROSQVIST, G.; RACK, F.; STAUBWASSER, M.; SCHNEIDER, R. R.; STEIG, E. J. Holocene climate variability. **Quaternary Research**, v. 62, n. 3, p. 243-255 2004.

MCCAVE, I. N.; KIEFER, T.; THORNALLEY, D. J. R.; ELDERFIELD, H. Deep flow in the Madagascar-Mascarene Basin over the last 150 000 years. **Philosophical Transactions of the Royal Society of London Series a-Mathematical Physical and Engineering Sciences**, v. 363, n. 1826, p. 81-99 2005.

MCCAVE, I. N.; MANIGHETTI, B.; ROBINSON, S. G. Sortable Silt and Fine Sediment Size Composition Slicing - Parameters for Paleocurrent Speed and **Paleoceanography**. **Paleoceanography**, v. 10, n. 3, p. 593-610 1995.

MCCONNELL, M. C.; THUNELL, R. C. Calibration of the planktonic foraminiferal Mg/Ca paleothermometer: sediment trap results from the Guaymas Basin, Gulf of California. **Paleoceanography**, v. 20, n. 2, 2005.

MCMANUS, J. F.; FRANCOIS, R.; GHERARDI, J. M.; KEIGWIN, L. D.; BROWN-LEGER, S. Collapse and rapid resumption of Atlantic meridional circulation linked to deglacial climate changes. **Nature**, v. 428, n. 6985, p. 834-837 2004.

MELLINGER, R. M. **Quantitative X-ray diffraction analysis of clay minerals. An evaluation**. Saskatchewan Res. Council. Canada, p.1-46. 1979

MELO, L. D.; MARENGO, J. A. The influence of changes in orbital parameters over South American climate using the CPTEC AGCM: simulation of climate during the mid Holocene. **The Holocene**, v. 18, n. 4, p. 501-516 2008.

MENDES, I.; GONZALEZ, R.; DIAS, J. M. A.; LOBO, F.; MARTINS, V. Factors influencing recent benthic foraminifera distribution on the Guadiana shelf (Southwestern Iberia). **Marine Micropaleontology**, v. 51, n. 1-2, p. 171-192 2004.

MEYERS, P. A. Preservation of Elemental and Isotopic Source Identification of Sedimentary Organic-Matter. **Chemical Geology**, v. 114, n. 3-4, p. 289-302 1994.

_____. Organic geochemical proxies of paleoceanographic, paleolimnologic, and paleoclimatic processes. **Organic Geochemistry**, v. 27, n. 5-6, p. 213-250 1997.

MIX, A. C. Influence of Productivity Variations on Long-Term Atmospheric Co₂. **Nature**, v. 337, n. 6207, p. 541-544 1989.

MOLLER, O. O.; PIOLA, A. R.; FREITAS, A. C.; CAMPOS, E. J. D. The effects of river discharge and seasonal winds on the shelf off southeastern South America. **Continental Shelf Research**, v. 28, n. 13, p. 1607-1624 2008.

MORENO, A.; CACHO, I.; CANALS, M.; GRIMALT, J. O.; SANCHEZ-VIDAL, A. Millennial-scale variability in the productivity signal from the Alboran Sea record, Western Mediterranean Sea. **Palaeogeography, Palaeoclimatology, Palaeoecology**, v. 211, n. 3-4, p. 205-219 2004.

MOY, C. M.; SELTZER, G. O.; RODBELL, D. Y.; ANDERSON, D. M. Variability of El Niño/Southern Oscillation activity at millennial timescales during the Holocene epoch. **Nature**, v. 420, n. 6912, p. 162-165 2002.

MUELBERT, J. H.; SINQUE, C. Distribution of bluefish (*Pomatomus saltatrix*) larvae along the Continental Shelf off southern Brazil. **Marine and Freshwater Research**, v. 47, n. 2, p. 311-314 1996.

MULITZA, S.; ARZ, H.; MÜCKE, K.-V.; MOOS, C.; NIEBLER, H. S.; PÄTZOLD, J.; SEGL, M. The South Atlantic isotope record of planktonic foraminifera. In: FISHER, G. and WEFER, G. (Ed.). **Use of proxies in Paleoceanography: examples from the South Atlantic**. Berlin: Springer-Verlag, 1999. p.427-445.

MULITZA, S.; BOLTOVSKOY, D.; DONNER, B.; MEGGERS, H.; PAUL, A.; WEFER, G. Temperature: delta O-18 relationships of planktonic foraminifera collected from surface waters. **Palaeogeography Palaeoclimatology Palaeoecology**, v. 202, n. 1-2, p. 143-152 2003.

MULITZA, S.; DURKOOP, A.; HALE, W.; WEFER, G.; NIEBLER, H. S. Planktonic foraminifera as recorders of past surface-water stratification. **Geology**, v. 25, n. 4, p. 335-338 1997.

MURRAY, J. W. **Ecology and palaeoecology of benthic foraminifera**. London: Longman Scientific and Technical, 1991.

_____. **Ecology and Applications of Benthic Foraminifera**. Cambridge: Cambridge University Press, 2006.

MURRAY, J. W.; ALVE, E.; CUNDY, A. The origin of modern agglutinated foraminiferal assemblages: evidence from a stratified fjord. **Estuarine Coastal and Shelf Science**, v. 58, n. 3, p. 677-697 2003.

MUSCHITIELLO, F.; HAMMARLUND, D.; WOHLFARTH, B. New insights into the Holocene Thermal Maximum: feedback and triggering mechanisms. PAGES 4th Open Science Meeting, 2013, Goa, India. PAGES.

NAGAI, R. H.; FERREIRA, P. A. L.; MULKHERJEE, S.; MARTINS, V. M.; FIGUEIRA, R. C. L.; SOUSA, S. H. M.; MAHIQUES, M. M. Hydrodynamic controls on the mineralogy and natural and artificial radionuclide distributions in surface sediments from the Brazilian continental shelf between Cabo Frio (23°S) and the mouth of the Rio de La Plata (38°S). **Continental Shelf Research**, submitted.

NAGAI, R. H.; SOUSA, S. H. M.; BURONE, L.; MAHIQUES, M. M. Paleoproductivity changes during the Holocene in the inner shelf of Cabo Frio, southeastern Brazilian continental margin: Benthic foraminifera and sedimentological proxies. **Quaternary International**, v. 206, p. 62-71 2009.

NESBITT, H. W.; FEDO, C. M.; YOUNG, G. M. Quartz and feldspar stability, steady and non-steady-state weathering, and petrogenesis of siliciclastic sands and muds. **The Journal of Geology**, v. 105, n. 2, p. 173-192 1997.

NURNBERG, D.; BIJMA, J.; HEMLEBEN, C. Assessing the reliability of magnesium in foraminiferal calcite as a proxy for water mass temperatures. **Geochimica Et Cosmochimica Acta**, v. 60, n. 5, p. 803-814 1996.

NURNBERG, D.; MULLER, A.; SCHNEIDER, R. R. Paleo-sea surface temperature calculations in the equatorial east Atlantic from Mg/Ca ratios in planktic foraminifera: A comparison to sea surface temperature estimates from U-37(K'), oxygen isotopes, and foraminiferal transfer function. **Paleoceanography**, v. 15, n. 1, p. 124-134 2000.

OLIVEIRA, A.; ROCHA, F.; RODRIGUES, A.; JOUANNEAU, J.; DIAS, A.; WEBER, O.; GOMES, C. Clay minerals from the sedimentary cover from the Northwest Iberian shelf. **Progress in Oceanography**, v. 52, n. 2-4, p. 233-247 2002.

OPPO, D. W.; MCMANUS, J.; CULLEN, J. L. Deepwater variability in the Holocene epoch. **Nature GeoScience**, v. 422, p. 277-278 2003.

PALMA, E. D.; MATANO, R. P. Disentangling the upwelling mechanisms of the South Brazil Bight. **Continental Shelf Research**, v. 29, n. 11-12, p. 1525-1534 2009.

PARK, Y. A.; KHIM, B. K. Clay-Minerals of the Recent Fine-Grained Sediments on the Korean Continental Shelves. **Continental Shelf Research**, v. 10, n. 12, p. 1179-1191 1990.

PARRA, M.; FAUGÈRES, J.-C.; GROUSSET, F.; PUJOL, C. Sr-Nd isotopes as tracers of fine-grained detrital sediments: the South-Barbados accretionary prism during the last 150 kyr. **Marine Geology**, v. 136, p. 225-243 1997.

PASQUINI, A. I.; DEPETRIS, P. J. Discharge trends and flow dynamics of South American rivers draining the southern Atlantic seaboard: An overview. **Journal of Hydrology**, v. 333, n. 2-4, p. 385-399 2007.

PAYTAN, A. Ocean Paleoproductivity. In: GORNITZ, V. (Ed.). **Encyclopedia of Paleoclimatology and Ancient Environments**. London: Kluwer Academic Publishers, 2008. p.643-651.

PAYTAN, A.; SHELLNBARGER, G. G.; STREET, J. H.; GONNEEA, M. E.; DAVIS, K.; YOUNG, M. B.; MOORE, W. S. Submarine groundwater discharge: An important source of new inorganic nitrogen to coral reef ecosystems. **Limnology and Oceanography**, v. 51, n. 1, p. 343-348 2006.

PESSENDA, L. C. R.; GOUVEIA, S. E. M.; ARAVENA, R.; BOULET, R.; VALENCIA, E. P. E. Holocene fire and vegetation changes in southeastern Brazil as deduced from fossil charcoal and soil carbon isotopes. **Quaternary International**, v. 114, p. 35-43 2004.

PETSCHICK, R.; KUHN, G.; GINGELE, F. Clay mineral distribution in surface sediments of the South Atlantic: Sources, transport, and relation to oceanography. **Marine Geology**, v. 130, n. 3-4, p. 203-229 1996.

PFEIFER, K.; KASTEN, S.; HENSEN, C.; SCHULZ, H. D. Reconstruction of primary productivity from the barium contents on surface sediments of the South Atlantic Ocean. **Marine Geology**, v. 177, p. 13-24 2001.

PIELOU, E. C. **Ecological diversity**. New York: John Wiley, 1975.

PIOLA, A. R.; MATANO, R. P.; PALMA, E. D.; MOLLER, O. O.; CAMPOS, E. J. D. The influence of the Plata River discharge on the western South Atlantic shelf. **Geophysical Research Letters**, v. 32, n. 1, 2005.

PIOLA, A. R.; ROMERO, S. I.; ZAJACZKOVSKI, U. Space-time variability of the Plata plume inferred from ocean color. **Continental Shelf Research**, v. 28, n. 13, p. 1556-1567 2008.

PRAHL, F. G.; BENNETT, J. T.; CARPENTER, R. The early diagenesis of aliphatic hydrocarbons and organic matter in sedimentary particulates from Dabob Bay, Washington. **Geochimica Et Cosmochimica Acta**, v. 44, p. 1967-1976 1980.

PRAHL, F. G.; ERTEL, J. R.; GONI, M. A.; SPARROW, M. A.; EVERSMEYER, B. Terrestrial Organic-Carbon Contributions to Sediments on the Washington Margin. **Geochimica Et Cosmochimica Acta**, v. 58, n. 14, p. 3035-3048 1994.

REBOITA, M. S.; GAN, M. A.; ROCHA, R. P.; AMBRIZZI, T. Regimes de precipitação na América do Sul: uma revisão bibliográfica. **Revista Brasileira de Meteorologia**, v. 25, n. 2, p. 185-204 2010.

REGENBERG, M.; STEPH, S.; NURNBERG, D.; TIEDEMANN, R.; GARBE-SCHONBERG, D. Calibrating Mg/Ca ratios of multiple planktonic foraminiferal species with delta O-18-calcification temperatures: Paleothermometry for the upper water column. **Earth and Planetary Science Letters**, v. 278, n. 3-4, p. 324-336 2009.

REVEL, M.; SINKO, J. A.; GROUSSET, F. E.; BISCAYE, P. E. Sr and Nd isotopes as tracers of north Atlantic lithic particles: Paleoclimatic implications. **Paleoceanography**, v. 11, n. 1, p. 95-113 1996.

ROBERT, C.; DIESTER-HAASS, L.; PATUREL, J. Clay mineral assemblages, siliciclastic input and paleoproductivity at ODP Site 1085 off Southwest Africa: A late Miocene-early Pliocene history of Orange river discharges and Benguela current activity, and their relation to global sea level change. **Marine Geology**, v. 216, n. 4, p. 221-238 2005.

ROBINSON, R. S.; KIENAST, M.; LUIZA ALBUQUERQUE, A.; ALTABET, M.; CONTRERAS, S.; DE POL HOLZ, R.; DUBOIS, N.; FRANCOIS, R.; GALBRAITH, E.; HSU, T.-C.; IVANOCHKO, T.; JACCARD, S.; KAO, S.-J.; KIEFER, T.; KIENAST, S.; LEHMANN, M.; MARTINEZ, P.; MCCARTHY, M.; MÖBIUS, J.; PEDERSEN, T.; QUAN, T. M.; RYABENKO, E.; SCHMITTNER, A.; SCHNEIDER, R.; SCHNEIDER-MOR, A.; SHIGEMITSU, M.; SINCLAIR, D.;

SOMES, C.; STUDER, A.; THUNELL, R.; YANG, J.-Y. A review of nitrogen isotopic alteration in marine sediments. **Paleoceanography**, v. 27, n. 4, 2012.

ROCHA, J.; MILLIMAN, J. D.; SANTANA, C. I.; VICALVI, M. A. Continental margin sedimentation off Brazil. Part 5: Southern Brazil. **Contributions to Sedimentology**, v. 4, p. 117-150 1975.

RODRIGUES, R. R.; LORENZZETTI, J. A. A numerical study of the effects of bottom topography and coastline geometry on the Southeast Brazilian coastal upwelling. **Continental Shelf Research**, v. 21, p. 371-394 2001.

RODWELL, M. J.; HOSKINS, B. J. Subtropical anticyclones and summer monsoons. **Journal of Climate**, v. 14, p. 3192-3211 2001.

RUHLEMANN, C.; DIEKMANN, B.; MULITZA, S.; FRANK, M. Late Quaternary changes of western equatorial Atlantic surface circulation and Amazon lowland climate recorded in Ceara Rise deep-sea sediments. **Paleoceanography**, v. 16, n. 3, p. 293-305 2001.

RUHLEMANN, C.; MULITZA, S.; MULLER, P. J.; WEFER, G.; ZAHN, R. Warming of the tropical Atlantic Ocean and slowdown of thermohaline circulation during the last deglaciation. **Nature**, v. 402, n. 6761, p. 511-514 1999.

RUTBERG, R. L.; HEMMING, S. R.; GOLDSTEIN, S. L. Reduced North Atlantic Deep Water flux to the glacial Southern Ocean inferred from neodymium isotope ratios. **Nature**, v. 405, n. 6789, p. 935-938 2000.

SAHER, M.; KRISTENSEN, D. K.; HALD, M.; PAVLOVA, O.; JØRGENSEN, L. L. Changes in distribution of calcareous benthic foraminifera in the central Barents Sea between the periods 1965–1992 and 2005–2006. **Global and Planetary Change**, v. 98-99, p. 81-96 2012.

SCHMIDT, M. W.; SPERO, H. J.; LEA, D. W. Links between salinity variation in the Caribbean and North Atlantic thermohaline circulation. **Nature**, v. 428, n. 6979, p. 160-163 2004.

SCHMIEDL, G.; BOVÉE, F.; BUSCAIL, R.; HEMLEBEN, C.; MEDERNACH, L.; PICON, P. Trophic control of benthic foraminiferal abundance and microhabitat in the bathyal Gulf of Lions, western Mediterranean Sea. **Marine Micropaleontology**, v. 40, p. 167-188 2000.

SCHMIEDL, G.; MACKENSEN, A. Late Quaternary paleoproductivity and deep water circulation in the eastern South Atlantic Ocean: Evidence from benthic foraminifera. **Palaeogeography Palaeoclimatology Palaeoecology**, v. 130, p. 43-80 1997.

SCHMIEDL, G.; MACKENSEN, A.; MULLER, G. Recent benthic foraminifera from the eastern South Atlantic Ocean: dependence on food supply and water masses. **Marine Micropaleontology**, v. 32, p. 249-287 1997.

SCHONFELD, J. Benthic foraminifera and pore-water oxygen profiles: A re-assessment of species boundary conditions at the western Iberian Margin. **Journal of Foraminiferal Research**, v. 31, n. 2, p. 86-107 2001.

SCHÖNFELD, J. Recent benthic foraminifera assemblages in deep high-energy environments from the Gulf of Cadiz (Spain). **Marine Micropaleontology**, v. 44, p. 141-162 2002.

SCHRAG, D. P.; ADKINS, J. F.; MCINTYRE, K.; ALEXANDER, J. L.; HODELL, A.; CHARLES, C. D.; MCMANUS, J. F. The oxygen isotopic composition of seawater during the Last Glacial Maximum. **Quaternary Science Reviews**, v. 21, p. 331-342 2002.

SCHRODER, C. J.; SCOTT, D. B.; MEDIOLI, F. S. Can Smaller Benthic Foraminifera Be Ignored in Paleoenvironmental Analyses. **Journal of Foraminiferal Research**, v. 17, n. 2, p. 101-105 1987.

SCHULTZ, L. G. Quantitative interpretation of mineralogical composition from X-ray and chemical data for the Pierre Shale. **U.S. Geol. Surv. Prof. Pap.**, v. 391-C, p. 1-31 1964.

SHACKLETON, N. J.; OPDYKE, N. D. Oxygen isotope and paleomagnetic stratigraphy of equatorial Pacific core V28-238: Oxygen isotope temperatures and ice volumes on a 105 year scale. **Quaternary Research**, v. 3, p. 39-55 1973.

SHANNON, C.; WEAVER, W. **The Mathematical Theory of Communication**. 5th. 1999.

SIDDALL, M.; ROHLING, E. E.; ALMOGI-LABIN, A.; HEMBLEBEN, C.; MEISCHNER, D.; SCHMELZER, I.; SMEED, D. A. Sea-level fluctuations during the last glacial cycle. **Nature**, v. 423, n. 6942, p. 853-858 2003.

SILLIMAN, J. E.; MEYERS, P. A.; BOURBONNIERE, R. A. Record of postglacial organic matter delivery and burial in sediments of Lake Ontario. **Organic Geochemistry**, v. 24, n. 4, p. 463-472 1996.

SILVEIRA, I. C. A.; SCHMIDT, A. C. K.; CAMPOS, E. J. D.; GODOI, S. S.; IKEDA, Y. A Corrente do Brasil ao largo da costa leste Brasileira. **Revista Brasileira de Oceanografia**, v. 48, n. 2, p. 171-183 2000.

SMART, C. W. Abyssal NE Atlantic benthic foraminifera during the last 15 kyr: Relation to variations in seasonality of productivity. **Marine Micropaleontology**, v. 69, n. 2, p. 193-211 2008.

SMART, C. W.; KING, S. C.; GOODAY, A. J.; MURRAY, J. W.; THOMAS, E. A benthic foraminiferal proxy of pulsed organic matter paleofluxes. **Marine Micropaleontology**, v. 23, p. 89-99 1994.

SMART, C. W.; WAELEBROECK, C.; MICHEL, E.; MAZAUD, A. Benthic foraminiferal abundance and stable isotope changes in the Indian Ocean sector of the Southern Ocean during the last 20 kyr: Paleooceanographic implications. **Palaeogeography Palaeoclimatology Palaeoecology**, v. 297, n. 3-4, p. 537-548 2010.

SOUSA, S. H. M.; GODOI, S. S.; AMARAL, P.; COELHO, T. M.; CIOTTI, A. Distribution of living planktonic foraminifera in relation to oceanic processes on the southeastern continental Brazilian margin (23° - 25° S and 40° - 44° W). **Continental Shelf Research**, submitted.

SOUZA, R. B.; ROBINSON, I. S. Lagrangian and satellite observations of the Brazilian Coastal Current. **Continental Shelf Research**, v. 24, n. 2, p. 241-262 2004.

STAUBWASSER, M.; SIROCKO, F. On the formation of laminated sediments on the continental margin off Pakistan: the effects of sediment provenance and sediment redistribution. **Marine Geology**, v. 172, n. 1-2, p. 43-56 2001.

STEPH, S.; REGENBERG, M.; TIEDEMANN, R.; MULITZA, S.; NÜRNBERG, D. Stable isotopes of planktonic foraminifera from tropical Atlantic/Caribbean core-tops: Implications for reconstructing upper ocean stratification. **Marine Micropaleontology**, v. 71, n. 1-2, p. 1-19 2009.

STRAMMA, L.; ENGLAND, M. H. On the water masses and mean circulation of the South Atlantic Ocean. **Journal of Geophysical Research-Oceans**, v. 104, n. C9, p. 20863-20883 1999.

STRIKIS, N. M.; CRUZ, F. W.; CHENG, H.; KARMANN, I.; EDWARDS, R. L.; VUILLE, M.; WANG, X.; DE PAULA, M. S.; NOVELLO, V. F.; AULER, A. S. Abrupt variations in South American monsoon rainfall during the Holocene based on a speleothem record from central-eastern Brazil. **Geology**, v. 39, n. 11, p. 1075-1078 2011.

SUN, Y. C.; CHI, P. H.; SHIUE, M. Y. Comparison of different digestion methods for total decomposition of siliceous and organic environmental samples. **Analytical Sciences**, v. 17, n. 12, p. 1395-1399 2001.

SUNYÉ, P. S.; SERVAIN, J. Effects of seasonal variations in meteorology and oceanography on the Brazilian sardine fishery. **Fisheries Oceanography**, v. 7, n. 2, p. 89-100 1998.

TEDESCO, K.; THUNELL, R.; ASTOR, Y.; MULLER-KARGER, F. The oxygen isotope composition of planktonic foraminifera from the Cariaco Basin, Venezuela: Seasonal and interannual variations. **Marine Micropaleontology**, v. 62, n. 3, p. 180-193 2007.

TEIL, H. Correspondence Factor-Analysis - an Outline of Its Method. **Journal of the International Association for Mathematical Geology**, v. 7, n. 1, p. 3-13 1975.

THOMPSON, S.; EGLINTON, G. Fractionation of a Recent Sediment for Organic Geochemical Analysis. **Geochimica Et Cosmochimica Acta**, v. 42, n. 2, p. 199-& 1978.

THOREZ, J. **Practical Identification of Clay Minerals A Handbook for Teachers and Students in Clay Mineralogy**. Belgium: Lelotte (Dison), 1976.

TRIBOVILLARD, N.; ALGEO, T. J.; LYONS, T.; RIBOULLEAU, A. Trace metals as paleoredox and paleoproductivity proxies: An update. **Chemical Geology**, v. 232, n. 1-2, p. 12-32 2006.

VAN MORKHOVEN, F. P. C. M.; BERGGREN, W. A.; EDWARDS, A. S. **Cenozoic cosmopolitan deep-water benthic foraminifera**. Elf Aquitaine, 1986.

VANCE, D.; THIRLWALL, M. An assessment of mass discriminations in MC-ICPMS using Nd isotopes. **Chemical Geology**, v. 185, p. 227-240 2002.

VÉNEC-PEYRÉ, M.-T.; CAULET, J.-P. Paleoproductivity changes in the upwelling system of Socotra (Somali Basin, NW Indian Ocean) during the last 72,000 years: evidences from biological sig**Natures**. **Marine Micropaleontology**, v. 40, p. 321-344 2000.

VERA, C.; BAEZ, J.; DOUGLAS, M.; EMMANUEL, C. B.; MARENGO, J.; MEITIN, J.; NICOLINI, M.; NOGUES-PAEGLE, J.; PAEGLE, J.; PENALBA, O.; SALIO, P.; SAULO, C.; SILVA DIAS, M. A.; SILVA DIAS, P.; ZIPSER, E. The South American Low-Level Jet Experiment. **Bulletin of the American Meteorological Society**, v. 87, n. 1, p. 63-77 2006.

VERA, C.; HIGGINS, W.; AMADOR, J.; AMBRIZZI, T.; GARREAU, R.; GOCHIS, D.; GUTZLER, D.; LETTENMAIER, D.; MARENGO, J.; MECHOSO, C. R.; NOGUES-PAEGLE, J.; DIAS, P. L. S.; ZHANG, C. Toward a unified view of the American Monsoon Systems. **Journal of Climate**, v. 19, n. 20, p. 4977-5000 2006.

VERA, C.; VIGLIAROLO, P. K.; BERBERY, E. H. Cold season synoptic-scale waves over subtropical South America. **Monthly Weather Review**, v. 130, n. 3, p. 684-699 2002.

VIDAL, L.; LABEYRIE, L.; CORTIJO, E.; ARNOLD, M.; DUPLESSY, J. C.; MICHEL, E.; BECQUE, S.; VANWEERING, T. C. E. Evidence for changes in the North Atlantic Deep Water linked to meltwater surges during the Heinrich events. **Earth and Planetary Science Letters**, v. 146, n. 1-2, p. 13-27 1997.

VIDINHA, J. M.; ROCHA, F.; ANDRADE, C.; GOMES, C. Mineralogical characterization of the fine fraction of the beach and dune sediments situated between Espinho and Torreira (Portugal). **Cuaternary Geomorfology**, v. 12, n. 49-56, 1998.

VILLALBA, R.; GROSJEAN, M.; KIEFER, T. Long-term multi-proxy climate reconstructions and dynamics in South America (LOTRED-SA): State of the art and perspectives. **Palaeogeography, Palaeoclimatology, Palaeoecology**, v. 281, n. 3-4, p. 175-179 2009.

VROON, P. Z.; VANBERGEN, M. J.; KLAVER, G. J.; WHITE, W. M. Strontium, Neodymium, and Lead Isotopic and Trace-Element Signatures of the East Indonesian Sediments - Provenance and Implications for Banda Arc Magma Genesis. **Geochimica Et Cosmochimica Acta**, v. 59, n. 12, p. 2573-2598 1995.

Waelbroeck, C.; Labeyrie, L.; Michel, E.; Duplessy, J. C.; McManus, J. F.; Lambeck, K.; Balbon, E.; Labracherie, M. Sea-level and deep water temperature changes derived from benthic foraminifera isotopic records. **Quaternary Science Reviews**, v. 21, n. 1-3, p. 295-305 2002.

WAINER, I.; TASCHETTO, A. S. Climatologia na região entre o Cabo de São Tomé (RJ) e o Chuí (RS). Diagnóstico para os períodos relativos aos levantamentos pesqueiros do Programa REVIZEE. In: ROSSI-WONGTSHOWSKI, C. L. D. B. e MADUREIRA, L. S.-P. (Ed.). **O ambiente oceanográfico da plataforma continental e do talude na região Sul/Sudeste do Brasil**: Edusp, 2006. p.121-160.

WALSH, J. J. Importance of Continental Margins in the Marine Biogeochemical Cycling of Carbon and Nitrogen. **Nature**, v. 350, n. 6313, p. 53-55 1991.

WANG, X. F.; AULER, A. S.; EDWARDS, R. L.; CHENG, H.; ITO, E.; SOLHEID, M. Interhemispheric anti-phasing of rainfall during the last glacial period. **Quaternary Science Reviews**, v. 25, n. 23-24, p. 3391-3403 2006.

WANG, X. F.; AULER, A. S.; EDWARDS, R. L.; CHENG, H.; ITO, E.; WANG, Y. J.; KONG, X. G.; SOLHEID, M. Millennial-scale precipitation changes in southern Brazil over the past 90,000 years. **Geophysical Research Letters**, v. 34, n. 23, 2007.

WANNER, H.; BEER, J.; BUTIKOFER, J.; CROWLEY, T. J.; CUBASCH, U.; FLUCKIGER, J.; GOOSSE, H.; GROSJEAN, M.; JOOS, F.; KAPLAN, J. O.; KUTTEL, M.; MULLER, S. A.; PRENTICE, I. C.; SOLOMINA, O.; STOCKER, T. F.; TARASOV, P.; WAGNER, M.; WIDMANN, M. Mid- to Late Holocene climate change: an overview. **Quaternary Science Reviews**, v. 27, n. 19-20, p. 1791-1828 2008.

WANNER, H.; SOLOMINA, O.; GROSJEAN, M.; RITZ, S. P.; JETEL, M. Structure and origin of Holocene cold events. **Quaternary Science Reviews**, v. 30, n. 21-22, p. 3109-3123 2011.

WEFER, G.; BERGER, W. H.; BIJMA, J.; FISHER, G. Clues to the Ocean history: a brief overview of proxies. In: FISHER, G. e WEFER, G. (Ed.). **Use of proxies in**

Paleoceanography: examples from the South Atlantic. Berlin: Springer-Verlag, 1999. cap. 1-68,

WELDEAB, S.; EMEIS, K. C.; HEMLEBEN, C.; VENNEMENN, T. W.; SCHULZ, H. Sr and Nd isotope composition of Late Pleistocene sapropels and nonsapropelic sediments from the Eastern Mediterranean Sea: Implications for detrital influx and climatic conditions in the source areas. **Geochimica Et Cosmochimica Acta**, v. 66, n. 20, p. 3585-3598 2002.

WELDEAB, S.; FRANK, M.; STICHEL, T.; HALEY, B.; SANGEN, M. Spatio-temporal evolution of the West African monsoon during the last deglaciation. **Geophysical Research Letters**, v. 38, 2011.

WELDEAB, S.; SCHNEIDER, R. R.; KÖLLING, M. Deglacial sea surface temperature and salinity increase in the western tropical Atlantic in synchrony with high latitude climate instabilities. **Earth and Planetary Science Letters**, v. 241, n. 3-4, p. 699-706 2006.

WELDEAB, S.; SIEBEL, W.; WEHAUSEN, R.; EMEIS, K. C.; SCHMIEDL, G.; HEMLEBEN, C. Late Pleistocene sedimentation in the Western Mediterranean Sea: implications for productivity changes and climatic conditions in the catchment areas. **Palaeogeography Palaeoclimatology Palaeoecology**, v. 190, p. 121-137 2003.

WOLLENBURG, J. E.; KNIES, J.; MACKENSEN, A. High-resolution paleoproductivity fluctuations during the past 24 kyr as indicated by benthic foraminifera in the marginal Arctic Ocean. **Palaeogeography, Palaeoclimatology, Palaeoecology**, v. 204, n. 3-4, p. 209-238 2004.

WOLLENBURG, J. E.; KUHN, W. The response of benthic foraminifera to carbon flux and primary production in the Arctic Ocean. **Marine Micropaleontology**, v. 40, p. 189-231 2000.

ŽARIĆ, S.; DONNER, B.; FISCHER, G.; MULITZA, S.; WEFER, G. Sensitivity of planktic foraminifera to sea surface temperature and export production as derived from sediment trap data. **Marine Micropaleontology**, v. 55, n. 1-2, p. 75-105 2005.

ZARRIESS, M.; MACKENSEN, A. Testing the impact of seasonal phytodetritus deposition on delta C-13 of epibenthic foraminifer *Cibicides wuellerstorfi*: A 31,000 year high-resolution record from the northwest African continental slope. **Paleoceanography**, v. 26, 2011.

ZEMBRUSKI, S. G. Geomorfologia da margem continental sul brasileira e das bacias oceânicas adjacentes. In: CHAVES, H. A. F. (Ed.). **Geomorfologia da margem continental brasileira e das bacias oceânicas adjacentes**. Série Projeto REMAC. Rio de Janeiro: PETROBRAS-CENPES-DINTEP, v.7, 1979. p.129-177.

ZHANG, R.; DELWORTH, T. L. Simulated tropical response to a substantial weakening of the Atlantic thermohaline circulation. **Journal of Climate**, v. 18, n. 12, p. 1853-1860 2005.

ZHOU, J. Y.; LAU, K. M. Does a monsoon climate exist over South America? **Journal of Climate**, v. 11, n. 5, p. 1020-1040 1998.

Plate 1

Benthic foraminifera - *A. angulosa* (a, b); *B. subspinensis* (c, d); *Brizalina* spp. (e, broken specimen); *B. marginata* (f); *B. elegantissima* (j); *C. ungerianus* (h,i); *G. subglobosa* (l, m); and *G. umbonata* (n,o,p). Planktonic foraminifera – *G. ruber* (p) (j,k).

Plate 2

Benthic foraminifera – *Epistominella* spp. (a, b, bronke specimens); *I. norcrossi* (c,d); and *S. earlandi* (e,f).

Appendix 1 - Main sedimentological (grain size) and geochemical (sedimentary organic matter and inorganic constituents, mineralogy, and planktonic *G. ruber* (p) isotopic composition) data obtained for core 7605. (CD)

Appendix 2 – Core 7605 benthic foraminifera community data, identified taxa microhabitat classification and relative frequency (%), and values of density (tests·10cc⁻¹), percentages of fragments, non-identified specimens, epifauna and infauna specimens, productivity indexes BFHP (%) and BFAR (tests·cm⁻²·kyr⁻¹) and ecological parameters richness (S), Shannon diversity (H') and equitability (J'). Where: epifauna (E) and infauna (I). (CD)

Appendix 3 – Main sedimentological (grain size) and geochemical (sedimentary organic matter and inorganic constituents, mineralogy, and planktonic *G. ruber* (p) isotopic and elemental composition) data obtained for core 7610. (CD)

Appendix 4 – Main sedimentological (grain size) and geochemical (sedimentary organic matter and inorganic constituents, mineralogy, and planktonic *G. ruber* (p) isotopic and elemental composition) data obtained for core 7616. (CD)

Appendix 5 - Core 7616 benthic foraminifera community data, identified taxa microhabitat classification and relative frequency (%), and values of density (tests·10cc⁻¹), percentages of fragments, non-identified specimens, epifauna and infauna specimens, productivity indexes BFHP (%) and BFAR (tests·cm⁻²·kyr⁻¹) and ecological parameters richness (S), Shannon diversity (H') and equitability (J'). Where: epifauna (E) and infauna (I). (CD)

Appendix 1 - Main sedimentological (grain size) and geochemical (sedimentary organic matter and inorganic constituents, mineralogy, and planktonic *G. ruber* (p) isotopic composition) data obtained for core 7605. Where, * stands for absence of data.

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCO ₃ (%)	TOC (%)	N _{tot} (%)	δ ¹³ C (‰ vs. VPDB)	δ ¹⁵ N (‰ vs. VPDB)	CN ratio
0	611	3,99	56,83	39,18	4,60	19,60	*	0,13	*	1,54	*
2	639	4,59	66,93	28,48	4,85	17,94	0,88	0,13	-20,73	2,37	6,85
4	668	6,42	77,98	15,60	5,28	20,10	0,96	0,12	-20,26	2,29	8,18
6	696	4,23	70,19	25,58	4,88	17,76	0,96	0,13	-20,54	3,13	7,09
8	726	4,52	62,30	33,18	4,74	17,34	0,87	0,12	-20,74	1,50	7,01
10	757	3,70	55,59	40,71	4,56	16,91	0,52	0,12	-20,55	2,10	4,41
12	790	3,82	56,31	39,86	4,57	17,56	0,92	0,12	-20,62	1,59	7,54
14	824	4,98	74,86	20,16	5,08	21,25	0,82	0,11	-20,71	2,98	7,42
16	860	*	*	*	*	18,29	0,86	0,10	-20,35	2,40	8,64
18	899	*	*	*	*	20,24	0,65	0,10	-20,67	3,59	6,53
20	941	7,05	77,43	15,52	5,32	9,47	0,52	0,11	-20,03	2,35	4,61
22	986	*	*	*	*	21,06	0,67	0,10	-20,32	3,81	6,49
24	1034	4,92	75,94	19,14	5,08	15,99	0,97	0,11	-20,71	3,11	8,58
26	1086	5,81	79,73	14,47	5,28	13,43	0,68	0,12	-20,84	2,20	5,82
28	1142	5,62	79,22	15,16	5,25	25,95	0,81	0,10	-20,50	1,47	7,89
30	1202	*	*	*	*	18,65	0,60	0,09	-20,43	2,54	6,85
32	1267	*	*	*	*	18,10	0,61	0,09	-20,21	2,15	6,69
34	1337	4,36	74,88	20,76	4,94	18,12	0,78	0,11	-20,50	2,25	7,25
36	1412	3,80	74,97	21,23	4,92	17,77	*	0,10	*	2,76	*
38	1492	3,38	67,86	28,75	4,66	18,79	*	0,09	-20,60	2,21	*
40	1578	*	*	*	*	17,60	0,78	*	-20,05	*	*
42	1671	4,36	58,86	36,78	4,65	15,53	0,73	0,09	-20,24	2,60	7,70
44	1770	4,42	68,56	27,02	4,82	16,61	0,44	0,13	-20,40	2,29	3,32
46	1876	4,10	64,64	31,26	4,68	17,69	0,75	0,11	-20,59	2,03	6,76
48	1989	4,42	74,21	21,37	4,93	17,24	0,35	0,09	-20,85	2,51	4,09

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size				Sedimentary organic matter					
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	δ ¹³ C (‰ vs. VPDB)	δ ¹⁵ N (‰ vs. VPDB)	CN ratio
50	2109	3,91	62,23	33,86	4,43	16,39	0,61	0,09	-20,37	3,89	6,51
52	2237	3,26	60,97	35,78	4,44	17,21	0,71	0,09	-20,78	3,13	8,35
54	2372	3,12	63,91	32,97	4,61	17,51	0,66	0,09	-20,58	4,58	7,26
56	2514	4,10	64,32	31,58	4,63	15,72	0,54	0,08	-20,85	3,59	6,90
58	2664	3,14	48,81	48,05	4,20	16,01	0,56	0,09	-20,65	3,51	6,46
60	2820	*	*	*	*	12,97	0,44	*	-20,96	*	*
68	3507	3,49	54,46	42,05	4,18	15,91	0,52	0,08	-20,41	2,66	6,59
70	3694	*	*	*	*	15,76	0,36	0,07	-20,58	2,09	5,22
72	3885	3,65	54,61	41,73	4,23	14,12	0,34	0,06	-20,97	3,95	5,60
74	4082	6,57	70,46	22,97	5,03	14,51	0,29	0,08	-20,68	4,27	3,63
76	4283	4,57	62,88	32,56	4,57	14,02	0,21	0,07	-21,15	2,98	2,86
78	4489	3,05	49,25	47,70	4,06	13,46	0,22	0,06	-21,10	2,71	3,45
80	4699	3,76	49,42	46,81	3,90	13,65	*	0,05	*	2,76	*
82	4914	2,63	43,09	54,28	3,68	13,67	0,36	*	-20,95	*	*
84	5132	3,98	47,40	48,62	3,89	14,06	*	0,06	*	2,79	*
86	5354	5,28	60,18	34,54	4,43	15,25	*	0,06	*	2,91	*
88	5579	1,60	30,97	67,42	3,03	14,49	*	0,07	*	3,95	*
90	5807	3,10	46,64	50,26	3,69	13,64	0,19	0,05	-21,35	2,69	3,48
92	6038	8,07	71,06	20,87	5,18	13,83	0,19	*	-20,93	*	*
94	6272	1,20	25,86	72,95	2,62	13,23	*	0,05	*	3,69	*
96	6508	4,14	43,70	52,16	3,80	15,89	*	0,05	*	3,37	*
98	6746	3,19	35,10	61,71	3,25	12,73	*	*	*	*	*
100	6987	0,50	14,14	85,36	2,06	11,77	*	0,04	*	3,60	*
102	7228	*	*	*	*	11,12	*	0,25	*	5,00	*
104	7471	*	*	*	*	11,29	*	*	*	*	*
106	7715	*	*	*	*	12,34	*	*	*	*	*

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	Sedimentary inorganic constituents								
		Al (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Ti (mg/kg)	Ba (mg/kg)	Fe/Ca ratio	Ti/Ca ratio	Ba/Al ratio	Ba/Ca ratio
0	611	71442,40	21712,10	38209,50	3916,26	200,43	1,76	0,18	0,00	0,01
2	639	49619,90	16593,30	26098,80	2519,10	205,41	1,57	0,15	0,00	0,01
4	668	85653,20	19817,70	42872,20	4140,59	203,56	2,16	0,21	0,00	0,01
6	696	97751,30	25540,90	54588,00	5239,84	204,77	2,14	0,21	0,00	0,01
8	726	125738,00	27770,70	56429,70	5171,05	197,04	2,03	0,19	0,00	0,01
10	757	75132,10	21068,50	43132,40	4433,22	211,21	2,05	0,21	0,00	0,01
12	790	92021,00	25659,20	49307,90	4848,92	216,87	1,92	0,19	0,00	0,01
14	824	79000,50	20566,90	42544,30	4273,19	222,37	2,07	0,21	0,00	0,01
16	860	75821,50	20664,50	39700,40	4015,22	226,93	1,92	0,19	0,00	0,01
18	899	95095,30	28536,50	50538,20	5193,55	217,14	1,77	0,18	0,00	0,01
20	941	87170,20	24048,70	47337,90	4824,42	215,92	1,97	0,20	0,00	0,01
22	986	*	38618,00	*	4276,36	219,78	*	0,11	*	0,01
24	1034	89097,00	24745,40	47445,00	4761,17	221,03	1,92	0,19	0,00	0,01
26	1086	122954,00	31546,70	53064,50	4791,02	227,57	1,68	0,15	0,00	0,01
28	1142	67514,10	21500,10	37149,30	3702,44	194,34	1,73	0,17	0,00	0,01
30	1202	*	20688,00	*	4214,30	217,57	*	0,20	*	0,01
32	1267	97163,50	30531,40	60305,30	5921,80	167,42	1,98	0,19	0,00	0,01
34	1337	156983,00	37427,70	62194,20	5908,78	203,71	1,66	0,16	0,00	0,01
36	1412	*	31682,40	*	3537,56	220,85	*	0,11	*	0,01
38	1492	54249,80	18795,80	24744,40	2670,90	233,02	1,32	0,14	0,00	0,01
40	1578	*		*		194,64	*		*	
42	1671	*	32180,10	*	3598,07	244,00	*	0,11	*	0,01
44	1770	98330,10	25374,40	36124,00	3582,38	209,63	1,42	0,14	0,00	0,01
46	1876	60559,80	23075,80	31606,70	3459,85	211,04	1,37	0,15	0,00	0,01
48	1989	*	49461,80	*	4464,34	208,07	*	0,09	*	0,00

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	Sedimentary inorganic constituents								
		Al (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Ti (mg/kg)	Ba (mg/kg)	Fe/Ca ratio	Ti/Ca ratio	Ba/Al ratio	Ba/Ca ratio
50	2109	*	40542,90	*	3897,37	206,74	*	0,10	*	0,01
52	2237	105267,00	29307,30	39451,30	3747,86	203,30	1,35	0,13	0,00	0,01
54	2372	*	28004,30	*	3231,28	211,77	*	0,12	*	0,01
56	2514	58174,80	22408,70	26917,50	2978,28	221,76	1,20	0,13	0,00	0,01
58	2664	60414,40	24620,90	28785,90	3290,65	217,50	1,17	0,13	0,00	0,01
60	2820	53899,30	23479,70	26296,50	3166,17	230,46	1,12	0,13	0,00	0,01
68	3507	44321,20	19878,80	22139,50	2808,73	250,60	1,11	0,14	0,01	0,01
70	3694	40640,10	18784,60	21179,80	2491,39	231,94	1,13	0,13	0,01	0,01
72	3885	50144,90	26355,40	25936,60	3065,52	214,13	0,98	0,12	0,00	0,01
74	4082	40351,20	18431,00	20222,50	2311,25	208,06	1,10	0,13	0,01	0,01
76	4283	52591,50	24225,50	25495,50	2977,97	220,69	1,05	0,12	0,00	0,01
78	4489	46068,00	20553,60	22925,50	2683,58	206,55	1,12	0,13	0,00	0,01
80	4699	44713,00	22073,60	21232,20	2769,18	217,01	0,96	0,13	0,00	0,01
82	4914	30545,50	19302,60	14180,60	2138,73	193,84	0,73	0,11	0,01	0,01
84	5132	32449,60	17776,20	14619,50	1983,30	266,11	0,82	0,11	0,01	0,01
86	5354	44461,40	23846,10	22062,40	2721,07	221,86	0,93	0,11	0,00	0,01
88	5579	47570,50	25702,40	24442,30	3161,87	212,00	0,95	0,12	0,00	0,01
90	5807	42677,40	20796,90	20521,50	2589,22	225,17	0,99	0,12	0,01	0,01
92	6038	85260,40	38557,20	36260,10	4175,08	218,98	0,94	0,11	0,00	0,01
94	6272	*	*	*	*	211,40	*	*	*	*
96	6508	54468,30	24034,10	19780,10	2445,64	239,06	0,82	0,10	0,00	0,01
98	6746	56540,20	35993,20	23901,80	2951,93	269,42	0,66	0,08	0,00	0,01
100	6987	46425,80	49020,40	22499,70	2885,24	200,51	0,46	0,06	0,00	0,00
102	7228	24837,30	52070,10	11928,60	1501,24	197,97	0,23	0,03	0,01	0,00
104	7471	20010,00	79446,30	8228,04	1059,42	195,95	0,10	0,01	0,01	0,00
106	7715	23445,50	23070,00	*	*	205,05	0,00	0,00	0,01	*

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy								
		Analcime (%)	Anidrite (%)	Bassanite (%)	Calcite (%)	Chlorite (%)	Dolomite (%)	K Feldapars (%)	Phyllosilicates (%)	Halite (%)
0	611	*	*	*	*	*	*	*	*	*
2	639	0,00	0,00	0,00	12,15	2,84	0,00	0,00	21,32	0,64
4	668	0,00	0,00	0,00	6,97	0,00	0,00	4,25	53,07	0,30
6	696	0,00	0,00	0,59	6,08	0,00	0,00	0,00	43,97	3,36
8	726	*	*	*	*	*	*	*	*	*
10	757	*	*	*	*	*	*	*	*	*
12	790	*	*	*	*	*	*	*	*	*
14	824	*	*	*	*	*	*	*	*	*
16	860	*	*	*	*	*	*	*	*	*
18	899	*	*	*	*	*	*	*	*	*
20	941	*	*	*	*	*	*	*	*	*
22	986	1,97	0,00	0,00	4,42	0,00	0,00	15,63	37,88	2,84
24	1034	0,00	0,00	0,00	9,10	0,87	0,00	0,00	34,67	1,73
26	1086	*	*	*	*	*	*	*	*	*
28	1142	0,00	0,00	0,00	15,39	1,19	0,00	4,91	44,60	2,90
30	1202	*	*	*	*	*	*	*	*	*
32	1267	*	*	*	*	*	*	*	*	*
34	1337	*	*	*	*	*	*	*	*	*
36	1412	*	*	*	*	*	*	*	*	*
38	1492	*	*	*	*	*	*	*	*	*
40	1578	*	*	*	*	*	*	*	*	*
42	1671	*	*	*	*	*	*	*	*	*
44	1770	*	*	*	*	*	*	*	*	*
46	1876	0,00	2,14	0,00	5,83	0,00	0,00	4,08	34,95	2,04
48	1989	1,68	0,45	0,00	8,04	0,00	0,00	6,26	27,93	0,34

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy								
		Analcime (%)	Anidrite (%)	Bassanite (%)	Calcite (%)	Chlorite (%)	Dolomite (%)	K Feldapars (%)	Phyllosilicates (%)	Halite (%)
50	2109	0,00	0,00	0,00	11,67	0,00	0,00	6,23	17,51	0,78
52	2237	*	*	*	*	*	*	*	*	*
54	2372	*	*	*	*	*	*	*	*	*
56	2514	*	*	*	*	*	*	*	*	*
58	2664	4,24	1,36	0,00	9,66	0,23	0,00	3,05	38,14	0,34
60	2820	4,23	0,00	0,00	9,38	0,00	0,78	0,00	36,48	0,91
68	3507	2,65	0,00	0,00	7,64	0,00	0,00	6,69	40,87	1,70
70	3694	*	*	*	*	*	*	*	*	*
72	3885	0,00	1,56	0,00	8,35	0,20	0,00	15,82	18,31	2,49
74	4082	0,00	0,00	0,00	11,13	0,31	4,17	6,03	9,28	2,09
76	4283	*	*	*	*	*	*	*	*	*
78	4489	*	*	*	*	*	*	*	*	*
80	4699	0,00	1,04	0,00	7,53	0,52	0,00	7,01	51,91	0,91
82	4914	3,77	0,40	0,00	9,51	0,00	0,00	1,66	36,97	1,51
84	5132	0,90	0,00	0,00	8,69	0,24	1,27	6,88	18,10	1,99
86	5354	*	*	*	*	*	*	*	*	*
88	5579	*	*	*	*	*	*	*	*	*
90	5807	1,29	0,39	0,00	9,26	0,00	0,00	10,58	30,85	4,19
92	6038	1,32	0,71	0,00	9,12	0,00	1,32	4,50	19,83	1,32
94	6272	1,26	0,00	0,00	13,33	0,00	0,00	6,06	42,40	3,43
96	6508	*	*	*	*	*	*	*	*	*
98	6746	*	*	*	*	*	*	*	*	*
100	6987	*	*	*	*	*	*	*	*	*
102	7228	1,31	0,60	0,00	11,65	0,00	0,00	4,78	36,58	1,49
104	7471	3,67	0,00	0,00	8,81	0,00	0,00	4,41	38,55	2,75
106	7715	0,49	0,00	0,00	10,65	0,00	1,31	6,31	47,32	0,00

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy							
		Magn/Maghe (%)	Opal C/CT (%)	Plagioclase (%)	Pirite (%)	Quartz (%)	Siderite (%)	Zeólitos (%)	FDM/FCM index
0	611	*	*	*	*	*	*	*	*
2	639	0,00	9,00	26,44	1,07	38,38	0,00	0,00	0,33
4	668	0,00	5,46	7,28	1,52	20,70	0,45	0,00	1,65
6	696	1,72	6,72	6,40	1,44	29,74	0,00	0,00	1,22
8	726	*	*	*	*	*	*	*	*
10	757	*	*	*	*	*	*	*	*
12	790	*	*	*	*	*	*	*	*
14	824	*	*	*	*	*	*	*	*
16	860	*	*	*	*	*	*	*	*
18	899	*	*	*	*	*	*	*	*
20	941	*	*	*	*	*	*	*	*
22	986	0,00	6,95	4,42	3,16	22,73	0,00	0,00	0,89
24	1034	0,00	13,87	10,40	0,65	29,58	0,00	0,00	0,87
26	1086	*	*	*	*	*	*	*	*
28	1142	0,00	8,03	4,01	0,09	20,07	0,00	0,00	1,54
30	1202	*	*	*	*	*	*	*	*
32	1267	*	*	*	*	*	*	*	*
34	1337	*	*	*	*	*	*	*	*
36	1412	*	*	*	*	*	*	*	*
38	1492	*	*	*	*	*	*	*	*
40	1578	*	*	*	*	*	*	*	*
42	1671	*	*	*	*	*	*	*	*
44	1770	*	*	*	*	*	*	*	*
46	1876	0,00	1,75	5,24	0,29	43,69	0,00	0,00	0,66
48	1989	1,03	7,15	13,85	0,45	32,84	0,00	0,00	0,53

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy								
		Magn/Maghe (%)	Opal C/CT (%)	Plagioclase (%)	Pirite (%)	Quartz (%)	Siderite (%)	Zeólitos (%)	DM index	FDM/FCM index
50	2109	0,00	7,00	19,84	8,95	28,02	0,00	0,00	51,75	0,32
52	2237	*	*	*	*	*	*	*	*	*
54	2372	*	*	*	*	*	*	*	*	*
56	2514	*	*	*	*	*	*	*	*	*
58	2664	0,00	4,07	14,24	1,02	23,90	0,00	0,00	65,08	0,93
60	2820	0,00	5,73	17,59	0,65	24,23	0,00	0,00	60,72	0,87
68	3507	0,00	4,25	11,46	0,32	24,42	0,00	0,00	71,97	0,96
70	3694	*	*	*	*	*	*	*	*	*
72	3885	0,00	10,55	7,32	0,44	35,16	0,00	0,00	69,29	0,31
74	4082	2,14	11,13	9,28	0,23	44,52	0,00	0,00	59,83	0,16
76	4283	*	*	*	*	*	*	*	*	*
78	4489	*	*	*	*	*	*	*	*	*
80	4699	0,00	3,63	8,83	1,04	18,11	0,00	0,00	77,03	1,53
82	4914	0,00	4,23	12,98	0,30	28,67	0,00	0,00	67,30	0,85
84	5132	0,00	3,26	10,14	3,98	44,80	0,00	0,00	69,77	0,29
86	5354	*	*	*	*	*	*	*	*	*
88	5579	*	*	*	*	*	*	*	*	*
90	5807	0,00	1,76	11,17	0,59	28,21	1,18	0,55	69,64	0,62
92	6038	0,00	8,99	19,04	1,06	31,73	1,06	0,00	56,06	0,36
94	6272	0,00	3,23	0,40	0,81	29,08	0,00	0,00	77,54	1,19
96	6508	*	*	*	*	*	*	*	*	*
98	6746	*	*	*	*	*	*	*	*	*
100	6987	*	*	*	*	*	*	*	*	*
102	7228	0,00	5,97	14,78	1,79	21,05	0,00	0,00	62,41	0,90
104	7471	3,25	1,47	9,91	0,73	26,44	0,00	0,00	69,40	0,95
106	7715	0,00	6,31	1,58	1,05	24,71	0,26	0,00	78,34	1,45

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	<i>G. ruber</i> (p) isotopic composition		core 7606 alkenone based temperature (°C, Bicego, 2005)	$\delta^{18}\text{O}_{\text{w-lvc}}$ (‰, SMOW)
		$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{18}\text{O}$ (‰, VPDB)		
0	611	1,84	-1,28	*	*
2	639	1,94	-1,01	*	*
4	668	1,29	-0,81	*	*
6	696	1,83	-0,92	*	*
8	726	2,21	-0,95	*	*
10	757	1,91	-0,91	*	*
12	790	1,71	-1,14	*	*
14	824	*	*	*	*
16	860	2,05	-1,13	*	*
18	899	*	*	*	*
20	941	1,83	-0,63	23,75	0,87
22	986	1,88	-1,17	24,16	0,42
24	1034	1,14	-1,14	*	*
26	1086	*	*	*	*
28	1142	1,83	-1,57	24,33	0,05
30	1202	1,98	-1,09	23,97	0,46
32	1267	*	*	*	*
34	1337	1,94	-1,48	24,73	0,23
36	1412	1,82	-1,04	24,61	0,65
38	1492	1,88	-0,83	24,72	0,88
40	1578	1,53	-0,97	24,41	0,68
42	1671	1,59	-0,95	24,61	0,74
44	1770	1,70	-0,77	24,60	0,91
46	1876	1,53	-1,17	*	*
48	1989	1,51	-1,05	25,28	0,78

Cont. Appendix 1 -

Core depth (cm)	Estimated age (yr cal. BP)	<i>G. ruber</i> (p) isotopic composition		core 7606 alkenone based temperature (°C, Bicego, 2005)	$\delta^{18}\text{O}_{\text{w-ivc}}$ (‰, SMOW)
		$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{18}\text{O}$ (‰, VPDB)		
50	2109	1,24	-1,15	25,54	0,73
52	2237	1,68	-1,31	24,63	0,38
54	2372	1,79	-1,02	25,75	0,91
56	2514	1,48	-0,54	25,21	1,27
58	2664	1,75	-1,58	25,18	0,23
60	2820	1,75	-0,72	26,15	1,29
68	3507	2,03	-0,89	25,38	0,96
70	3694	1,70	-1,29	23,87	0,23
72	3885	1,83	-0,62	25,67	1,29
74	4082	1,62	-0,84	26,50	1,24
76	4283	*	*	*	*
78	4489	2,29	-0,92	25,35	0,92
80	4699	1,53	-0,97	25,23	0,84
82	4914	1,74	-0,89	26,85	1,26
84	5132	1,55	-0,53	26,76	1,60
86	5354	1,74	-0,59	26,76	1,54
88	5579	1,50	-0,97	26,22	1,05
90	5807	1,65	-0,83	27,03	1,36
92	6038	1,57	-0,91	26,65	1,20
94	6272	1,82	-0,92	26,10	1,06
96	6508	1,95	-1,13	25,63	0,74
98	6746	1,82	-0,90	25,73	0,99
100	6987	1,54	-1,14	25,92	0,78
102	7228	1,58	-1,25	25,30	0,52
104	7471	1,40	-0,77	25,76	1,09
106	7715	1,53	-1,05	24,88	0,61

Appendix 2 - Core 7605 benthic foraminifera community data, identified taxa microhabitat classification and relative frequency (%), and values of total density (tests·10cc⁻¹), percentages of fragments, non-identified specimens, epifauna and infauna specimens, productivity indexes BFHP (%) and BFAR (tests·cm⁻²·kyr⁻¹) and ecological parameters richness (S), Shannon diversity (H') and equitability (J'). Where: epifauna (E) and infauna (I).

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			611	824	941
			Benthic foraminifera (%)		
<i>Ammonia beccarii</i> (Linné, 1758)	I	Murray, 1991 - genera Ammonia	0,75	0,00	0,00
<i>Ammonia</i> spp.	I	Murray, 1991	0,00	0,00	0,00
<i>Amphicoryna scalaris</i> (Batsch, 1791)	I	Fontanier et al., 2003 - genera Amphicoryna	0,00	0,00	0,00
<i>Amphicoryna</i> spp.	I	Fontanier et al., 2003	0,00	0,00	0,00
<i>Angulogerina angulosa</i> (Williamson, 1858)	I	Corliss, 1985; Corliss e Chen, 1988	25,53	20,03	23,36
<i>Angulogerina</i> spp.	I	Corliss, 1985; Corliss e Chen, 1989	0,75	1,59	0,82
<i>Bolivina albatrossi</i> Cushman, 1922	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina doniezi</i> Cushman & Wickenden, 1929	I	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Bolivina pseudoplicata</i> Heron-Allen & Earland, 1930	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina pulchella</i> (d'Orbigny, 1839)	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina pulchella f. primitiva</i> Cushman, 1930	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,23	0,00
<i>Bolivina seminuda</i> Cushman, 1911	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina skagerrakensis</i> Qvale & Nigam, 1985	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina subspinosus</i> Cushman, 1922	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,61
<i>Bolivina translucens</i> Phleger & Parker, 1951	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina</i> sp.1	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina</i> spp.	I	Corliss, 1985; Murray, 1991	0,25	0,00	0,20
<i>Brizalina ordinaria</i> (Phleger & Parker, 1952)	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	0,00	0,00	0,41
<i>Brizalina spathulata</i> (Williamson, 1858)	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	0,00	0,00	0,00
<i>Brizalina subaenariensis</i> (Cushman, 1922)	I	Corliss, 1985; Corliss e Chen, 1988	1,25	1,59	1,64
<i>Brizalina</i> sp.1	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	0,25	0,00	0,00
<i>Brizalina</i> sp.2	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	0,00	0,00	0,00
<i>Brizalina</i> spp.	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	0,25	1,59	0,41
<i>Buccella peruviana</i> (d'Orbigny, 1839)	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	0,00	0,00	0,00
<i>Buccella</i> spp.	I	Murray, 1991 - genera Buccella	0,00	0,23	0,00
<i>Bulimina aculeata</i> d'Orbigny, 1826	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	2,00	0,23	0,41
<i>Bulimina elongata</i> d'Orbigny, 1846	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	0,00	0,23	0,00
<i>Bulimina gibba</i> Fornasini, 1900	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	1,00	0,00	0,00
<i>Bulimina marginata</i> d'Orbigny, 1826	I	Murray, 1991; Corliss e Chen, 1988; Fontanier et al., 2002 - genera Bulimina	3,75	6,83	9,84
<i>Bulimina mexicana</i> Cushman, 1922	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	0,00	0,00	0,00
<i>Bulimina pseudoaffinis</i> Kleinpell, 1938	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	0,00	0,23	0,82
<i>Bulimina subulata</i> Cushman & Parker, 1947	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	0,00	0,00	0,00

Cont. Appendix 2 -

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			611	824	941
			Benthic foraminifera (%)		
<i>Bulimina</i> spp.	I	Murray, 1991; Fontanier et al., 2002	2,50	2,05	2,05
<i>Buliminella elegantissima</i> (d' Orbigny 1839)	I	Murray, 1991 - genera Buliminella	2,75	0,68	0,00
<i>Cancris auriculus</i> (Fichtel & Moll, 1798)	E	Murray, 1991; Fontanier et al., 2002 - genera Cancris	0,00	0,00	0,00
<i>Cancris</i> sp.1	E	Murray, 1991; Fontanier et al., 2002 - genera Cancris	0,00	0,00	0,20
<i>Cancris</i> sp.2	E	Murray, 1991; Fontanier et al., 2002 - genera Cancris	0,00	0,00	0,00
<i>Cancris</i> spp.	E	Murray, 1991	0,00	0,46	0,00
<i>Cassidulina carinata</i> (Silvestri, 1896)	I	Murray, 1991 - genera Cassidulina	0,00	0,68	0,00
<i>Cassidulina laevigata</i> d'Orbigny, 1826	I	Murray, 1991 - genera Cassidulina	0,00	0,00	0,00
<i>Cassidulina</i> spp.	I	Murray, 1991 - genera Cassidulina	0,00	1,14	0,00
<i>Cibicides ungerianus</i> (d' Orbigny, 1846)	E	Murray, 1991 - genera Cibicides	0,50	0,68	0,00
<i>Cibicides</i> spp.	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991	0,25	0,23	0,00
<i>Cibicoides mundulus</i> (Brady, Parker & Jones, 1888)	E	Murray, 1991 - genera Cibicoides	0,00	0,00	0,00
<i>Cibicoides pachyderma</i> (Rzehak, 1886)	E	Murray, 1991 - genera Cibicoides	0,00	0,00	0,00
<i>Cibicoides wuellerstorfi</i> (Schwager, 1866)	E	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Cibicoides</i> spp.	E	Murray, 1991	0,00	0,00	0,00
<i>Clavulina humilis</i> Brady, 1884			0,00	0,23	0,00
<i>Clavulina multicamerata</i> Chapman, 1907			0,00	0,00	0,00
<i>Clavulina</i> spp.			0,00	0,00	0,00
<i>Dentalina ariana</i> Patterson & Pettis, 1986	I	Corliss e Chen, 1988 - genera Dentalina	0,00	0,00	0,00
<i>Dentalina bradyensis</i> (Dervieux, 1894)	I	Corliss e Chen, 1988 - genera Dentalina	0,00	0,00	0,00
<i>Dentalina</i> spp.	I	Corliss e Chen, 1988	0,00	0,00	0,00
<i>Deuteramina</i> spp.			0,00	0,00	0,00
<i>Discorbinella bertheloti</i> (d' Orbigny, 1839)			0,00	0,00	0,00
<i>Discorbinella</i> spp.			0,00	0,00	0,00
<i>Discorbis williamsoni</i> Chapman & Parr, 1932	E	Murray, 1991 - genera Discorbis	0,00	0,00	0,00
<i>Discorbis</i> spp.	E	Murray, 1991 - genera Discorbis	1,00	0,00	0,00
<i>Dorothia goessi</i> (Cushman, 1911)			0,00	0,00	0,00
<i>Dorothia</i> sp.			0,00	0,00	0,00
<i>Edentostomia</i> sp. nov. Brady, 1884			0,00	0,00	0,00
<i>Elphidium excavatum</i> Terquem, 1875	E	Murray, 1991 - genera Elphidium	0,00	0,00	0,20
<i>Elphidium</i> spp. (not identified broken specimens)	E	Murray, 1991 - genera Epistominella	0,00	0,00	0,00
<i>Epistominella</i> spp.	E	Wollenburg and Mackensen, 2009	0,50	0,91	0,00
<i>Evolvocassidulina orientalis</i> (Cushman, 1922)			0,00	0,00	0,00
<i>Fissurina laevigata</i> Reuss, 1850	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,20
<i>Fissurina lucida</i> (Williamson, 1884)	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Fissurina marginata</i> (Montagu, 1803)	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Fissurina quadricostulata</i> Silvestri, 1902	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00

Cont. Appendix 2 -

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			611	824	941
			Benthic foraminifera (%)		
<i>Fissurina staphyllearia</i> Schwager, 1866	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Fissurina</i> sp. 1	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Fissurina</i> sp. 2	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Fissurina</i> sp. 3	I	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Fissurina</i> spp.	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Favulina hexagona</i> (Williamson, 1848)	I	Corliss e Chen, 1988 - genera Flavulina	0,00	0,00	0,00
<i>Favulina melo</i> (d' Orbigny, 1839)	I	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Fursenkoina complanata</i> (Egger, 1893)	I	Murray, 1991 - genera Fursenkoina	0,00	0,23	0,00
<i>Fursenkoina</i> spp.	I	Murray, 1991 - genera Fursenkoina	0,00	0,23	0,00
<i>Gavelinopsis praegeri</i> (Heron-Allen & Earland, 1913)	E	Murray, 1991 - genera Gavelinopsis	1,00	0,23	0,00
<i>Gavelinopsis umbonifer</i> (Parr, 1950)	E	Murray, 1991 - genera Gavelinopsis	0,00	0,00	0,00
<i>Gavelinopsis</i> spp.	E	Corliss, 1985; Corliss e Chen, 1988	0,50	0,68	0,00
<i>Glabrata milleti</i> (Wright, 1911)	E	Murray, 1991 - genera Glabrata	0,00	0,23	0,00
<i>Globocassidulina minuta</i> (Cushman, 1933)	I	Murray, 1991 - genera Globocassidulina	0,00	0,00	0,00
<i>Globocassidulina subglobosa</i> (Brady, 1881)	I	Murray, 1991 - genera Globocassidulina; Fontanier <i>et al.</i> , 2002	27,53	21,40	18,03
<i>Globocassidulina</i> spp.	I	Murray, 1991	7,26	4,32	2,87
<i>Gyroidina altiformis</i> R.E. & K.C. Stewart, 1930	E	Fontanier <i>et al.</i> , 2002	0,00	0,00	0,00
<i>Gyroidina umbonata</i> (Silvestri, 1898)	E	Murray, 1991; Corliss e Chen, 1988 - genera Gyroidina; Fontanier <i>et al.</i> , 2008	3,00	5,46	6,76
<i>Gyroidina</i> spp.	E	Fontanier <i>et al.</i> , 2003	1,25	0,46	1,02
<i>Hoeglundina elegans</i> (d' Orbigny, 1826)	E	Corliss, 1985; Fontanier <i>et al.</i> , 2002	0,00	0,00	0,41
<i>Islandiella norcrossi</i> (Cushman, 1933)	I	Murray, 1991 - genera Islandiella; Corliss e Chen, 1988	0,00	1,59	0,82
<i>Islandiella</i> spp.	I	Murray, 1991	1,50	0,00	0,82
<i>Lagena clavata</i> (d'Orbigny, 1846)	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena hispidula</i> Cushman, 1913	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena laevis</i> (Montagu, 1803)	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena laevis</i> , f. tenuis Williamson, 1848	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena laevis</i> , f. typica Williamson, 1848	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena striata</i> (d'Orbigny, 1839)	I	Corliss e Chen, 1988 - genera Lagena	0,25	0,23	0,00
<i>Lagena</i> spp.	I	Corliss e Chen, 1988	0,00	0,00	0,00
<i>Lenticulina thalmani</i> (Hessland, 1943)	E	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Lenticulina</i> sp.1	E	Murray, 1991; Fontanier <i>et al.</i> , 2002; 2003 - genera Lenticulina	0,00	0,00	0,00
<i>Lenticulina</i> sp.3	E	Murray, 1991; Fontanier <i>et al.</i> , 2002; 2003 - genera Lenticulina	0,00	0,00	0,00
<i>Lenticulina</i> sp.4	E	Murray, 1991; Fontanier <i>et al.</i> , 2002; 2003 - genera Lenticulina	0,00	0,00	0,00
<i>Lenticulina</i> sp.5	E	Murray, 1991; Fontanier <i>et al.</i> , 2002; 2003 - genera Lenticulina	0,00	0,00	0,00

Cont. Appendix 2 -

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			611	824	941
			Benthic foraminifera (%)		
<i>Lenticulina</i> sp.6	E	Murray, 1991; Fontanier et al., 2002; 2003 - genera Lenticulina	0,00	0,00	0,00
<i>Lenticulina</i> spp.	E	Murray, 1991	0,00	0,00	0,20
<i>Liesbusella</i> sp.			0,00	0,00	0,00
<i>Lobatula lobatula</i> (Walker & Jacob, 1798)	E	Wollenburg and Mackensen, 2009	0,00	0,00	0,20
<i>Melonis barleeanus</i> (Williamson, 1858)	I	Murray, 1992; Corliss and Chen, 1988 - genera Melonis	0,00	0,00	0,00
<i>Melonis</i> spp.	I	Murray, 1992; Corliss and Chen, 1989	0,00	0,00	0,00
<i>Miliolinella subrotunda</i> (Montagu, 1803)	E	Corliss, 1991 - Miliolideos	0,00	0,00	0,00
<i>Neolenticulina variabilis</i> (Reuss, 1850)	E	Corliss, 1985; Corliss e Chen, 1988 - genera Neolenticulina	0,00	0,00	0,00
<i>Nonion</i> sp.1	I	Murray, 1991; Fontanier et al., 2002 - genera Nonion	0,00	0,00	0,00
<i>Nonion</i> sp.	I	Murray, 1991; Fontanier et al., 2002	0,00	0,00	0,20
<i>Nonionella turgida</i> (Williamson, 1858)	I	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Nonionella</i> spp.	I	Murray, 1991	0,25	0,00	0,00
<i>Nonionoides grateloupi</i> (d'Orbigny, 1826)	I	Murray, 1991 - genera Nonionoides	0,00	0,23	0,00
<i>Nonionoides</i> sp.1	I	Murray, 1991 - genera Nonionoides	0,00	0,00	0,00
<i>Nonionoides</i> spp.	I	Murray, 1991	0,00	0,00	0,00
<i>Oolina alcocki</i> (White, 1956)			0,00	0,00	0,00
<i>Oolina borealis</i> Loeblich & Tappan, 1954			0,00	0,00	0,00
<i>Oridorsalis</i> spp.	E	Murray, 1991	0,00	0,00	0,00
<i>Oridorsalis umbonatus</i> (Reuss, 1851)	E	Murray, 1991 - genera Oridorsalis	0,00	0,00	0,00
<i>Osanguriella umbonifera</i> (Cushman, 1933)			0,00	0,00	0,00
<i>Paracassidulina nipponensis</i> (Eade, 1969)	I	Corliss, 1985; Corliss e Chen, 1988 - genera Paracassidulina	0,25	0,00	0,00
<i>Planulina umbilicata</i>	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991 - genera Planulina	0,00	0,00	0,00
<i>Planulina</i> spp.	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991 - genera Planulina	0,00	0,00	0,00
<i>Polymorphinella</i> sp.			0,00	0,00	0,00
<i>Procerolagena gracilis</i> (Williamson, 1848)	E	Corliss, 1985; Corliss e Chen, 1988	0,00	0,23	0,00
<i>Procerolagena setigera</i> Millett, 1901			0,00	0,00	0,00
<i>Pseudogaudryna</i> sp. nov. Baker, 1960			0,00	0,23	0,20
<i>Pseudononion atlanticum</i> (Cushman, 1936)			0,00	0,23	0,20
<i>Pullenia quadriloba</i>	I	Corliss, 1985; Corliss e Chen, 1988 - genera Pseudononion	0,75	0,00	0,41
<i>Pullenia bulloides</i> (d'Orbigny, 1846)	I	Murray, 1991 - genera Pullenia	0,00	0,00	0,00
<i>Pullenia osloensis</i> Feyling-Hanssen, 1954	I	Murray, 1991 - genera Pullenia	0,00	0,00	0,00
<i>Pullenia quinqueloba</i> (Reuss, 1851)	I	Murray, 1991 - genera Pullenia	0,00	0,00	0,00
<i>Pyrgo depressa</i> (d'Orbigny, 1826)	E	Corliss, 1991 - Miliolideos; Murray, 1991 - genera Pyrgo	0,00	0,00	0,00
<i>Pyrgo elongata</i> (d'Orbigny, 1826)	E	Corliss, 1991 - Miliolideos; Murray, 1991 - genera Pyrgo	0,00	0,23	0,00
<i>Pyrgo murrhina</i> (Schwager, 1866)	E	Corliss, 1991 - Miliolideos; Murray, 1991 - genera Pyrgo	0,00	0,00	0,00
<i>Pyrgo nasuta</i> Cushman, 1935	E	Corliss, 1991 - Miliolideos; Murray, 1991 - genera Pyrgo	0,00	0,00	0,00
<i>Pyrgo oblonga</i> (d'Orbigny, 1839)	E	Corliss, 1991 - Miliolideos; Murray, 1991 - genera Pyrgo	0,00	0,00	0,00

Cont. Appendix 2 -

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			611	824	941
			Benthic foraminifera (%)		
<i>Pyrgo ringens</i> (Lamarck, 1804)	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,00	0,23	0,00
<i>Pyrgo</i> sp.1	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,25	0,00	0,00
<i>Pyrgo</i> sp.2	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,00	0,00	0,00
<i>Pyrgo</i> sp.3	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,00	0,00	0,00
<i>Pyrgo</i> sp.4	E	Corliss, 1991 - Miliolideos ; Murray, 1991	0,00	0,00	0,00
<i>Pyrgo</i> spp.	E	Corliss, 1991 - Miliolideos	0,00	0,00	0,00
<i>Quinqueloculina akneriana</i> d' Orbigny, 1846	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,00	0,00	0,00
<i>Quinqueloculina amygdaloides</i> (Brady, 1884)	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,00	0,00	0,00
<i>Quinqueloculina atlantica</i> Boltovskoy, 1957	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,00	0,00	0,00
<i>Quinqueloculina intricata</i> (Terquem, 1878)	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,00	0,00	0,00
<i>Quinqueloculina lamarckiana</i> d' Orbigny, 1839	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,25	0,00	0,61
<i>Quinqueloculina milletti</i> (Wiesner, 1923)	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,00	0,00	0,00
<i>Quinqueloculina</i> spp.	E	Corliss, 1991 - Miliolideos ; Murray, 1991	0,00	0,23	0,61
<i>Rosalina globularis</i> (d' Orbigny, 1826)	E	Murray, 1991 - genera Rosalina	0,00	0,00	0,00
<i>Rosalina</i> sp.1	E	Murray, 1991 - genera Rosalina	0,00	0,00	0,00
<i>Rosalina</i> sp.2.	E	Murray, 1991 - genera Rosalina	0,00	0,00	0,00
<i>Rosalina</i> spp.	E	Murray, 1991	0,00	0,00	0,00
<i>Saracenaria</i> sp.	E	Heinz et al., 2004	0,00	0,00	0,20
<i>Seabrookia earlandi</i> Wright, 1891	E		0,00	0,00	0,00
<i>Sigmoilopsis schlumbergeri</i> (Silvestri, 1904)	E	Di Stefano et al., 2010; Pipper and Reichenbacher, 2010 - genera Sigmoilopsis	0,50	0,00	0,00
<i>Siphonaperta</i> sp.1			0,00	0,23	0,00
<i>Siphonaperta</i> sp.2			0,00	0,00	0,00
<i>Siphonina bradyana</i> Cushman, 1927			0,00	0,00	0,00
<i>Siphonina</i> sp.1.			0,00	0,00	0,00
<i>Spiroglutina</i> spp.	E	Corliss, 1985; Corliss e Chen, 1988; Corliss, 1991	0,00	0,00	0,00
<i>Spiroloculina</i> sp.1	E	Corliss, 1985; Corliss e Chen, 1988; Corliss, 1991	0,00	0,00	0,00
<i>Spiroloculina</i> sp.2	E	Corliss, 1985; Corliss e Chen, 1988; Corliss, 1992	0,00	0,00	0,00
<i>Spiroplectinella wrightii</i> (Silvestri, 1903)	I		0,00	0,00	0,00
<i>Stainforthia complanata</i> (Egger, 1895)	I	Bubenshchikova et al., 2008	0,00	0,00	0,00
<i>Stainforthia</i> spp.	E	Bubenshchikova et al., 2008	0,00	0,00	0,00
<i>Textullaria</i> sp.1	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991	0,00	0,00	0,00
<i>Textullaria</i> sp.2	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991	0,00	0,00	0,00
<i>Textullaria</i> sp.3	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991	0,00	0,00	0,00
<i>Textullaria</i> sp.4	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991	0,00	0,00	0,00

Cont. Appendix 2 -

	Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
				611	824	941
				Benthic foraminifera (%)		
<i>Textullaria</i> spp.		E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991	0,00	0,00	0,00
<i>Trifarina angulosa</i> (Williamson, 1858)		I	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991 - genera Trifarina	0,00	0,00	0,00
<i>Trifarina bradyi</i> Cushman, 1923		I	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991 - genera Trifarina	0,00	0,00	0,00
<i>Triloculina</i> sp.2		E	Corliss, 1991 - Miliolideos	0,00	0,00	0,00
<i>Triloculina</i> spp.		E	Corliss, 1991 - Miliolideos	0,00	0,68	0,00
<i>Triloculinella</i> spp.		E	Corliss, 1991 - Miliolideos	0,00	0,00	0,00
<i>Uvigerina auberiana</i> d'Orbigny, 1839		I	Murray, 1991; Fontanier et al., 2002 - genera Uvigerina	0,00	0,00	0,00
<i>Uvigerina peregrina</i> Cushman, 1923		I	Murray, 1991; Corliss e Chen, 1988 - genera Uvigerina	0,00	0,23	0,00
<i>Uvigerina</i> spp.		I	Murray, 1991 Fontanier et al., 2002 - genera Uvigerina	0,00	0,00	0,20
<i>Valvulineria bradyana</i> (Fornasini, 1900)		I	Fontanier <i>et al.</i> , 2002	0,00	0,00	0,00
total density (tests•10 cc ⁻¹)				14784	8160	8060
fragments (%)				9,38	14,12	8,68
not identified (%)				0,00	5,00	0,74
E (%)				7,76	10,47	8,81
I (%)				80,09	66,24	65,57
BFHP index (%)				14,27	14,34	16,60
BFAR index (tests•cm ⁻² •kyr ⁻¹)				1060717	447178	359760
R				29	37	29
H'				2,19	2,36	2,16
J'				0,65	0,65	0,64

Cont. Appendix 2 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)														
	1034	1142	1202	1337	1492	1671	1876	2109	2372	2514	2664	3507	3694	4082	4283
	Benthic foraminifera (%)														
<i>Ammonia beccarii</i> (Linné, 1758)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Ammonia</i> spp.	0,00	0,00	0,00	0,00	0,00	0,22	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Amphicoryna scalaris</i> (Batsch, 1791)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,35	0,00	0,00	0,00	0,00	0,00	0,13	0,00
<i>Amphicoryna</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,17	0,00	0,00
<i>Angulogerina angulosa</i> (Williamson, 1858)	13,76	19,03	18,19	33,68	32,07	12,15	21,16	20,15	17,95	25,35	10,62	21,82	2,42	19,18	17,70
<i>Angulogerina</i> spp.	5,22	3,12	2,87	4,33	3,36	7,95	7,12	2,48	2,28	0,00	1,89	0,00	22,00	1,78	1,96
<i>Bolivina albatrossi</i> Cushman, 1922	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina doniezi</i> Cushman & Wickenden, 1929	0,24	0,00	0,00	0,00	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13	0,00
<i>Bolivina pseudoplicata</i> Heron-Allen & Earland, 1930	0,00	0,00	0,00	0,00	0,00	0,00	0,41	0,00	0,00	0,00	0,24	0,00	0,17	0,00	0,10
<i>Bolivina pulchella</i> (d'Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina pulchella f. primitiva</i> Cushman, 1930	0,00	0,00	0,64	0,00	0,19	0,00	0,00	0,27	0,25	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina seminuda</i> Cushman, 1911	0,00	0,00	0,00	0,00	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina skagerrakensis</i> Qvale & Nigam, 1985	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina subspinensis</i> Cushman, 1922	0,24	0,00	0,00	0,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,35	0,13	0,00
<i>Bolivina translucens</i> Phleger & Parker, 1951	0,00	0,00	0,00	0,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina</i> sp.1	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina</i> spp.	0,00	0,16	0,00	0,00	0,00	0,00	0,20	0,00	0,25	0,00	0,71	0,00	0,17	0,00	0,00
<i>Brizalina ordinaria</i> (Phleger & Parker, 1952)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Brizalina spathulata</i> (Williamson, 1858)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,54	0,00	0,00	0,00	0,13	0,00
<i>Brizalina subbaenariensis</i> (Cushman, 1922)	1,66	0,33	0,96	0,33	2,42	0,44	0,61	0,88	1,26	2,16	0,00	1,79	1,39	0,38	0,39
<i>Brizalina</i> sp.1	0,95	0,00	0,32	0,67	0,00	0,44	0,00	0,00	0,00	0,00	0,24	0,18	0,17	0,00	0,10
<i>Brizalina</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Brizalina</i> spp.	0,71	0,16	0,96	0,67	0,00	2,65	0,20	0,35	1,52	0,54	0,71	0,54	0,69	0,13	0,39
<i>Buccella peruviana</i> (d'Orbigny, 1839)	0,00	0,49	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,20
<i>Buccella</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina aculeata</i> d'Orbigny, 1826	0,95	0,33	0,32	0,33	0,37	0,00	0,00	0,09	0,00	0,00	0,00	0,18	0,00	0,00	0,10
<i>Bulimina elongata</i> d'Orbigny, 1846	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina gibba</i> Fornasini, 1900	0,47	0,00	0,00	0,00	0,00	0,66	0,00	0,18	0,00	0,27	0,00	0,00	0,00	0,00	0,00
<i>Bulimina marginata</i> d'Orbigny, 1826	5,46	5,90	2,55	2,67	7,09	3,53	4,68	2,83	6,83	7,82	2,83	13,77	5,89	5,97	8,80
<i>Bulimina mexicana</i> Cushman, 1922	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina pseudocaffinis</i> Kleinpell, 1938	0,00	0,49	0,32	1,00	0,00	0,66	0,61	0,00	0,00	0,00	0,00	0,00	0,17	0,00	0,00
<i>Bulimina subulata</i> Cushman & Parker, 1947	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Cont. Appendix 2 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)														
	1034	1142	1202	1337	1492	1671	1876	2109	2372	2514	2664	3507	3694	4082	4283
	Benthic foraminifera (%)														
<i>Bulimina</i> spp.	0,71	1,31	0,96	1,00	0,93	1,10	1,63	1,06	0,76	0,00	0,00	1,79	0,87	0,64	1,76
<i>Buliminella elegantissima</i> (d' Orbigny 1839)	3,32	4,10	1,91	5,00	0,75	1,32	2,03	1,77	0,51	0,81	0,71	0,00	0,87	0,51	0,39
<i>Cancris auriculus</i> (Fichtel & Moll, 1798)	0,00	0,00	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cancris</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cancris</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cancris</i> spp.	0,00	0,00	0,00	0,00	0,75	0,00	0,00	0,18	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cassidulina carinata</i> (Silvestri, 1896)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cassidulina laevigata</i> d'Orbigny, 1826	0,00	0,00	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cassidulina</i> spp.	0,24	0,16	0,00	0,00	0,37	0,00	0,41	0,71	1,01	0,54	0,00	1,25	0,00	0,25	0,49
<i>Cibicides ungerianus</i> (d' Orbigny, 1846)	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cibicides</i> spp.	0,00	0,00	0,00	0,00	0,19	0,00	0,00	0,18	0,51	0,27	0,00	0,36	0,17	0,00	0,49
<i>Cibicoides mundulus</i> (Brady, Parker & Jones, 1888)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cibicoides pachyderma</i> (Rzehak, 1886)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,27	0,00	0,00	0,00	0,25	0,00
<i>Cibicoides wuellerstorfi</i> (Schwager, 1866)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Cibicoides</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Clavulina humilis</i> Brady, 1884	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Clavulina multicamerata</i> Chapman, 1907	0,00	0,00	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Clavulina</i> spp.	0,00	0,00	0,00	0,00	0,19	0,00	0,41	0,09	0,00	0,00	0,24	0,00	0,00	0,00	0,20
<i>Dentalina ariena</i> Patterson & Pettis, 1986	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Dentalina bradyensis</i> (Dervieux, 1894)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Dentalina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,10
<i>Deuteramina</i> spp.	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Discorbinella bertheloti</i> (d' Orbigny, 1839)	0,00	0,00	0,00	0,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Discorbinella</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,00
<i>Discorbis williamsoni</i> Chapman & Parr, 1932	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Discorbis</i> spp.	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20
<i>Dorothia goessi</i> (Cushman, 1911)	0,00	0,00	0,00	0,00	0,00	0,66	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,00
<i>Dorothia</i> sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Edentostomia</i> sp. nov. Brady, 1884	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Elphidium excavatum</i> Terquem, 1875	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Elphidium</i> spp. (not identified broken specimens)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Epistominella</i> spp.	0,00	1,97	3,83	4,67	0,00	2,87	2,44	1,24	1,52	0,81	5,43	0,00	1,04	2,79	2,35
<i>Evolvocassidulina orientalis</i> (Cushman, 1922)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Fissurina laevigata</i> Reuss, 1850	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Fissurina lucida</i> (Williamson, 1884)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Fissurina marginata</i> (Montagu, 1803)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,17	0,00	0,00
<i>Fissurina quadricostulata</i> Silvestri, 1902	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,51	0,00	0,00	0,00	0,35	0,00	0,00

Cont. Appendix 2 -

	Estimated age (yr cal. BP)														
	Benthic foraminifera taxa														
	1034	1142	1202	1337	1492	1671	1876	2109	2372	2514	2664	3507	3694	4082	4283
	Benthic foraminifera (%)														
<i>Fissurina staphyllearia</i> Schwager, 1866	0,24	0,00	0,00	0,00	0,19	0,00	0,20	0,00	0,00	0,00	0,00	0,00	0,17	0,00	0,00
<i>Fissurina</i> sp. 1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13	0,00
<i>Fissurina</i> sp. 2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Fissurina</i> sp. 3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Fissurina</i> spp.	0,00	0,00	0,32	0,00	0,00	0,00	0,00	0,00	0,25	0,00	0,00	0,18	0,00	0,00	0,20
<i>Favulina hexagona</i> (Williamson, 1848)	0,24	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,10
<i>Favulina melo</i> (d' Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Fursenkoina complanata</i> (Egger, 1893)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Fursenkoina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,27	0,00	0,00	0,00	0,00	0,00
<i>Gavelinopsis praegeri</i> (Heron-Allen & Earland, 1913)	0,00	0,16	0,00	0,00	1,31	0,00	0,41	0,09	0,00	0,27	0,00	0,00	0,69	0,00	0,39
<i>Gavelinopsis umbonifer</i> (Parr, 1950)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Gavelinopsis</i> spp.	0,95	0,00	0,32	0,00	0,00	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Glabratella milletti</i> (Wright, 1911)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Globocassidulina minuta</i> (Cushman, 1933)	0,00	0,00	0,00	0,00	0,19	0,00	0,00	0,18	0,00	0,00	0,00	0,00	0,00	0,25	0,00
<i>Globocassidulina subglobosa</i> (Brady, 1881)	28,94	30,34	38,30	22,67	13,43	37,32	35,40	41,55	29,33	17,53	35,17	9,48	21,82	28,58	32,67
<i>Globocassidulina</i> spp.	6,40	7,05	7,66	4,33	2,61	4,42	5,70	6,36	2,78	5,39	11,33	1,25	2,94	5,59	3,33
<i>Gyroidina altiformis</i> R.E. & K.C. Stewart, 1930	0,00	0,00	0,00	0,00	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Gyroidina umbonata</i> (Silvestri, 1898)	3,08	8,04	2,87	5,00	4,66	3,75	3,66	3,27	7,08	2,97	3,54	6,26	8,83	1,65	5,48
<i>Gyroidina</i> spp.	1,90	1,15	3,83	3,00	1,49	0,88	2,03	0,44	0,00	1,08	1,65	1,07	0,35	1,14	1,17
<i>Hoeglundina elegans</i> (d' Orbigny, 1826)	0,24	0,00	0,00	0,33	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,10
<i>Islandiella norcrossi</i> (Cushman, 1933)	0,00	1,31	0,64	0,33	1,49	1,10	1,22	1,68	2,28	3,24	0,94	4,65	2,77	4,06	2,05
<i>Islandiella</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena clavata</i> (d'Orbigny, 1846)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena hispidula</i> Cushman, 1913	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena laevis</i> (Montagu, 1803)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena laevis</i> , f. tenuis Williamson, 1848	0,00	0,00	0,00	0,00	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13	0,00
<i>Lagena laevis</i> , f. typica Williamson, 1848	0,00	0,00	0,00	0,00	0,00	0,22	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena striata</i> (d'Orbigny, 1839)	0,00	0,00	0,00	0,00	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,20
<i>Lagena</i> spp.	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,18	0,00	0,00	0,10
<i>Lenticulina thalmani</i> (Hessland, 1943)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.3	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.5	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,17	0,00	0,00

Cont. Appendix 2 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)														
	1034	1142	1202	1337	1492	1671	1876	2109	2372	2514	2664	3507	3694	4082	4283
	Benthic foraminifera (%)														
<i>Pyrgo ringens</i> (Lamarck, 1804)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,10
<i>Pyrgo</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Pyrgo</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,25	0,00	0,00	0,00	0,00	0,00	0,00
<i>Pyrgo</i> sp.3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,10
<i>Pyrgo</i> sp.4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Pyrgo</i> spp.	0,00	0,00	0,00	0,00	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Quinqueloculina akneriana</i> d' Orbigny, 1846	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Quinqueloculina amygdaloides</i> (Brady, 1884)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Quinqueloculina atlantica</i> Boltovskoy, 1957	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Quinqueloculina intricata</i> (Terquem, 1878)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Quinqueloculina lamarckiana</i> d'Orbigny, 1839	0,00	0,16	0,00	0,00	0,19	0,22	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,20
<i>Quinqueloculina milleti</i> (Wiesner, 1923)	0,00	0,00	0,00	0,33	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Quinqueloculina</i> spp.	0,00	0,00	0,64	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Rosalina globularis</i> (d' Orbigny, 1826)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Rosalina</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,00
<i>Rosalina</i> sp2.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Rosalina</i> spp.	0,00	0,16	0,32	0,00	0,00	0,22	0,00	0,00	0,00	0,00	0,47	1,07	0,00	0,00	0,29
<i>Saracenaria</i> sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Seabrookia earlandi</i> Wright, 1891	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,35	0,13	0,20
<i>Sigmoilopsis schlumbergeri</i> (Silvestri, 1904)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,10
<i>Siphonaperta</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Siphonaperta</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Siphonina bradyana</i> Cushman, 1927	0,00	0,16	0,00	0,33	0,00	0,00	0,00	0,00	0,25	0,00	0,24	0,72	0,00	0,25	0,20
<i>Siphonina</i> sp1.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Spiroglutina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Spiroloculina</i> sp.1	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Spiroloculina</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Spiroplectinella wrightii</i> (Silvestri, 1903)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Stainforthia complanata</i> (Egger, 1895)	0,00	0,16	0,64	0,00	0,00	0,44	0,20	0,00	0,00	0,00	0,24	0,00	0,00	0,00	0,29
<i>Stainforthia</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Textullaria</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Textullaria</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Textullaria</i> sp.3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Textullaria</i> sp.4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Cont. Appendix 2 -

	Benthic foraminifera taxa												Estimated age (yr cal. BP)					
	1034	1142	1202	1337	1492	1671	1876	2109	2372	2514	2664	3507	3694	4082	4283			
	Benthic foraminifera (%)																	
<i>Textullaria</i> spp.	0,00	0,00	0,00	0,33	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	0,00	0,00			
<i>Trifarina angulosa</i> (Williamson, 1858)	1,42	0,00	0,00	0,00	2,61	0,00	0,00	0,53	0,00	0,00	0,00	0,00	0,00	0,00	0,38			
<i>Trifarina bradyi</i> Cushman, 1923	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00			
<i>Triloculina</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00			
<i>Triloculina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00			
<i>Triloculinella</i> spp.	0,00	0,00	0,32	0,00	0,00	0,00	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00			
<i>Uvigerina auberiana</i> d' Orbigny, 1839	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00			
<i>Uvigerina peregrina</i> Cushman, 1923	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00			
<i>Uvigerina</i> spp.	0,00	0,00	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00			
<i>Valvulineria bradyana</i> (Fornasini, 1900)	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,27	0,00	0,27	0,00	0,00	0,00	0,00	0,00			
total density (tests•10 cc ⁻¹)	5392	19476	25920	21883	6816	21504	25648	30300	13146	11256	13200	9432	22148	15175	30275			
fragments (%)	5,93	4,62	2,43	1,44	3,99	8,33	0,00	5,05	5,75	16,04	4,55	3,31	4,65	2,47	3,24			
not identified (%)	0,00	2,22	1,74	0,72	0,00	1,82	0,00	0,00	2,56	0,00	3,64	1,78	6,42	0,33	0,81			
E (%)	4,98	10,99	8,94	10,34	7,46	7,51	7,73	6,10	9,61	5,39	9,44	8,58	11,95	5,46	10,37			
I (%)	74,71	76,76	82,65	81,02	71,79	76,41	84,84	83,09	69,03	66,87	67,99	60,45	66,33	70,88	73,65			
BFHP index (%)	15,89	13,61	9,89	12,34	12,68	11,26	10,58	8,04	11,63	13,21	5,90	18,78	11,43	8,76	12,32			
BFAR index (tests•cm ⁻² •kyr ⁻¹)	207831	647037	799773	583720	157835	434466	454574	474039	184496	150602	169002	101282	231267	150709	294014			
R	29	36	30	23	30	27	31	40	23	23	21	33	30	28	42			
H'	2,25	2,18	2,11	2,06	2,16	2,09	2,09	1,83	2,06	2,02	1,88	2,27	2,17	1,91	2,13			
J'	0,67	0,61	0,62	0,66	0,63	0,63	0,61	0,50	0,66	0,64	0,62	0,65	0,64	0,57	0,57			

Cont. Appendix 2 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)													
	4489	4699	4914	5132	5354	5579	5807	6038	6508	6987	7228	7471	7715	7959
	Benthic foraminifera (%)													
<i>Ammonia beccarii</i> (Linné, 1758)	0,00	0,00	0,00	0,00	0,00	0,12	0,00	0,00	0,00	0,07	0,00	0,00	0,00	0,00
<i>Ammonia</i> spp.	0,00	0,12	0,00	0,00	0,00	0,00	0,66	0,00	0,00	0,07	0,00	0,00	0,00	0,51
<i>Amphicoryna scalaris</i> (Batsch, 1791)	0,00	0,00	0,15	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,19	0,12	0,14	0,00
<i>Amphicoryna</i> spp.	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,24	0,00	0,00
<i>Angulogerina angulosa</i> (Williamson, 1858)	21,25	18,57	18,28	14,81	18,46	17,16	15,44	26,72	18,14	8,28	15,09	6,59	13,14	11,59
<i>Angulogerina</i> spp.	0,00	2,35	1,77	1,89	1,06	2,54	2,65	2,24	1,56	0,00	1,53	1,08	1,00	0,64
<i>Bolivina albatrossi</i> Cushman, 1922	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina doniezi</i> Cushman & Wickenden, 1929	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,18	0,00	0,00	0,48	0,00	0,00
<i>Bolivina pseudoplicata</i> Heron-Allen & Earland, 1930	0,00	0,00	0,08	0,00	0,13	0,18	1,10	0,00	0,00	0,00	0,19	0,00	0,00	0,38
<i>Bolivina pulchella</i> (d'Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina pulchella f. primitiva</i> Cushman, 1930	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina seminuda</i> Cushman, 1911	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,96	0,00	0,00	0,00
<i>Bolivina skagerrakensis</i> Qvale & Nigam, 1985	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina subspinensis</i> Cushman, 1922	0,19	0,12	0,08	0,27	0,00	0,00	0,00	0,00	0,00	0,00	0,38	0,00	0,14	0,00
<i>Bolivina translucens</i> Phleger & Parker, 1951	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,00
<i>Bolivina</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina</i> spp.	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13
<i>Brizalina ordinaria</i> (Phleger & Parker, 1952)	0,00	0,00	0,00	0,00	0,00	0,00	0,44	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Brizalina spathulata</i> (Williamson, 1858)	0,00	0,00	0,00	0,00	0,00	0,24	0,00	0,11	0,37	0,07	0,00	0,24	0,00	0,00
<i>Brizalina subaenariensis</i> (Cushman, 1922)	1,74	0,94	0,23	1,08	0,66	0,24	0,88	0,67	0,27	0,00	0,57	0,48	0,57	0,89
<i>Brizalina</i> sp.1	0,39	0,00	0,08	0,27	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Brizalina</i> sp.2	0,00	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Brizalina</i> spp.	0,58	0,59	0,23	0,54	0,93	0,42	1,76	0,11	0,46	0,29	0,00	0,00	0,43	0,13
<i>Buccella peruviana</i> (d'Orbigny, 1839)	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,00
<i>Buccella</i> spp.	0,00	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina aculeata</i> d'Orbigny, 1826	0,19	0,00	0,00	0,54	0,27	0,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina elongata</i> d'Orbigny, 1846	0,19	0,35	0,00	0,27	0,40	0,00	0,00	0,00	0,00	0,00	0,76	0,00	1,00	0,38
<i>Bulimina gibba</i> Fornasini, 1900	0,00	0,00	0,00	0,00	0,27	0,12	0,44	0,00	0,00	0,07	0,19	0,12	0,00	0,64
<i>Bulimina marginata</i> d'Orbigny, 1826	10,63	11,28	5,40	15,08	6,77	5,62	6,84	7,04	7,79	2,20	12,80	15,33	12,57	8,91
<i>Bulimina mexicana</i> Cushman, 1922	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina pseudoaffinis</i> Kleinpell, 1938	0,00	0,00	0,00	0,00	0,66	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,57	0,89
<i>Bulimina subulata</i> Cushman & Parker, 1947	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,12	0,00	0,00

Cont. Appendix 2 -

	Benthic foraminifera taxa	Estimated age (yr cal. BP)													
		4489	4699	4914	5132	5354	5579	5807	6038	6508	6987	7228	7471	7715	7959
		Benthic foraminifera (%)													
<i>Bulimina</i> spp.	0,77	0,12	0,93	0,00	0,00	0,97	0,00	1,68	0,92	1,03	3,82	1,08	0,29	7959	
<i>Buliminella elegantissima</i> (d' Orbigny 1839)	0,19	0,24	0,23	0,27	0,80	0,18	0,00	0,11	0,27	0,00	0,19	0,00	0,43	0,76	
<i>Cancris auriculus</i> (Fichtel & Moll, 1798)	0,00	0,00	0,00	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,13	
<i>Cancris</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00	
<i>Cancris</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Cancris</i> spp.	0,00	0,00	0,00	0,00	0,27	0,12	0,00	0,45	0,00	0,00	0,38	0,24	0,00	0,13	
<i>Cassidulina carinata</i> (Silvestri, 1896)	0,00	0,00	0,00	0,00	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Cassidulina laevigata</i> d'Orbigny, 1826	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Cassidulina</i> spp.	0,19	0,47	0,31	0,81	0,00	0,12	0,66	0,22	0,37	0,00	0,38	1,32	0,29	0,00	
<i>Cibicides ungerianus</i> (d' Orbigny, 1846)	0,00	0,00	0,15	2,15	1,33	0,06	1,76	0,67	2,02	0,59	5,92	3,95	3,14	3,57	
<i>Cibicides</i> spp.	0,58	0,59	0,00	0,27	0,00	0,18	0,00	0,56	0,82	0,59	0,19	2,40	0,00	0,38	
<i>Cibicoides mundulus</i> (Brady, Parker & Jones, 1888)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,07	0,00	0,00	0,00	0,00	
<i>Cibicoides pachyderma</i> (Rzehak, 1886)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,09	0,07	0,00	0,00	0,00	0,00	
<i>Cibicoides wuellerstorfi</i> (Schwager, 1866)	0,00	0,00	0,00	0,54	0,00	0,00	0,00	0,00	0,00	0,00	0,96	0,00	0,00	0,00	
<i>Cibicoides</i> spp.	0,39	0,00	0,00	0,54	0,00	0,00	0,22	0,00	0,73	0,07	0,38	0,00	0,57	0,00	
<i>Clavulina humilis</i> Brady, 1884	0,00	0,00	0,08	0,00	0,13	0,00	0,22	0,00	0,00	0,07	0,38	0,00	0,14	0,00	
<i>Clavulina multicamerata</i> Chapman, 1907	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Clavulina</i> spp.	0,39	0,00	0,00	0,00	0,00	0,06	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Dentalina ariana</i> Patterson & Pettis, 1986	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Dentalina bradyensis</i> (Dervieux, 1894)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Dentalina</i> spp.	0,00	0,00	0,00	0,00	0,13	0,00	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,13	
<i>Deuteramina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Discorbinella bertheloti</i> (d' Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Discorbinella</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Discorbis williamsoni</i> Chapman & Parr, 1932	0,19	0,12	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,24	0,00	0,00	
<i>Discorbis</i> spp.	0,00	0,00	0,08	0,00	0,00	0,97	0,00	0,11	1,65	0,59	0,57	0,48	0,57	1,53	
<i>Dorothia goessi</i> (Cushman, 1911)	0,00	0,00	0,00	0,27	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Dorothia</i> sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,12	0,29	0,00	
<i>Edentostomia</i> sp. nov. Brady, 1884	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Elphidium excavatum</i> Terquem, 1875	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Elphidium</i> spp. (not identified broken specimens)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Epistominella</i> spp.	0,58	0,94	1,31	0,00	0,93	0,91	0,66	0,00	1,10	0,95	0,19	0,60	2,14	1,02	
<i>Evolvocassidulina orientalis</i> (Cushman, 1922)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,07	0,00	0,00	0,00	0,00	
<i>Fissurina laevigata</i> Reuss, 1850	0,00	0,00	0,15	0,00	0,00	0,06	0,00	0,00	0,00	0,07	0,00	0,12	0,00	0,00	
<i>Fissurina lucida</i> (Williamson, 1884)	0,00	0,00	0,15	0,00	0,00	0,00	0,00	0,00	0,18	0,07	0,00	0,12	0,14	0,13	
<i>Fissurina marginata</i> (Montagu, 1803)	0,00	0,12	0,00	0,00	0,13	0,06	0,00	0,00	0,00	0,07	0,00	0,12	0,14	0,25	
<i>Fissurina quadricostulata</i> Silvestri, 1902	0,00	0,00	0,08	0,00	0,00	0,06	0,00	0,00	0,09	0,07	0,00	0,12	0,00	0,00	

Cont. Appendix 2 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)													
	4489	4699	4914	5132	5354	5579	5807	6038	6508	6987	7228	7471	7715	7959
	Benthic foraminifera (%)													
<i>Fissurina staphyllearia</i> Schwager, 1866	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,13
<i>Fissurina</i> sp. 1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,00	0,00	0,00
<i>Fissurina</i> sp. 2	0,00	0,00	0,08	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,12	0,00	0,00
<i>Fissurina</i> sp. 3	0,00	0,00	0,23	0,00	0,00	0,00	0,00	0,00	0,09	0,07	0,00	0,00	0,00	0,00
<i>Fissurina</i> spp.	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,15	0,19	0,00	0,43	0,38
<i>Favulina hexagona</i> (Williamson, 1848)	0,00	0,00	0,08	0,00	0,00	0,00	0,00	0,11	0,09	0,00	0,00	0,24	0,00	0,25
<i>Favulina imelo</i> (d' Orbigny, 1839)	0,00	0,00	0,08	0,00	0,00	0,18	0,22	0,11	0,09	0,07	0,00	0,24	0,00	0,13
<i>Fursenkoina complanata</i> (Egger, 1893)	0,00	0,00	0,08	0,00	0,00	0,24	0,00	0,34	0,00	0,00	0,00	0,00	0,00	0,00
<i>Fursenkoina</i> spp.	0,00	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,24	0,00	0,00
<i>Gavelinopsis praegeri</i> (Heron-Allen & Earland, 1913)	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,22	0,27	0,00	0,00	1,20	0,00	0,00
<i>Gavelinopsis umbonifer</i> (Parr, 1950)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,29	0,00	0,00	0,00	0,00
<i>Gavelinopsis</i> spp.	0,00	0,00	0,00	0,00	0,53	0,00	0,00	0,00	0,00	0,07	0,00	0,12	0,00	0,00
<i>Glabratala milletti</i> (Wright, 1911)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Globocassidulina minuta</i> (Cushman, 1933)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,12	0,00	0,00
<i>Globocassidulina subglobosa</i> (Brady, 1881)	18,55	26,68	29,69	11,31	26,30	35,59	24,93	12,19	18,14	0,00	12,23	10,54	25,99	15,92
<i>Globocassidulina</i> spp.	2,13	4,23	7,25	1,89	3,98	6,10	4,63	2,79	3,12	0,00	1,34	1,44	3,43	2,04
<i>Gyroidina altiformis</i> R.E. & K.C. Stewart, 1930	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Gyroidina umbonata</i> (Silvestri, 1898)	9,47	7,76	7,09	6,73	4,65	3,69	5,07	4,47	1,56	0,73	3,06	1,80	2,14	3,06
<i>Gyroidina</i> spp.	0,00	1,18	1,16	0,00	1,06	1,03	1,54	1,34	0,18	0,29	0,00	1,08	0,00	0,00
<i>Hoeglundina elegans</i> (d' Orbigny, 1826)	0,00	0,00	0,00	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Islandiella norcrossi</i> (Cushman, 1933)	2,90	4,70	3,01	6,46	5,45	2,05	6,40	1,34	2,93	0,88	4,01	0,72	2,00	0,13
<i>Islandiella</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena clavata</i> (d'Orbigny, 1846)	0,58	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena hispidula</i> Cushman, 1913	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00
<i>Lagena laevis</i> (Montagu, 1803)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,38	0,00	0,00	0,00
<i>Lagena laevis</i> , f. tenuis Williamson, 1848	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena laevis</i> , f. typica Williamson, 1848	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena striata</i> (d'Orbigny, 1839)	0,00	0,00	0,08	0,00	0,00	0,18	0,00	0,11	0,00	0,00	0,00	0,24	0,29	0,00
<i>Lagena</i> spp.	0,00	0,00	0,00	0,27	0,00	0,18	0,00	0,00	0,00	0,07	0,00	0,00	0,00	0,00
<i>Lenticulina thalmani</i> (Hessland, 1943)	0,00	0,00	0,00	0,27	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.1	0,00	0,00	0,00	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.5	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00

Cont. Appendix 2 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)													
	4489	4699	4914	5132	5354	5579	5807	6038	6508	6987	7228	7471	7715	7959
	Benthic foraminifera (%)													
<i>Lenticulina</i> sp.6	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> spp.	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,00	0,00
<i>Liesbusella</i> sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,00
<i>Lobatula lobatula</i> (Walker & Jacob, 1798)	0,19	0,59	0,69	0,00	0,27	0,00	0,00	0,00	0,64	0,00	0,00	0,57	0,00	0,89
<i>Melonis barleeanus</i> (Williamson, 1858)	0,97	0,35	0,00	1,08	0,40	0,24	0,22	0,11	0,00	0,00	0,00	0,19	0,48	0,00
<i>Melonis</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,00	0,12	0,00
<i>Miliolinella subrotunda</i> (Montagu, 1803)	0,00	0,00	0,00	0,00	0,00	0,00	0,22	0,00	0,00	0,00	0,00	0,19	0,00	0,25
<i>Neolenticulina variabilis</i> (Reuss, 1850)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13
<i>Nonion</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Nonion</i> sp.	0,00	0,12	0,00	0,00	0,13	0,00	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Nonionella turgida</i> (Williamson, 1858)	0,00	0,00	0,15	0,00	0,40	0,30	0,22	0,11	0,00	0,00	0,00	0,19	0,00	0,51
<i>Nonionella</i> spp.	0,19	0,00	0,08	0,54	0,00	0,30	0,00	0,11	0,27	0,00	0,00	0,36	0,00	0,00
<i>Nonionoides grateloupi</i> (d'Orbigny, 1826)	0,00	0,00	0,00	0,54	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Nonionoides</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,00	0,00	0,00
<i>Nonionoides</i> spp.	0,39	0,47	0,23	0,00	0,13	0,00	0,44	0,11	0,18	0,00	0,00	0,57	0,00	0,13
<i>Oolina alcocki</i> (White, 1956)	0,00	0,00	0,08	0,00	0,00	0,12	0,00	0,11	0,09	0,00	0,00	0,00	0,00	0,00
<i>Oolina borealis</i> Loeblich & Tappan, 1954	0,00	0,00	0,00	0,00	0,00	0,00	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Oridorsalis</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,09	0,00	0,00	0,00	0,00	0,00
<i>Oridorsalis umbonatus</i> (Reuss, 1851)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,00
<i>Osanguriella umbonifera</i> (Cushman, 1933)	0,00	0,24	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Paracassidulina nipponensis</i> (Eade, 1969)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Planulina umbilicata</i>	0,00	0,00	0,00	0,00	0,00	0,12	0,00	0,11	0,00	0,81	0,00	1,44	0,00	0,00
<i>Planulina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00
<i>Polymorphinella</i> sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Procerolagena gracilis</i> (Williamson, 1848)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Procerolagena setigera</i> Millett, 1901	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00
<i>Pseudogaudryna</i> sp. nov. Baker, 1960	0,00	0,35	0,00	0,00	0,27	0,00	0,66	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Pseudononion atlanticum</i> (Cushman, 1936)	0,19	0,00	0,23	0,00	0,13	0,36	0,22	0,56	0,46	0,00	0,00	0,60	0,86	0,38
<i>Pulenia quadriloba</i>	0,00	0,71	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Pullenia bulloides</i> (d'Orbigny, 1846)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00
<i>Pullenia osloensis</i> Feyling-Hanssen, 1954	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,00	0,00	0,12	0,00	0,00
<i>Pullenia quinqueloba</i> (Reuss, 1851)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,00
<i>Pyrgo depressa</i> (d' Orbigny, 1826)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Pyrgo elongata</i> (d'Orbigny, 1826)	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Pyrgo murrhina</i> (Schwager, 1866)	0,00	0,00	0,00	0,00	0,00	0,00	0,22	0,11	0,00	0,00	0,00	0,12	0,00	0,00
<i>Pyrgo nasuta</i> Cushman, 1935	0,19	0,00	0,00	0,00	0,00	0,18	0,00	0,11	0,09	0,00	0,00	0,12	0,00	0,00
<i>Pyrgo oblonga</i> (d' Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,12	0,00	0,00

Cont. Appendix 2 -

	Benthic foraminifera taxa	Estimated age (yr cal. BP)													
		Benthic foraminifera (%)													
		4489	4699	4914	5132	5354	5579	5807	6038	6508	6987	7228	7471	7715	7959
	<i>Pyrgo ringens</i> (Lamarck, 1804)	0,00	0,00	0,00	0,00	0,13	0,06	0,00	0,00	0,00	0,07	0,00	0,12	0,00	0,00
	<i>Pyrgo</i> sp.1	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Pyrgo</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,14	0,00
	<i>Pyrgo</i> sp.3	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Pyrgo</i> sp.4	0,00	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13
	<i>Pyrgo</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,24	0,00	0,00
	<i>Quinqueloculina akneriana</i> d' Orbigny, 1846	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,18	0,37	0,00	0,72	0,00	0,00
	<i>Quinqueloculina amygdaloides</i> (Brady, 1884)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,12	0,00	0,00
	<i>Quinqueloculina atlantica</i> Boltovskoy, 1957	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,27	0,00	0,00	0,24	0,00	0,13
	<i>Quinqueloculina intricata</i> (Terquem, 1878)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13
	<i>Quinqueloculina lamarckiana</i> d'Orbigny, 1839	0,00	0,00	0,00	0,00	0,13	0,00	0,44	0,11	0,09	0,07	0,00	0,24	0,14	0,51
	<i>Quinqueloculina milletti</i> (Wiesner, 1923)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Quinqueloculina</i> spp.	0,19	0,00	0,00	0,27	0,00	0,00	0,22	0,00	0,00	0,00	0,19	0,12	0,14	0,13
	<i>Rosalina globularis</i> (d' Orbigny, 1826)	0,00	0,00	0,00	2,15	0,93	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Rosalina</i> sp.1	0,00	0,00	0,85	0,00	0,00	0,00	0,00	2,24	2,93	0,00	0,00	0,36	0,00	0,00
	<i>Rosalina</i> sp2.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,07	0,00	0,00	0,00	0,00
	<i>Rosalina</i> spp.	0,00	0,00	0,00	0,00	0,27	0,00	0,66	0,00	0,00	0,00	2,10	0,00	0,86	0,51
	<i>Saracenaria</i> sp.	0,00	0,00	0,00	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Seabrookia earlandi</i> Wright, 1891	0,39	0,00	0,31	0,27	0,13	0,42	0,66	0,00	0,37	0,07	0,57	0,12	0,43	0,64
	<i>Sigmilopsis schlumbergeri</i> (Silvestri, 1904)	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,38	0,00	0,57	0,13
	<i>Siphonaperta</i> sp.1	0,00	0,00	0,15	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,14	0,00
	<i>Siphonaperta</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13
	<i>Siphonina bradyana</i> Cushman, 1927	0,39	0,00	0,00	0,00	0,13	0,00	0,22	0,00	0,00	0,00	0,19	0,00	0,14	0,13
	<i>Siphonina</i> sp1.	0,00	0,00	0,15	0,00	0,00	0,06	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Spiroglutina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,22	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Spiroloculina</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,13
	<i>Spiroloculina</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Spiroplectinella wrightii</i> (Silvestri, 1903)	0,00	0,00	0,00	0,00	0,00	0,00	0,22	0,00	0,00	0,00	0,19	0,12	0,43	0,25
	<i>Stainforthia complanata</i> (Egger, 1895)	0,00	0,00	0,00	0,54	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,25
	<i>Stainforthia</i> spp.	0,00	0,00	0,00	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,19	0,00	0,00	0,00
	<i>Textullaria</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,22	0,00	0,36	0,43	0,76
	<i>Textullaria</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,18	0,00	0,00	0,12	0,00	0,38
	<i>Textullaria</i> sp.3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,00	0,38	0,48	0,00	0,00
	<i>Textullaria</i> sp.4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00	0,00

Cont. Appendix 2 -

	Benthic foraminifera taxa	Estimated age (yr cal. BP)													
		4489	4699	4914	5132	5354	5579	5807	6038	6508	6987	7228	7471	7715	7959
		Benthic foraminifera (%)													
<i>Textullaria</i> spp.															
	<i>Trifarina angulosa</i> (Williamson, 1858)	0,00	0,00	0,00	0,00	0,00	0,00	0,66	0,00	0,27	0,00	0,00	0,24	0,00	0,00
	<i>Trifarina bradyi</i> Cushman, 1923	0,00	0,12	0,00	0,00	0,00	1,33	0,00	1,34	0,64	0,29	0,00	1,08	0,00	0,00
	<i>Triloculina</i> sp.2	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Triloculina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,19	0,00	0,29	0,00
	<i>Triloculinella</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,22	0,00	0,00	0,00	0,19	0,00	0,00	0,51
	<i>Uvigerina auberiana</i> d' Orbigny, 1839	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,00	0,00	0,14	0,00
	<i>Uvigerina peregrina</i> Cushman, 1923	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,09	0,00	0,00	0,00	0,00	0,00
	<i>Uvigerina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	<i>Valvulineria bradyana</i> (Fornasini, 1900)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	total density (tests•10 cc ⁻¹)	19355	35476	32310	19224	23960	34725	41847	15875	19700	5760	27864	13025	40104	15000
	fragments (%)	5,06	3,31	4,27	8,24	2,84	2,52	3,98	2,68	4,57	4,51	6,46	2,88	4,85	2,80
	not identified (%)	2,78	0,97	0,93	4,12	0,50	0,58	2,39	0,16	0,89	0,69	2,84	0,00	1,62	1,20
	E (%)	12,75	10,34	10,64	13,20	9,83	6,83	11,25	9,84	14,01	5,94	16,81	16,29	13,00	15,28
	I (%)	62,79	74,04	71,56	58,45	69,07	76,61	70,37	60,03	57,54	14,37	56,36	45,40	65,13	47,63
	BFHP index (%)	15,26	13,75	7,71	19,39	11,42	9,06	11,91	10,40	10,63	3,74	20,25	18,45	16,42	14,90
	BFAR index (tests•cm ⁻² •kyr ⁻¹)	184103	331024	296180	173365	212856	304281	362131	135831	165348	47663	229483	106936	328741	205436
	R	36	32	46	28	41	47	40	47	56	37	45	56	51	54
	H'	2,21	2,13	2,15	2,36	2,25	2,08	2,51	2,29	2,57	2,30	2,67	2,79	2,48	2,74
	J'	0,62	0,61	0,56	0,71	0,61	0,54	0,68	0,59	0,64	0,64	0,70	0,69	0,63	0,69

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
52--54	1999	*	*	*	*	*	*	*	*	*	*
54--56	2050	*	*	*	*	*	*	*	*	*	*
56--58	2101	6,43	88,21	5,36	6,08	21,68	0,80	0,14	-20,62	0,80	5,91
58--60	2153	8,89	89,20	1,92	6,46	21,64	0,80	0,14	-20,69	-2,39	5,86
60--62	2204	7,19	88,93	3,87	6,22	20,86	0,67	0,10	-20,80	0,90	6,43
62--64	2256	6,50	87,29	6,21	6,06	21,57	0,62	0,12	-21,34	2,01	5,09
64--66	2307	7,32	88,64	4,04	6,22	20,98	0,49	0,12	-20,95	1,89	4,04
66--68	2359	7,50	89,36	3,13	6,31	21,55	0,50	0,12	-20,46	1,32	4,26
68--70	2411	8,55	89,55	1,90	6,44	22,68	0,48	0,11	-20,36	0,54	4,22
70--72	2463	8,13	88,45	3,42	6,32	21,18	0,49	0,12	-20,03	1,82	4,20
72--74	2515	7,74	89,41	2,84	6,32	22,51	0,58	0,11	-20,77	0,22	5,09
74--76	2567	6,46	89,60	3,93	6,16	20,31	0,65	*	-21,24	*	*
76--78	2620	5,13	87,49	7,38	5,90	20,72	0,70	0,12	-20,85	1,59	5,78
78--80	2672	6,73	89,39	3,88	6,20	20,60	0,49	0,11	-20,11	1,41	4,49
80--82	2725	7,61	91,35	1,05	6,36	20,29	0,46	0,18	-19,95	2,55	2,60
82--84	2778	5,74	92,97	1,28	6,22	20,98	0,42	*	-19,78	*	*
84--86	2831	6,95	88,88	4,17	6,19	21,41	0,47	*	-20,44	*	*
86--88	2884	7,88	89,83	2,28	6,38	20,33	0,49	*	-20,70	*	*
88--90	2937	8,19	90,97	0,84	6,43	20,35	0,51	0,10	-21,01	1,02	4,95
90--92	2991	5,80	91,07	3,13	6,07	20,02	0,60	0,13	-20,67	0,91	4,65
92--94	3044	7,44	89,18	3,38	6,25	21,15	0,52	0,13	-20,10	1,99	4,00
94--96	3098	8,15	89,91	1,94	6,41	19,73	0,43	0,13	-19,47	2,37	3,32
96--98	3152	6,06	87,14	6,80	6,01	20,52	0,59	0,12	-21,73	3,18	4,96
98--100	3206	6,31	87,26	6,44	6,04	19,95	0,55	0,13	-20,46	1,48	4,30
100--102	3261	6,82	84,87	8,31	6,05	21,14	0,50	*	-20,16	*	*
102--104	3315	6,50	86,79	6,71	6,04	21,01	0,48	0,11	-20,41	2,10	4,34
104--106	3370	7,21	88,52	4,27	6,22	20,76	0,54	0,12	-20,72	2,83	4,45

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size				Sedimentary organic matter					
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (ϕ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
106--108	3425	6,78	89,81	3,40	6,20	20,86	0,36	0,11	-20,23	2,31	3,27
108--110	3480	5,80	85,16	9,04	5,89	19,98	0,38	0,11	-20,30	2,29	3,27
110--112	3536	5,79	87,87	6,34	6,00	20,57	0,54	0,11	-20,50	2,87	4,79
112--114	3591	5,51	74,20	20,29	5,52	20,64	0,39	0,12	-20,62	1,06	3,22
114--116	3647	6,46	88,84	4,70	6,13	20,00	0,46	0,11	-19,95	2,64	4,04
116--118	3703	6,72	90,03	3,25	6,18	20,41	0,54	0,11	-21,38	3,52	4,80
118--120	3759	6,09	80,82	13,09	5,78	20,19	0,60	0,11	-21,34	3,13	5,25
120--122	3815	4,97	78,22	16,81	5,55	19,93	0,63	0,13	-21,50	5,65	4,92
122--124	3872	5,77	85,17	9,05	5,89	19,46	0,64	0,13	-21,39	5,50	4,85
124--126	3928	6,04	84,42	9,53	5,89	19,41	0,53	0,13	-21,71	5,44	3,93
126--128	3985	5,80	78,65	15,55	5,70	20,05	0,66	0,13	-21,19	4,80	5,27
128--130	4042	5,58	81,64	12,78	5,75	20,05	0,67	0,12	-21,45	4,94	5,77
130--132	4099	5,72	83,03	11,25	5,81	20,53	0,54	0,12	-21,22	4,84	4,62
132--134	4157	6,91	88,67	4,43	6,19	20,33	0,55	0,12	-21,35	4,66	4,40
134--136	4214	6,31	79,90	13,80	5,79	20,87	0,53	0,11	-21,36	4,75	4,80
136--138	4272	6,55	83,13	10,32	5,96	20,45	0,47	0,12	-21,43	5,23	3,98
138--140	4330	6,25	83,21	10,54	5,90	20,67	0,78	*	-21,37	*	*
140--142	4388	6,34	79,67	13,99	5,78	20,26	0,63	0,11	-21,49	4,70	5,56
142--144	4446	6,83	83,87	9,30	5,99	20,65	0,63	0,08	-21,84	4,39	8,15
144--146	4505	6,69	81,21	12,11	5,91	21,15	0,63	0,11	-21,40	4,61	5,58
146--148	4563	7,16	83,98	8,86	6,05	21,21	0,48	0,10	-21,39	4,34	5,00
148--150	4622	7,41	86,63	5,96	6,17	20,68	0,47	0,09	-21,63	4,59	5,07
150--152	4681	7,19	81,99	10,82	6,00	19,85	0,29	0,09	-21,95	4,84	3,16
152--154	4741	8,76	89,90	1,34	6,53	21,58	0,52	0,09	-21,80	4,75	5,67
154--156	4800	7,24	84,15	8,61	6,07	22,84	0,34	0,10	-21,81	4,95	3,42
156--158	4860	9,01	89,97	1,02	6,52	20,92	0,40	0,08	-21,77	4,98	4,94
158--160	4919	7,75	84,66	7,59	6,17	19,64	0,21	0,07	-22,05	4,55	3,01

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCO ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
160--162	4979	7,23	83,96	8,82	6,07	20,19	0,18	0,08	-21,96	4,16	2,10
162--164	5039	7,21	81,19	11,60	5,99	19,86	0,34	0,09	-21,63	5,36	3,65
164--166	5099	7,26	79,76	12,98	5,95	21,42	0,15	0,08	-22,48	5,30	1,81
166--168	5160	7,69	85,48	6,83	6,16	20,60	0,48	*	-21,80	*	*
168--170	5220	8,16	83,61	8,23	6,18	20,66	0,32	0,10	-21,74	4,59	3,35
170--172	5281	5,39	70,94	23,67	5,37	20,21	0,21	0,10	-21,77	4,51	2,18
172--174	5342	4,84	67,63	27,52	5,20	21,19	0,21	0,09	-22,01	4,86	2,45
174--176	5402	5,19	73,77	21,05	5,44	24,70	0,33	0,09	-21,79	5,01	3,49
176--178	5463	4,60	63,97	31,43	5,06	17,11	0,19	*	-21,78	*	*
178--180	5524	6,42	73,92	19,67	5,62	21,06	0,39	0,11	-21,48	5,07	3,62
180--182	5586	6,05	76,88	17,07	5,66	21,10	0,25	0,10	-21,87	5,07	2,41
182--184	5647	6,85	80,66	12,49	5,89	20,66	0,39	0,10	-21,58	5,18	3,88
184--186	5708	5,64	77,52	16,84	5,63	19,85	0,27	0,09	-21,64	3,68	3,09
186--188	5770	5,57	73,90	20,52	5,50	20,43	0,42	0,09	-22,54	5,06	4,81
188--190	5832	5,78	72,34	21,88	5,49	20,28	0,38	0,10	-21,72	4,48	3,96
190--192	5893	5,88	79,95	14,17	5,74	21,04	0,49	0,10	-21,61	4,77	5,06
192--194	5955	6,39	76,20	17,42	5,71	20,45	0,26	0,09	-21,65	4,24	2,88
194--196	6017	5,83	74,07	20,09	5,55	21,64	0,19	0,09	-22,25	4,22	2,09
196--198	6079	5,43	68,39	26,17	5,32	20,90	0,17	0,09	-21,90	5,31	1,81
198--200	6141	5,43	65,25	29,33	5,23	21,41	0,33	0,09	-22,25	4,75	3,65

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Sedimentary inorganic constituents								
		Al (mg/kg)	Ba (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Ti (mg/kg)	Fe/Ca ratio	Ti/Ca ratio	Ba/Al ratio	Ba/Ca ratio
52--54	1999	*	*	*	*	*	*	*	*	*
54--56	2050	65362,60	183,57	24695,40	38510,50	3634,38	1,559	0,147	0,003	0,007
56--58	2101	59961,20	178,47	26292,90	34713,50	3342,05	1,320	0,127	0,003	0,007
58--60	2153	*	*	*	*	*	*	*	*	*
60--62	2204	61636,90	180,71	28880,50	35448,90	3450,44	1,227	0,119	0,003	0,006
62--64	2256	61632,50	179,26	24397,30	35838,50	3395,09	1,469	0,139	0,003	0,007
64--66	2307	57471,80	187,58	23786,10	33454,60	3216,46	1,406	0,135	0,003	0,008
66--68	2359	56665,10	176,74	25475,50	32544,30	3215,91	1,277	0,126	0,003	0,007
68--70	2411	56142,80	176,04	28561,40	32334,60	3197,82	1,132	0,112	0,003	0,006
70--72	2463	57697,80	189,83	27298,20	34334,60	3411,44	1,258	0,125	0,003	0,007
72--74	2515	57876,30	182,61	26073,70	35182,20	3391,23	1,349	0,130	0,003	0,007
74--76	2567	62195,10	181,33	27533,00	35944,50	3582,42	1,306	0,130	0,003	0,007
76--78	2620	72764,20	179,12	24446,60	42571,50	4062,32	1,741	0,166	0,002	0,007
78--80	2672	*	*	*	*	*	*	*	*	*
80--82	2725	67749,00	198,60	28314,00	39073,80	3758,26	1,380	0,133	0,003	0,007
82--84	2778	62927,70	199,55	29052,70	36094,80	3614,11	1,242	0,124	0,003	0,007
84--86	2831	59132,20	188,42	28402,70	35429,90	3541,96	1,247	0,125	0,003	0,007
86--88	2884	62272,30	192,52	26709,40	35598,80	3538,56	1,333	0,132	0,003	0,007
88--90	2937	61929,80	192,56	28043,00	35943,80	3537,79	1,282	0,126	0,003	0,007
90--92	2991	64100,30	191,00	27814,90	36955,80	3608,75	1,329	0,130	0,003	0,007
92--94	3044	62275,70	187,02	27412,60	36301,40	3542,61	1,324	0,129	0,003	0,007
94--96	3098	64061,50	197,22	27757,10	37818,70	3619,88	1,362	0,130	0,003	0,007
96--98	3152	58423,00	185,93	25860,30	34973,90	3318,25	1,352	0,128	0,003	0,007
98--100	3206	63152,30	181,81	26600,80	37322,90	3673,91	1,403	0,138	0,003	0,007
100--102	3261	59458,70	185,35	26309,50	35205,50	3442,90	1,338	0,131	0,003	0,007
102--104	3315	58955,60	181,56	26010,30	34363,30	3430,30	1,321	0,132	0,003	0,007
104--106	3370	60735,20	183,58	28005,00	35478,50	3446,67	1,267	0,123	0,003	0,007

Sedimentary inorganic constituents

Sedimentary inorganic constituents

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy									
		Analcime (%)	Anatase (%)	Anidrite (%)	Bassanite (%)	Calcite (%)	Chlorite (%)	Dolomite (%)	K Feldapars (%)	Phyllosilicates (%)	Halite (%)
0--2	691	1,66	0,00	0,69	0,00	6,36	0,10	0,00	2,07	66,53	0,00
2--4	741	0,00	0,00	0,47	0,00	22,16	0,00	0,00	1,33	43,60	5,61
4--6	791	0,00	0,00	0,00	0,00	7,84	0,15	0,00	3,64	66,48	0,00
6--8	841	*	*	*	*	*	*	*	*	*	*
8--10	891	*	*	*	*	*	*	*	*	*	*
10--12	941	*	*	*	*	*	*	*	*	*	*
12--14	991	0,00	0,00	1,89	0,00	10,05	0,63	0,00	0,00	53,42	3,46
14--16	1041	2,24	0,00	0,00	0,00	15,50	1,06	0,00	4,17	52,16	2,98
16--18	1091	1,61	0,00	0,86	0,00	9,36	0,02	0,00	2,75	62,42	2,07
18--20	1141	*	*	*	*	*	*	*	*	*	*
20--22	1191	*	*	*	*	*	*	*	*	*	*
22--24	1241	*	*	*	*	*	*	*	*	*	*
24--26	1291	*	*	*	*	*	*	*	*	*	*
26--28	1341	*	*	*	*	*	*	*	*	*	*
28--30	1391	*	*	*	*	*	*	*	*	*	*
30--32	1442	0,00	1,68	0,00	0,00	11,02	0,00	0,00	0,00	47,74	2,20
32--34	1492	0,00	0,00	1,17	0,00	11,39	0,00	0,00	1,56	54,53	1,27
34--36	1542	2,02	0,00	1,21	0,00	6,25	0,54	0,00	3,33	60,51	2,42
38--40	1643	*	*	*	*	*	*	*	*	*	*
40--42	1694	*	*	*	*	*	*	*	*	*	*
42--44	1745	*	*	*	*	*	*	*	*	*	*
44--46	1795	*	*	*	*	*	*	*	*	*	*
46--48	1846	*	*	*	*	*	*	*	*	*	*
48--50	1897	*	*	*	*	*	*	*	*	*	*
50--52	1948	2,71	0,00	0,56	0,00	10,82	0,48	0,00	5,05	50,50	4,51

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy									
		Analcime (%)	Anatase (%)	Anidrite (%)	Bassanite (%)	Calcite (%)	Chlorite (%)	Dolomite (%)	K Feldapars (%)	Phyllosilicates (%)	Halite (%)
52--54	1999	0,92	0,00	0,69	0,00	8,55	0,00	0,00	0,00	48,64	2,36
54--56	2050	2,35	1,61	0,00	0,00	10,21	0,00	0,00	0,00	47,03	2,82
56--58	2101	*	*	*	*	*	*	*	*	*	*
58--60	2153	*	*	*	*	*	*	*	*	*	*
60--62	2204	*	*	*	*	*	*	*	*	*	*
62--64	2256	*	*	*	*	*	*	*	*	*	*
64--66	2307	*	*	*	*	*	*	*	*	*	*
66--68	2359	*	*	*	*	*	*	*	*	*	*
68--70	2411	*	*	*	*	*	*	*	*	*	*
70--72	2463	0,69	0,00	0,73	0,00	12,78	0,00	0,66	0,00	49,56	0,88
72--74	2515	1,16	0,00	0,71	0,00	12,37	0,00	0,00	0,00	41,91	4,19
74--76	2567	2,33	0,00	0,00	0,00	8,93	0,50	0,00	3,72	54,42	1,58
76--78	2620	*	*	*	*	*	*	*	*	*	*
78--80	2672	*	*	*	*	*	*	*	*	*	*
80--82	2725	*	*	*	*	*	*	*	*	*	*
82--84	2778	*	*	*	*	*	*	*	*	*	*
84--86	2831	*	*	*	*	*	*	*	*	*	*
86--88	2884	*	*	*	*	*	*	*	*	*	*
88--90	2937	*	*	*	*	*	*	*	*	*	*
90--92	2991	1,11	0,00	1,33	0,00	11,31	0,00	0,00	3,99	49,92	0,78
92--94	3044	2,02	0,00	0,81	0,00	11,32	0,27	0,00	0,00	40,44	4,04
94--96	3098	3,36	0,00	0,00	0,00	19,58	0,26	0,00	0,00	42,23	2,50
96--98	3152	*	*	*	*	*	*	*	*	*	*
98--100	3206	*	*	*	*	*	*	*	*	*	*
100--102	3261	*	*	*	*	*	*	*	*	*	*
102--104	3315	*	*	*	*	*	*	*	*	*	*
104--106	3370	1,95	0,00	0,83	0,00	16,38	0,00	0,00	7,18	43,69	0,86

Cont. Appendix 3 -

[illegible]

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy									
		Analcime (%)	Anatase (%)	Anidrite (%)	Bassanite (%)	Calcite (%)	Chlorite (%)	Dolomite (%)	K Feldapars (%)	Phyllosilicates (%)	Halite (%)
160--162	4979	0,60	0,00	0,00	0,00	8,70	0,00	0,00	0,00	58,01	1,33
162--164	5039	0,00	0,00	0,00	0,00	14,06	0,18	0,69	6,89	38,61	1,38
164--166	5099	1,67	0,00	0,00	0,00	15,55	0,00	0,00	0,00	35,12	3,01
166--168	5160	*	*	*	*	*	*	*	*	*	*
168--170	5220	*	*	*	*	*	*	*	*	*	*
170--172	5281	*	*	*	*	*	*	*	*	*	*
172--174	5342	*	*	*	*	*	*	*	*	*	*
174--176	5402	0,00	0,00	1,10	0,00	14,05	0,00	0,00	0,00	49,59	1,10
176--178	5463	2,22	0,00	0,00	0,00	12,45	0,13	0,00	2,96	48,42	1,09
178--180	5524	3,01	0,00	1,12	0,00	11,55	0,00	1,68	3,13	43,30	1,80
180--182	5586	*	*	*	*	*	*	*	*	*	*
182--184	5647	*	*	*	*	*	*	*	*	*	*
184--186	5708	*	*	*	*	*	*	*	*	*	*
186--188	5770	*	*	*	*	*	*	*	*	*	*
188--190	5832	*	*	*	*	*	*	*	*	*	*
190--192	5893	*	*	*	*	*	*	*	*	*	*
192--194	5955	4,62	0,00	2,46	0,73	8,54	0,00	0,00	0,00	46,15	0,17
194--196	6017	1,55	0,00	1,18	0,00	16,49	0,00	0,00	8,16	28,37	1,95
196--198	6079	0,58	0,00	0,00	0,00	13,66	0,00	0,00	0,00	53,12	1,17
198--200	6141	1,69	0,00	0,54	0,00	13,02	0,00	0,00	0,00	47,46	3,39

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy									
		Hematite (%)	Magn/Maghe (%)	Opal C/CT (%)	Plagioclase (%)	Pirite (%)	Quartz (%)	Siderite (%)	Rodocrosite (%)	DM index	FDM/FCM index
0--2	691	0,00	0,00	3,55	5,62	0,22	13,31	0,00	0,00	81,90	3,17
2--4	741	0,00	0,00	1,78	6,58	7,12	11,35	0,00	0,00	56,28	2,26
4--6	791	0,00	0,00	1,59	5,45	0,00	15,00	0,00	0,00	85,11	2,76
6--8	841	*	*	*	*	*	*	*	*	*	*
8--10	891	*	*	*	*	*	*	*	*	*	*
10--12	941	*	*	*	*	*	*	*	*	*	*
12--14	991	0,00	0,00	9,43	0,00	0,79	20,97	0,00	0,00	74,39	2,55
14--16	1041	0,00	1,68	3,18	4,77	0,20	13,12	0,00	0,00	69,45	2,36
16--18	1091	0,00	0,00	2,94	5,14	0,46	12,39	0,00	0,00	77,57	3,08
18--20	1141	*	*	*	*	*	*	*	*	*	*
20--22	1191	*	*	*	*	*	*	*	*	*	*
22--24	1241	*	*	*	*	*	*	*	*	*	*
24--26	1291	*	*	*	*	*	*	*	*	*	*
26--28	1341	*	*	*	*	*	*	*	*	*	*
28--30	1391	*	*	*	*	*	*	*	*	*	*
30--32	1442	0,00	0,00	3,36	10,49	4,41	19,10	0,00	0,00	66,84	1,61
32--34	1492	0,00	0,00	6,43	5,84	0,29	17,53	0,00	0,00	73,61	2,19
34--36	1542	0,00	0,00	5,65	3,83	1,01	13,77	0,00	0,00	77,61	2,89
38--40	1643	*	*	*	*	*	*	*	*	*	*
40--42	1694	*	*	*	*	*	*	*	*	*	*
42--44	1745	*	*	*	*	*	*	*	*	*	*
44--46	1795	*	*	*	*	*	*	*	*	*	*
46--48	1846	*	*	*	*	*	*	*	*	*	*
48--50	1897	*	*	*	*	*	*	*	*	*	*
50--52	1948	0,00	1,39	2,65	5,05	0,36	16,41	0,00	0,00	71,96	1,90

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy									
		Hematite (%)	Magn/Maghe (%)	Opal C/CT (%)	Plagioclase (%)	Pirite (%)	Quartz (%)	Siderite (%)	Rodocrosite (%)	DM index	FDM/FCM index
52--54	1999	0,00	0,00	10,61	6,78	0,88	20,56	0,00	0,00	69,21	1,78
54--56	2050	0,00	1,45	6,99	9,27	0,13	18,14	0,00	0,00	65,16	1,72
56--58	2101	*	*	*	*	*	*	*	*	*	*
58--60	2153	*	*	*	*	*	*	*	*	*	*
60--62	2204	*	*	*	*	*	*	*	*	*	*
62--64	2256	*	*	*	*	*	*	*	*	*	*
64--66	2307	*	*	*	*	*	*	*	*	*	*
66--68	2359	*	*	*	*	*	*	*	*	*	*
68--70	2411	*	*	*	*	*	*	*	*	*	*
70--72	2463	0,00	0,00	6,61	6,94	0,44	20,71	0,00	0,00	70,27	1,79
72--74	2515	0,00	0,00	5,85	8,38	0,40	25,01	0,00	0,00	66,93	1,25
74--76	2567	0,00	0,00	5,58	5,58	1,12	16,74	0,00	0,00	74,88	2,09
76--78	2620	*	*	*	*	*	*	*	*	*	*
78--80	2672	*	*	*	*	*	*	*	*	*	*
80--82	2725	*	*	*	*	*	*	*	*	*	*
82--84	2778	*	*	*	*	*	*	*	*	*	*
84--86	2831	*	*	*	*	*	*	*	*	*	*
86--88	2884	*	*	*	*	*	*	*	*	*	*
88--90	2937	*	*	*	*	*	*	*	*	*	*
90--92	2991	0,00	0,00	8,43	6,43	0,89	15,14	0,67	0,00	69,05	1,95
92--94	3044	0,00	0,00	4,04	8,49	0,61	28,21	0,00	0,00	68,66	1,10
94--96	3098	0,00	0,00	4,99	0,00	1,15	26,20	0,00	0,00	68,43	1,61
96--98	3152	*	*	*	*	*	*	*	*	*	*
98--100	3206	*	*	*	*	*	*	*	*	*	*
100--102	3261	*	*	*	*	*	*	*	*	*	*
102--104	3315	*	*	*	*	*	*	*	*	*	*
104--106	3370	0,00	0,00	0,00	6,55	1,25	21,30	0,00	0,00	72,17	1,25

Cont. Appendix 3 -

[illegible]

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy									
		Hematite (%)	Magn/Maghe (%)	Opal C/CT (%)	Plagioclase (%)	Pirite (%)	Quartz (%)	Siderite (%)	Rodocrosite (%)	DM index	FDM/FCM index
160--162	4979	0,00	0,00	7,25	7,25	0,73	16,13	0,00	0,00	74,14	2,48
162--164	5039	0,00	1,27	9,10	7,72	0,83	19,44	0,00	0,00	64,94	1,13
164--166	5099	0,00	0,00	10,03	10,03	1,00	23,58	0,00	0,00	58,70	1,04
166--168	5160	*	*	*	*	*	*	*	*	*	*
168--170	5220	*	*	*	*	*	*	*	*	*	*
170--172	5281	*	*	*	*	*	*	*	*	*	*
172--174	5342	*	*	*	*	*	*	*	*	*	*
174--176	5402	0,00	0,00	5,51	7,16	2,48	19,01	0,00	0,00	68,60	1,89
176--178	5463	0,00	0,00	3,95	13,83	1,58	13,49	0,00	0,00	64,87	1,60
178--180	5524	0,00	0,00	5,29	5,29	1,44	22,37	0,00	0,00	68,81	1,41
180--182	5586	*	*	*	*	*	*	*	*	*	*
182--184	5647	*	*	*	*	*	*	*	*	*	*
184--186	5708	*	*	*	*	*	*	*	*	*	*
186--188	5770	*	*	*	*	*	*	*	*	*	*
188--190	5832	*	*	*	*	*	*	*	*	*	*
190--192	5893	*	*	*	*	*	*	*	*	*	*
192--194	5955	0,00	2,49	5,08	6,46	1,62	21,69	0,00	0,00	67,84	1,64
194--196	6017	0,00	0,00	7,80	7,45	1,77	25,27	0,00	0,00	61,80	0,69
196--198	6079	0,00	0,00	5,60	8,76	1,17	15,94	0,00	0,00	69,06	2,15
198--200	6141	0,00	0,00	6,51	8,14	0,54	18,71	0,00	0,00	66,17	1,77

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	G. ruber (p) geochemical composition					Mg/Ca based temperature (°C)	$\delta^{18}\text{O}_{\text{w-IVC}}$ (‰, SMOW)
		$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{18}\text{O}$ (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)			
0--2	691	*	*	*	*	*	*	*
2--4	741	*	*	*	*	*	*	*
4--6	791	*	*	*	*	*	*	*
6--8	841	1,75	-1,07	1,19	4,21	26,72	1,48	1,48
8--10	891	1,58	-1,02	1,21	4,16	26,60	1,50	1,50
10--12	941	1,78	-0,97	1,62	3,99	26,13	1,44	1,44
12--14	991	1,94	-0,70	*	*	*	*	*
14--16	1041	1,48	-0,66	1,05	3,76	25,48	1,61	1,61
16--18	1091	1,82	-0,90	0,94	3,94	25,99	1,48	1,48
18--20	1141	1,81	-1,01	1,12	4,01	26,19	1,42	1,42
20--22	1191	2,10	-1,06	1,00	4,09	26,40	*	*
22--24	1241	1,78	-1,17	1,24	4,36	27,12	1,47	1,47
24--26	1291	1,69	-0,67	1,29	4,37	27,13	1,97	1,97
26--28	1341	1,76	-1,10	1,49	4,21	26,71	1,45	1,45
28--30	1391	1,39	-0,59	1,10	3,48	24,61	1,48	1,48
30--32	1442	1,49	-0,98	1,47	3,93	25,95	1,39	1,39
32--34	1492	1,76	-0,75	1,16	3,66	25,18	1,45	1,45
34--36	1542	1,87	-1,36	1,59	3,55	24,83	0,77	0,77
38--40	1643	1,68	-1,53	1,42	3,72	25,35	0,71	0,71
40--42	1694	1,91	-0,84	*	*	*	*	*
42--44	1745	1,82	-0,90	*	*	*	*	*
44--46	1795	1,82	-0,99	1,26	3,45	24,52	1,06	1,06
46--48	1846	1,84	-0,89	1,16	3,91	25,89	1,47	1,47
48--50	1897	1,90	-0,97	1,51	3,99	26,11	1,45	1,45
50--52	1948	1,95	-0,87	1,59	4,32	27,01	1,74	1,74

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	G. ruber (p) geochemical composition				Mg/Ca based temperature (°C)	$\delta^{18}\text{O}_{\text{w-ivc}}$ (‰, SMOW)
		$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{18}\text{O}$ (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)		
52--54	1999	1,74	-1,03	*	*	*	*
54--56	2050	2,07	-1,02	1,01	4,31	26,99	1,59
56--58	2101	1,78	-1,02	1,31	3,94	25,98	1,36
58--60	2153	1,84	-1,30	1,20	4,06	26,31	1,16
60--62	2204	1,91	-1,27	1,18	3,62	25,04	0,90
62--64	2256	*	*	1,19	4,10	26,43	*
64--66	2307	1,75	-0,99	1,34	4,39	27,20	1,67
66--68	2359	1,54	-1,23	1,12	3,99	26,13	1,18
68--70	2411	1,49	-0,98	1,21	4,09	26,40	1,50
70--72	2463	1,41	-1,10	1,25	4,29	26,94	1,49
72--74	2515	1,36	-1,71	1,23	4,32	27,02	0,91
74--76	2567	1,27	-0,97	1,09	4,09	26,40	1,51
76--78	2620	1,74	-0,83	1,23	4,31	26,98	1,77
78--80	2672	1,55	-0,95	1,35	4,14	26,55	1,56
80--82	2725	1,45	-0,76	1,09	3,98	26,09	1,64
82--84	2778	1,39	-0,54	1,60	4,26	26,86	2,04
84--86	2831	1,53	-1,11	*	4,50	27,45	1,60
86--88	2884	1,63	-0,99	1,25	3,85	25,74	1,33
88--90	2937	1,51	-0,46	1,19	3,94	25,98	1,92
90--92	2991	1,59	-0,97	1,27	4,31	26,98	1,63
92--94	3044	1,97	-1,32	*	*	*	*
94--96	3098	1,18	-1,09	1,25	4,00	26,16	1,33
96--98	3152	1,29	-0,66	*	*	*	*
98--100	3206	1,68	-0,83	1,15	3,89	25,85	1,52
100--102	3261	1,53	-0,98	1,15	3,67	25,18	1,22
102--104	3315	1,48	-0,43	*	4,31	26,97	2,17
104--106	3370	1,86	-1,04	1,21	3,72	25,35	1,20

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	G. ruber (p) geochemical composition				Mg/Ca based temperature (°C)	$\delta^{18}\text{O}_{\text{w-ivc}}$ (‰, SMOW)
		$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{18}\text{O}$ (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)		
106--108	3425	1,57	-0,61	1,35	4,05	26,29	1,83
108--110	3480	1,54	-0,75	1,67	4,53	27,54	1,98
110--112	3536	1,68	-0,74	1,16	3,82	25,65	1,57
112--114	3591	1,82	-0,93	1,24	3,91	25,90	1,43
114--116	3647	1,78	-1,03	1,13	*	*	*
116--118	3703	1,70	-1,13	1,19	3,94	25,98	1,24
118--120	3759	1,67	-0,96	1,73	3,88	25,82	1,38
120--122	3815	1,82	-0,76	1,16	4,32	27,02	1,85
122--124	3872	*	*	*	*	*	*
124--126	3928	2,17	-1,00	1,24	3,57	24,90	1,14
126--128	3985	1,55	-0,52	1,58	4,08	26,37	1,95
128--130	4042	1,59	-0,63	*	4,65	27,82	2,16
130--132	4099	1,41	-0,67	1,37	4,00	26,16	1,74
132--134	4157	*	*	*	*	*	*
134--136	4214	1,90	-1,05	*	*	*	*
136--138	4272	2,03	-0,51	1,27	4,23	26,77	2,04
138--140	4330	1,81	-0,89	*	*	*	*
140--142	4388	1,83	-0,58	1,40	4,22	26,74	1,97
142--144	4446	1,76	-0,47	1,18	4,32	27,01	2,13
144--146	4505	1,44	-0,41		4,32	27,00	2,19
146--148	4563	1,75	-0,82	1,22	3,95	26,01	1,55
148--150	4622	1,96	-0,94	1,35	4,04	26,26	1,49
150--152	4681	1,92	-1,20		3,62	25,04	0,96
152--154	4741	1,79	-1,18	1,22	3,87	25,80	1,15
154--156	4800	1,64	-0,93	1,42	4,32	27,01	1,67
156--158	4860	1,78	-1,24	1,18	3,78	25,53	1,03
158--160	4919	1,68	-0,88	1,35	4,35	27,08	1,74

Cont. Appendix 3 -

Core depth (cm)	Estimated age (yr cal. BP)	G. ruber (p) geochemical composition				Mg/Ca based temperature (°C)	$\delta^{18}\text{O}_{\text{w-ivc}}$ (‰, SMOW)
		$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{18}\text{O}$ (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)		
160--162	4979	1,73	-0,86	1,04	3,53	24,78	1,24
162--164	5039	1,59	-0,77	1,25	4,28	26,92	1,81
164--166	5099	1,64	-0,75	1,18	4,31	26,98	1,84
166--168	5160	1,53	-0,59	*	*	*	*
168--170	5220	1,64	-0,86	1,36	4,08	26,38	1,60
170--172	5281	2,05	-0,94	*	4,15	26,57	1,56
172--174	5342	1,65	-0,72	1,23	4,24	26,80	1,83
174--176	5402	1,39	-0,70	1,35	4,05	26,31	1,74
176--178	5463	2,18	-1,06	1,50	4,14	26,53	1,43
178--180	5524	*	*	1,42	4,54	27,56	*
180--182	5586	1,73	-0,67	1,55	4,01	26,18	1,74
182--184	5647	1,50	-0,37	1,59	4,47	27,39	2,31
184--186	5708	1,55	-0,58	*	*	*	*
186--188	5770	1,36	-0,73	1,50	4,30	26,97	1,85
188--190	5832	1,57	-0,65	*	3,70	25,27	1,55
190--192	5893	1,71	-0,45	1,50	4,16	26,58	2,05
192--194	5955	1,81	-0,73	*	*	*	*
194--196	6017	1,39	-0,82	1,19	4,07	26,34	1,62
196--198	6079	1,53	-0,43	1,32	4,50	27,47	2,27
198--200	6141	2,10	-0,94	1,69	4,32	27,01	1,65

Appendix 4 - Main sedimentological (grain size) and geochemical (sedimentary organic matter and inorganic constituents, mineralogy, and planktonic *G. ruber* (p) isotopic and elemental composition) data obtained for core 7605. Where, * stands for absence of data.

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
0	917	12,17	80,16	7,67	6,18	*	*	*	*	*	*
2	957	13,37	82,50	4,13	6,40	26,48	1,35	0,23	-21,30	4,92	5,82
4	997	14,17	82,32	3,50	6,51	*	*	*	*	*	*
6	1037	13,74	81,99	4,28	6,49	*	*	0,24	*	5,34	*
8	1077	14,71	81,58	3,70	6,57	25,91	1,24	0,21	-21,30	4,58	5,82
10	1117	13,19	83,17	3,64	6,46	25,62	1,18	0,23	-21,35	5,16	5,23
12	1157	15,72	81,42	2,86	6,67	25,04	1,25	0,21	-21,38	4,79	5,91
14	1197	13,58	83,77	2,65	6,58	*	*	*	*	*	*
16	1237	15,24	82,03	2,73	6,65	27,39	1,19	0,21	-21,57	5,24	5,57
18	1276	14,44	82,86	2,71	6,68	25,81	1,21	0,19	-21,33	4,56	6,20
20	1316	16,53	81,81	1,66	6,78	25,26	1,14	0,22	-21,44	5,44	5,12
22	1355	15,78	81,73	2,48	6,72	21,00	1,15	0,22	-21,50	5,49	5,24
24	1395	14,80	82,23	2,98	6,63	25,44	1,15	0,21	-21,24	5,35	5,36
26	1434	16,70	79,99	3,32	6,75	26,63	1,00	0,22	-21,35	5,36	4,56
28	1473	16,00	81,20	2,80	6,73	23,50	1,22	0,22	-21,39	5,39	5,68
30	1512	14,49	84,37	1,14	6,69	25,15	1,14	0,21	-21,49	5,34	5,45
32	1551	16,01	79,34	4,65	6,65	24,55	1,13	0,21	-21,50	5,30	5,39
34	1589	15,37	80,74	3,89	6,61	24,36	1,09	0,21	-21,25	5,25	5,26
36	1628	16,12	78,71	5,17	6,70	24,76	1,13	0,21	-21,24	5,28	5,30
38	1666	16,79	77,83	5,39	6,77	23,22	1,16	0,21	-21,25	5,13	5,55
40	1704	16,73	81,16	2,12	6,79	23,59	1,15	0,21	-21,38	5,03	5,37
42	1742	16,82	82,72	0,46	6,90	23,55	1,15	0,21	-21,26	5,16	5,33
44	1779	16,38	77,77	5,85	6,73	24,24	1,09	0,22	-21,25	5,35	4,97
46	1817	19,12	74,32	6,56	6,89	25,33	1,06	0,22	-21,15	5,35	4,92
48	1854	21,34	77,26	1,39	7,14	24,79	1,12	0,22	-21,43	5,43	5,17

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
50	1890	17,52	78,21	4,27	6,83	24,36	1,06	0,25	-21,27	6,02	4,29
52	1927	16,99	79,41	3,60	6,80	24,66	1,15	0,20	-21,30	5,24	5,74
54	1963	18,68	77,71	3,61	6,89	25,02	1,03	0,20	-21,22	4,97	5,04
56	1999	18,75	76,61	4,64	6,96	24,59	0,92	0,21	-21,57	5,28	4,47
58	2035	17,29	78,79	3,93	6,73	26,14	1,18	0,20	-21,30	5,25	5,91
60	2070	6,34	89,83	3,84	6,08	25,65	0,94	0,21	-21,36	5,13	4,52
62	2105	5,97	89,34	4,69	6,00	25,21	1,02	0,23	-21,67	5,49	4,44
64	2140	6,93	90,11	2,95	6,19	29,09	0,95	0,21	-21,50	5,06	4,53
66	2175	5,04	86,44	8,52	5,73	24,26	1,06	0,21	-21,50	5,19	4,98
68	2209	6,27	88,56	5,17	6,01	19,24	1,05	0,21	-21,40	4,93	4,87
70	2243	8,08	86,94	4,98	6,16	24,78	0,96	0,21	-21,43	5,22	4,54
72	2277	6,23	90,71	3,06	6,08	24,20	1,09	0,21	-21,52	4,87	5,10
74	2311	5,96	90,54	3,51	6,03	24,45	1,00	0,21	-21,40	5,21	4,78
76	2344	5,75	90,77	3,48	6,01	24,10	0,99	0,21	-21,45	5,56	4,81
78	2377	7,15	88,71	4,14	6,10	24,11	1,06	0,21	-21,61	5,02	5,14
80	2410	7,30	88,24	4,45	6,11	25,30	1,01	0,21	-21,64	5,50	4,70
82	2443	6,90	87,09	6,01	6,02	23,57	0,96	0,15	-21,48	5,69	6,33
84	2475	7,33	89,81	2,86	6,16	25,47	1,03	0,15	-21,48	5,49	6,90
86	2508	6,49	91,01	2,50	6,13	24,57	0,93	0,15	-21,54	5,15	6,18
88	2540	7,09	87,73	5,19	6,03	25,62	0,98	0,15	-21,72	5,48	6,71
90	2571	7,66	88,38	3,97	6,17	25,85	1,04	0,15	-21,60	5,76	7,03
92	2603	7,62	87,46	4,93	6,12	26,17	1,00	0,15	-21,71	5,36	6,88
94	2634	9,05	88,23	2,72	6,36	26,49	0,91	0,15	-21,86	5,49	6,17
96	2665	6,51	90,34	3,16	6,11	24,13	1,09	0,15	-21,56	5,35	7,08
98	2696	6,61	90,37	3,02	6,14	26,54	1,01	0,15	-21,63	5,67	6,78
100	2727	7,56	90,83	1,61	6,27	26,20	0,96	0,14	-21,77	5,30	6,70
102	2758	7,95	88,49	3,56	6,22	32,59	0,91	0,13	-21,68	5,31	6,90

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
104	2788	10,36	87,83	1,81	6,52	31,53	0,78	0,14	-21,72	5,21	5,55
106	2818	9,64	87,75	2,61	6,42	33,39	0,70	0,14	-21,82	5,45	4,90
108	2848	9,77	87,79	2,45	6,41	0,38	1,22	0,15	-21,41	5,65	8,20
110	2878	5,56	70,51	23,92	5,32	6,10	1,13	0,14	-21,75	5,60	8,11
112	2908	8,99	87,35	3,66	6,30	27,62	0,85	0,14	-21,61	5,47	5,92
114	2938	9,69	87,56	2,76	6,40	67,90	0,44	0,14	-21,66	5,84	3,11
116	2968	8,78	87,10	4,12	6,30	37,53	0,78	0,14	-21,72	5,34	5,45
118	2998	9,49	88,07	2,43	6,40	13,99	1,13	0,15	-21,77	5,59	7,77
120	3028	8,25	85,95	5,81	6,17	26,56	0,96	0,15	-21,50	4,84	6,55
122	3058	6,96	79,53	13,52	5,77	37,28	0,74	0,15	-21,67	5,49	4,98
124	3089	7,47	85,25	7,28	6,02	39,11	0,72	0,15	-21,45	5,59	4,79
126	3119	9,96	88,04	2,00	6,49	26,91	0,86	0,14	-21,54	5,52	6,09
128	3150	7,65	86,94	5,41	6,12	25,94	1,01	0,15	-21,55	5,68	6,88
130	3181	8,85	87,18	3,97	6,31	39,18	0,72	0,14	-21,49	5,21	5,24
132	3212	9,01	87,40	3,59	6,34	36,09	0,81	0,15	-21,81	5,53	5,43
134	3243	8,58	88,08	3,34	6,31	20,25	1,03	0,15	-21,63	5,21	7,02
136	3275	8,92	87,61	3,47	6,33	44,62	0,59	0,14	-21,77	5,39	4,14
138	3307	9,11	87,19	3,70	6,33	41,51	0,64	0,14	-21,91	5,33	4,62
140	3339	9,82	88,66	1,52	6,56	25,56	0,95	0,15	-21,93	5,65	6,47
142	3372	9,12	85,76	5,12	6,37	0,48	1,34	0,15	-21,84	5,37	9,11
144	3405	10,70	88,36	0,94	6,66	27,77	*	0,15	*	5,27	*
146	3439	10,74	86,98	2,28	6,62	27,59	1,00	0,15	-22,07	5,40	6,70
148	3473	10,37	87,12	2,51	6,55	26,41	0,78	0,15	-21,96	5,60	5,29
150	3508	10,04	88,99	0,97	6,61	27,76	0,75	0,14	-21,82	5,45	5,40
152	3543	9,43	88,21	2,36	6,48	27,64	0,83	0,14	-21,89	5,23	5,79
154	3579	9,54	88,27	2,19	6,48	27,47	0,80	0,14	-21,96	5,19	5,79
156	3615	9,97	87,37	2,66	6,49	26,71	0,87	0,14	-21,93	5,57	6,05

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
158	3652	9,26	85,02	5,72	6,31	27,50	0,87	0,14	-21,54	5,47	6,12
160	3690	10,81	87,40	1,79	6,61	28,18	0,85	0,14	-21,68	5,00	6,21
162	3728	8,80	88,31	2,89	6,36	26,57	0,82	0,15	-21,91	5,13	5,56
164	3767	10,23	88,09	1,69	6,56	28,35	0,81	0,15	-22,14	5,37	5,30
166	3806	8,83	84,92	6,25	6,22	27,41	0,71	0,15	-21,75	5,24	4,79
168	3846	10,76	87,07	2,17	6,57	15,57	1,07	0,15	-21,96	5,18	7,08
170	3887	11,00	86,99	2,02	6,60	27,22	0,81	0,16	-21,65	5,17	5,15
172	3928	9,89	87,01	3,11	6,46	26,62	0,84	0,16	-21,74	5,53	5,33
174	3970	8,73	90,68	0,60	6,50	27,21	0,73	0,16	-22,12	5,43	4,64
176	4013	11,80	86,77	1,43	6,71	25,87	0,68	0,16	-21,70	5,52	4,16
178	4056	9,04	89,10	1,86	6,47	27,21	0,89	0,16	-21,63	5,60	5,62
180	4100	9,51	87,73	2,76	6,44	25,90	0,94	0,16	-21,94	5,96	6,01
182	4145	8,70	84,49	6,81	6,22	26,49	1,38	0,14	-22,38	5,15	9,80
184	4191	10,00	87,42	2,57	6,51	27,35	0,64	0,15	-21,77	5,51	4,19
186	4237	10,62	87,66	1,72	6,62	18,30	0,80	0,15	-21,49	5,08	5,34
188	4284	9,61	88,19	2,20	6,48	25,34	0,76	0,15	-21,56	5,40	5,22
190	4332	9,91	87,35	2,74	6,48	*	1,05	0,14	-21,59	5,25	7,39
192	4380	9,45	86,88	3,66	6,40	25,82	0,83	0,15	-21,69	5,44	5,51
194	4430	10,98	86,03	2,99	6,56	24,04	0,85	0,14	-21,73	4,77	5,90
196	4480	10,27	87,83	1,90	6,55	23,48	0,86	0,14	-21,57	4,84	5,92
198	4531	10,80	84,47	4,74	6,48	25,33	0,85	0,14	-21,74	5,23	5,95
200	4583	10,17	87,03	2,80	6,51	25,27	0,90	0,15	-21,77	5,47	6,13
202	4635	9,74	88,20	2,06	6,51	25,77	0,80	0,42	-21,75	4,52	1,90
204	4689	10,21	84,65	5,14	6,43	24,73	0,72	0,14	-21,71	4,16	5,30
206	4743	10,04	84,10	5,86	6,37	24,27	0,83	0,12	-21,74	4,85	6,83
208	4798	10,00	87,54	2,46	6,50	26,22	0,91	0,13	-21,62	4,05	7,06
210	4854	10,50	84,35	5,15	6,46	25,10	0,71	0,14	-21,75	4,59	5,14
212	4911	10,23	85,64	4,13	6,47	24,30	0,81	0,13	-21,63	4,45	6,31

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
214	4969	8,29	88,93	2,78	6,46	25,84	1,01	0,14	-21,85	4,67	6,99
216	5028	9,41	84,83	5,76	6,32	25,38	0,95	0,14	-22,00	4,25	6,98
218	5087	8,72	89,16	2,13	6,45	25,80	0,71	0,13	-22,08	5,46	5,40
220	5148	10,07	88,01	1,92	6,60	24,38	0,88	0,14	-21,94	4,87	6,22
222	5209	11,32	87,01	1,66	6,65	25,19	0,99	0,14	-21,73	4,26	6,87
224	5272	11,83	85,94	2,24	6,65	25,35	0,93	0,14	-21,85	4,99	6,54
226	5335	10,45	87,39	2,16	6,57	26,70	0,92	0,14	-21,87	4,43	6,40
228	5400	12,66	83,72	3,63	6,68	26,54	0,84	0,14	-21,85	4,83	6,07
230	5465	12,15	82,90	4,95	6,62	26,47	0,76	0,13	-21,96	4,81	5,83
232	5532	13,02	82,30	4,69	6,68	27,82	0,51	0,14	-21,87	4,87	3,69
234	5599	12,32	81,11	6,56	6,55	26,79	*	0,14	*	4,82	*
236	5667	9,12	90,38	0,50	6,58	31,85	0,73	0,13	-21,82	4,48	5,62
238	5737	11,08	83,78	5,14	6,54	26,19	0,68	0,13	-22,03	4,73	5,24
240	5807	9,98	85,08	4,93	6,43	27,02	0,49	0,12	-21,87	4,69	4,24
242	5879	9,58	83,37	7,05	6,31	28,87	0,79	0,12	-21,94	5,46	6,32
244	5952	9,32	73,79	16,89	5,92	26,23	1,59	0,12	-22,19	4,52	12,76
246	6025	9,98	80,19	9,83	6,26	25,95	0,49	0,12	-21,84	4,68	4,19
248	6100	9,00	83,21	7,78	6,22	30,53	0,77	0,11	-21,93	4,84	7,04
250	6176	7,00	86,55	6,46	6,18	26,11	0,42	0,11	-22,69	5,10	4,04
252	6253	9,77	72,81	17,42	5,96	25,23	0,58	0,12	-22,11	4,70	4,98
254	6331	10,43	80,70	8,87	6,33	25,39	0,19	0,12	-21,23	4,89	1,63
256	6411	10,16	81,96	7,88	6,34	25,06	0,62	0,12	-21,80	4,80	5,02
258	6491	10,24	77,96	11,80	6,21	24,99	0,40	0,12	-22,14	5,06	3,46
260	6572	9,80	79,39	10,82	6,18	28,49	0,39	*	-21,15	*	*
262	6655	10,23	76,24	13,52	6,11	26,20	0,37	0,12	-22,33	4,98	3,03
264	6738	10,43	79,59	9,98	6,27	26,26	0,57	0,13	-22,20	4,70	4,56
266	6823	11,63	80,47	7,90	6,45	26,28	0,27	*	-22,81	*	*
268	6908	11,08	80,36	8,56	6,40	26,54	0,53	*	-21,96	*	*

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Grain size			Sedimentary organic matter						
		Clay (%)	Silt (%)	Sand (%)	Mean diameter (Φ)	CaCo ₃ (%)	TOC (%)	N _{tot} (%)	$\delta^{13}\text{C}$ (‰ vs. VPDB)	$\delta^{15}\text{N}$ (‰ vs. VPDB)	CN ratio
270	6995	8,17	74,09	17,74	5,73	27,85	0,53	0,13	-21,96	5,09	4,00
272	7083	11,18	77,48	11,34	6,28	30,88	0,30	0,13	-22,72	5,19	2,29
274	7171	10,99	76,13	12,88	6,22	25,61	0,26	*	-22,54	*	*
276	7261	10,62	81,78	7,60	6,41	28,85	0,43	0,12	-21,78	5,31	3,62
278	7352	10,94	81,50	7,56	6,43	*	1,12	0,12	-21,95	4,53	9,61
280	7443	11,13	74,07	14,81	6,17	*	0,61	0,11	-21,99	4,89	5,33
282	7536	12,05	86,27	1,68	6,70	29,51	0,49	0,11	-21,57	5,03	4,31
284	7629	11,19	78,61	10,19	6,32	26,86	0,39	0,12	-21,89	3,87	3,27

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Sedimentary inorganic constituents									
		Al (mg/kg)	Ba (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Ti (mg/kg)	Fe/Ca ratio	Ti/Ca ratio	Ba/Al ratio	Ba/Ca ratio	
0	917	*	*	*	*	*	*	*	*	*	
2	957	84380,30	191,27	43746,90	38363,80	3723,62	0,877	0,085	0,002	0,004	
4	997	*	*	*	*	*	*	*	*	*	
6	1037	78516,30	195,21	42527,40	38801,40	3611,07	0,912	0,085	0,002	0,005	
8	1077	*	*	*	*	*	*	*	*	*	
10	1117	73852,40	193,29	47666,70	41282,50	3904,32	0,866	0,082	0,003	0,004	
12	1157	75167,60	202,00	38196,10	35150,00	3347,48	0,920	0,088	0,003	0,005	
14	1197	76298,90	192,86	41055,80	39829,00	3764,35	0,970	0,092	0,003	0,005	
16	1237	73305,00	194,64	40658,30	39088,50	3660,27	0,961	0,090	0,003	0,005	
18	1276	75139,00	218,99	41490,80	38749,90	3655,19	0,934	0,088	0,003	0,005	
20	1316	74046,80	198,05	43195,60	39465,60	3622,36	0,914	0,084	0,003	0,005	
22	1355	75313,20		40104,30	37303,80	3492,27	0,930	0,087			
24	1395	74781,80	187,76	39134,30	33488,20	3175,76	0,856	0,081	0,003	0,005	
26	1434	73011,70	200,76	40724,60	36511,90	3500,59	0,897	0,086	0,003	0,005	
28	1473	74117,30	197,55	41386,00	37151,00	3515,29	0,898	0,085	0,003	0,005	
30	1512	68348,90	189,27	43111,70	36285,30	3469,38	0,842	0,080	0,003	0,004	
32	1551	67648,00	195,35	41860,90	35386,00	3397,30	0,845	0,081	0,003	0,005	
34	1589	70914,10	*	41631,10	36622,50	3462,26	0,880	0,083	*	*	
36	1628	65186,30	196,78	47525,40	41390,50	4002,95	0,871	0,084	0,003	0,004	
38	1666	73901,50	147,82	43934,90	37311,40	3635,23	0,849	0,083	0,002	0,003	
40	1704	73289,90	137,84	40454,80	36393,90	3481,80	0,900	0,086	0,002	0,003	
42	1742	76497,50	*	38905,60	34420,40	3230,15	0,885	0,083	*	*	
44	1779	77604,20	152,95	42540,00	36557,20	3531,26	0,859	0,083	0,002	0,004	
46	1817	73046,10	150,63	42874,30	36258,80	3415,34	0,846	0,080	0,002	0,004	
48	1854	70919,90	168,47	41287,20	33293,50	3138,24	0,806	0,076	0,002	0,004	

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Sedimentary inorganic constituents									
		Al (mg/kg)	Ba (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Ti (mg/kg)	Fe/Ca ratio	Ti/Ca ratio	Ba/Al ratio	Ba/Ca ratio	
104	2788	69518,60	169,89	65565,10	33601,60	3676,66	0,51249	0,05608	0,002444	0,00259	
106	2818	63848,50	189,84	60178,80	31067,20	3368,79	0,51625	0,05598	0,002973	0,00315	
108	2848	73735,40	190,07	62900,20	35809,90	3879,19	0,56931	0,06167	0,002578	0,00302	
110	2878	79256,30	186,67	74222,80	38835,20	4140,18	0,52322	0,05578	0,002355	0,00251	
112	2908	62042,00	174,94	72755,60	30442,90	3200,92	0,41843	0,044	0,00282	0,0024	
114	2938	71881,70	179,05	84547,00	35358,30	3743,81	0,41821	0,04428	0,002491	0,00212	
116	2968	73721,60	183,86	70523,50	35893,30	3867,25	0,50896	0,05484	0,002494	0,00261	
118	2998	59744,50	184,61	60808,90	30678,20	3334,42	0,5045	0,05483	0,00309	0,00304	
120	3028	60022,10	176,08	69316,70	36910,40	4131,77	0,53249	0,05961	0,002934	0,00254	
122	3058	61622,80	178,49	66154,80	33347,30	3685,46	0,50408	0,05571	0,002897	0,0027	
124	3089	67702,70	176,74	72883,60	38786,20	4304,50	0,53217	0,05906	0,002611	0,00242	
126	3119	56657,60	176,44	63193,20	34129,30	3802,61	0,54008	0,06017	0,003114	0,00279	
128	3150	56347,10	174,63	62429,10	33953,30	3764,88	0,54387	0,06031	0,003099	0,0028	
130	3181	67491,40	212,92	66737,90	34145,20	3702,62	0,51163	0,05548	0,003155	0,00319	
132	3212	64413,00	220,94	61970,20	32229,70	3499,03	0,52008	0,05646	0,00343	0,00357	
134	3243	66602,60	217,36	64266,20	34226,90	3695,23	0,53258	0,0575	0,003264	0,00338	
136	3275	68130,80	221,16	69984,10	34895,50	3886,16	0,49862	0,05553	0,003246	0,00316	
138	3307	54195,10	209,92	67542,40	33973,50	3756,51	0,503	0,05562	0,003873	0,00311	
140	3339	68147,40	216,44	65914,80	34294,40	3893,01	0,52028	0,05906	0,003176	0,00328	
142	3372	65453,20	209,25	62884,30	33544,80	3707,96	0,53344	0,05896	0,003197	0,00333	
144	3405	54724,30	214,20	52649,90	27849,70	3069,15	0,52896	0,05829	0,003914	0,00407	
146	3439	60778,80	212,35	62286,10	33040,50	3679,06	0,53046	0,05907	0,003494	0,00341	
148	3473	64420,40	175,52	57672,50	33661,00	3616,30	0,58366	0,0627	0,002725	0,00304	
150	3508	63694,60	179,20	56941,90	32915,40	3594,80	0,57805	0,06313	0,002813	0,00315	
152	3543	63341,50	180,11	57162,80	32659,70	3646,30	0,57135	0,06379	0,002844	0,00315	
154	3579	48567,30	184,25	45071,80	25152,90	2779,38	0,55806	0,06167	0,003794	0,00409	
156	3615	64649,90	178,69	59934,50	33142,50	3657,32	0,55298	0,06102	0,002764	0,00298	

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Sedimentary inorganic constituents									
		Al (mg/kg)	Ba (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Ti (mg/kg)	Fe/Ca ratio	Ti/Ca ratio	Ba/Al ratio	Ba/Ca ratio	
158	3652	60842,50	174,34	55243,60	31412,70	3437,76	0,56862	0,06223	0,002865	0,00316	
160	3690	63626,70	183,11	60100,90	33277,50	3733,07	0,55369	0,06211	0,002878	0,00305	
162	3728	61707,50	181,61	58098,50	31925,50	3531,00	0,54951	0,06078	0,002943	0,00313	
164	3767	60111,40	183,46	57090,00	30994,40	3446,85	0,5429	0,06038	0,003052	0,00321	
166	3806	57644,60	183,57	55845,10	29992,10	3355,98	0,53706	0,06009	0,003185	0,00329	
168	3846	44130,20	173,57	50278,60	28861,00	3285,68	0,57402	0,06535	0,003933	0,00345	
170	3887	59351,70	183,07	56736,30	32175,10	3569,83	0,5671	0,06292	0,003085	0,00323	
172	3928	*	*	*	*	*	*	*	*	*	
174	3970	59262,50	181,37	54531,80	31338,40	3501,21	0,57468	0,0642	0,00306	0,00333	
176	4013	63673,20	190,55	57540,40	32852,40	3721,45	0,57094	0,06468	0,002993	0,00331	
178	4056	42446,70	181,59	39214,70	22145,80	2455,94	0,56473	0,06263	0,004278	0,00463	
180	4100	66122,40	181,27	62758,00	34028,90	3851,41	0,54222	0,06137	0,002741	0,00289	
182	4145	60186,50	182,82	58284,10	30616,20	3466,93	0,52529	0,05948	0,003038	0,00314	
184	4191	65201,30	180,92	63709,80	33373,20	3766,67	0,52383	0,05912	0,002775	0,00284	
186	4237	52451,60	185,20	51012,40	26751,40	3012,36	0,52441	0,05905	0,003531	0,00363	
188	4284	40899,00	180,87	43189,90	22149,30	2441,96	0,51284	0,05654	0,004422	0,00419	
190	4332	72530,10	183,78	68527,80	34980,60	4099,44	0,51046	0,05982	0,002534	0,00268	
192	4380	*	*	*	*	*	*	*	*	*	
194	4430	45970,00	164,41	52861,20	29573,00	3452,57	0,55945	0,06531	0,003577	0,00311	
196	4480	57312,80	187,14	57107,50	29469,50	3320,43	0,51604	0,05814	0,003265	0,00328	
198	4531	49548,00	169,18	55056,70	31887,40	3673,25	0,57917	0,06672	0,003414	0,00307	
200	4583	61016,90	184,48	60599,60	31053,40	3509,31	0,51244	0,05791	0,003023	0,00304	
202	4635	35363,30	179,19	47838,70	26425,10	3010,27	0,55238	0,06293	0,005067	0,00375	
204	4689	49519,70	179,89	57067,40	29877,30	3380,91	0,52354	0,05924	0,003633	0,00315	
206	4743	59026,10	173,32	62324,90	33133,20	3634,29	0,53162	0,05831	0,002936	0,00278	
208	4798	*	*	*	*	*	*	*	*	*	
210	4854	60736,90	175,36	62229,60	31237,10	3473,45	0,50197	0,05582	0,002887	0,00282	
212	4911	62601,60	170,83	61632,00	32642,70	3744,88	0,52964	0,06076	0,002729	0,00277	

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Sedimentary inorganic constituents									
		Al (mg/kg)	Ba (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Ti (mg/kg)	Fe/Ca ratio	Ti/Ca ratio	Ba/Al ratio	Ba/Ca ratio	
214	4969	47133,90	153,70	43733,50	30154,30	3772,20	0,6895	0,08625	0,003261	0,00351	
216	5028	45110,50	166,26	46988,00	25026,20	2871,74	0,53261	0,06112	0,003686	0,00354	
218	5087	34743,60	171,16	34707,80	19035,10	2121,07	0,54844	0,06111	0,004926	0,00493	
220	5148	60238,60	161,93	57280,60	34135,70	4026,03	0,59594	0,07029	0,002688	0,00283	
222	5209	55930,00	169,25	52000,40	29686,10	3275,46	0,57088	0,06299	0,003026	0,00325	
224	5272	74704,60	193,56	61851,60	35444,70	3720,47	0,57306	0,06015	0,002591	0,00313	
226	5335	69813,80	188,72	60239,30	33417,70	3497,40	0,55475	0,05806	0,002703	0,00313	
228	5400	*	*	*	*	*	*	*	*	*	
230	5465	77212,50	224,78	70763,00	37174,10	4034,34	0,52533	0,05701	0,002911	0,00318	
232	5532	64102,20	195,15	59028,00	30183,80	3223,90	0,51135	0,05462	0,003044	0,00331	
234	5599	72438,00	184,15	63473,50	34255,50	3667,95	0,53968	0,05779	0,002542	0,0029	
236	5667	*	*	*	*	*	*	*	*	*	
238	5737	60568,60	192,07	55526,50	28237,70	2975,42	0,50854	0,05359	0,003171	0,00346	
240	5807	62612,50	194,27	58379,40	29094,50	3172,16	0,49837	0,05434	0,003103	0,00333	
242	5879	53775,00	192,07	61141,80	25978,40	3040,80	0,42489	0,04973	0,003572	0,00314	
244	5952	51418,60	196,85	65270,60	28344,10	3067,25	0,43426	0,04699	0,003828	0,00302	
246	6025	62050,10	195,02	67029,40	29206,50	3232,44	0,43573	0,04822	0,003143	0,00291	
248	6100	58179,70	187,95	64011,90	26987,00	3026,63	0,42159	0,04728	0,003231	0,00294	
250	6176	56356,80	190,07	65362,10	26222,80	2939,06	0,40119	0,04497	0,003373	0,00291	
252	6253	51442,60	189,15	88450,40	24318,10	2794,69	0,27493	0,0316	0,003677	0,00214	
254	6331	61092,20	204,91	63081,20	28254,80	3178,52	0,44791	0,05039	0,003354	0,00325	
256	6411	59030,10	200,14	61702,80	27336,90	3074,77	0,44304	0,04983	0,00339	0,00324	
258	6491	*	*	*	*	*	*	*	*	*	
260	6572	56527,70	190,00	57938,90	26101,50	2901,91	0,4505	0,05009	0,003361	0,00328	
262	6655	51375,40	190,69	58302,20	23675,00	2667,73	0,40607	0,04576	0,003712	0,00327	
264	6738	54842,00	196,95	58332,00	25447,20	2799,26	0,43625	0,04799	0,003591	0,00338	
266	6823	57400,80	191,42	60074,60	27166,80	2902,89	0,45222	0,04832	0,003335	0,00319	
268	6908	54791,80	179,82	59674,10	25849,30	2773,70	0,43317	0,04648	0,003282	0,00301	

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Sedimentary inorganic constituents									
		Al (mg/kg)	Ba (mg/kg)	Ca (mg/kg)	Fe (mg/kg)	Ti (mg/kg)	Fe/Ca ratio	Ti/Ca ratio	Ba/Al ratio	Ba/Ca ratio	
270	6995	56445,10	181,94	76602,30	28635,00	3224,84	0,37381	0,0421	0,003223	0,00238	
272	7083	57232,80	178,18	64236,70	26582,70	2916,23	0,41382	0,0454	0,003113	0,00277	
274	7171	56716,00	182,45	64922,20	26809,00	2973,75	0,41294	0,0458	0,003217	0,00281	
276	7261	41718,10	178,08	46928,80	19854,50	2157,28	0,42308	0,04597	0,004269	0,00379	
278	7352	58038,30	184,37	64241,50	26318,90	2912,11	0,40969	0,04533	0,003177	0,00287	
280	7443	53814,90	170,97	85833,10	24966,70	2747,54	0,29087	0,03201	0,003177	0,00199	
282	7536	50535,50	160,49	74545,30	23969,60	2631,67	0,32154	0,0353	0,003176	0,00215	
284	7629	54185,60	182,72	61071,50	24895,30	2750,49	0,40764	0,04504	0,003372	0,00299	

Cont. Appendix 4 -

[illegible]

Cont. Appendix 4 -

[illegible]

Cont. Appendix 4 -

[illegible]

Cont. Appendix 4 -

[illegible]

Cont. Appendix 4 -

[illegible]

Cont. Appendix 4 -

[illegible]

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy		G. ruber (p) geochemical composition				Mg/Ca based temperature (°C)	δ ¹⁸ O _{w-ivc} (‰, SMOW)
		DM index	FDM/FCM index	δ ¹³ C (‰, VPDB)	δ ¹⁸ O (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)		
0	917	73,02	2,09	*	*	0,81	3,66	25,15	*
2	957	57,49	0,94	*	*	*	*	*	*
4	997	*	*	*	*	*	*	*	*
6	1037	76,31	4,03	*	*	*	*	*	*
8	1077	65,81	2,53	1,80	-0,74	1,15	4,15	26,57	2,32
10	1117	*	*	*	*	*	*	*	*
12	1157	*	*	1,81	-1,14	1,51	*	*	*
14	1197	*	*	*	*	*	*	*	*
16	1237	*	*	*	*	*	3,56	24,86	*
18	1276	*	*	1,62	-1,02	*	*	*	*
20	1316	*	*	*	*	*	*	*	*
22	1355	*	*	1,61	-1,13	*	*	*	*
24	1395	*	*	1,85	-1,05	1,04	3,81	25,62	1,79
26	1434	*	*	*	*	*	*	*	*
28	1473	67,73	2,01	2,03	-0,79	1,17	4,12	26,50	2,25
30	1512	70,47	1,69	*	*	*	*	*	*
32	1551	71,12	2,10	2,02	-1,30	1,14	3,56	24,87	1,38
34	1589	*	*	1,93	-1,28	0,92	3,76	25,46	1,52
36	1628	*	*	*	*	*	*	*	*
38	1666	*	*	1,29	-0,95	0,90	3,82	25,64	1,89
40	1704	*	*	1,71	-0,70	1,00	3,92	25,92	2,21
42	1742	*	*	2,02	-0,79	0,84	4,14	26,53	2,26
44	1779	*	*	*	*	*	*	*	*
46	1817	*	*	*	*	*	*	*	*
48	1854	*	*	1,96	-1,26	0,96	3,92	25,94	1,65

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy		G. ruber (p) geochemical composition					Mg/Ca based temperature (°C)	δ ¹⁸ O _{w-ivc} (‰, SMOW)
		DM index	FDM/FCM index	δ ¹³ C (‰, VPDB)	δ ¹⁸ O (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)			
50	1890	*	*	*	*	*	*	*	*	*
52	1927	*	*	1,55	-1,13	0,84	3,13	23,44	*	1,22
54	1963	*	*	*	*	*	*	*	*	*
56	1999	66,46	1,85	1,67	-0,99	2,10	4,15	26,57	*	2,06
58	2035	*	*	1,82	-0,92	1,19	3,95	26,01	*	2,00
60	2070	63,33	3,06	1,55	-0,55	1,10	4,05	26,29	*	2,44
62	2105	*	*	1,81	-0,98	1,02	3,54	24,80	*	1,67
64	2140	*	*	1,69	-0,52	1,04	3,84	25,69	*	2,34
66	2175	*	*	1,82	-0,62	1,13	3,69	25,25	*	2,14
68	2209	*	*	1,22	-0,66	1,00	3,86	25,76	*	2,21
70	2243	*	*	*	*	*	*	*	*	*
72	2277	*	*	1,71	-1,13	0,96	3,73	25,39	*	1,66
74	2311	*	*	2,04	-1,19	1,52	3,83	25,66	*	1,65
76	2344	*	*	1,92	-0,76	1,38	3,78	25,53	*	2,06
78	2377	*	*	1,66	-0,66	1,02	3,79	25,54	*	2,16
80	2410	*	*	1,95	-0,89	0,92	4,00	26,14	*	2,07
82	2443	*	*	1,58	-0,97	*	*	*	*	*
84	2475	*	*	1,93	-1,59		4,11	26,46	*	1,44
86	2508	67,38	1,87	1,70	-1,13	2,02	3,74	25,42	*	1,66
88	2540	63,73	2,16	1,66	-1,10	*	*	*	*	*
90	2571	60,22	1,86	1,35	-0,71	*	*	*	*	*
92	2603	*	*	1,90	-1,16	*	3,70	25,30	*	1,61
94	2634	*	*	*	*	*	*	*	*	*
96	2665	*	*	1,52	-0,76	1,06	4,04	26,26	*	2,22
98	2696	*	*	1,64	-0,65	1,23	4,34	27,06	*	2,51
100	2727	*	*	*	*	*	*	*	*	*
102	2758	*	*	1,66	-0,60	1,07	4,36	27,12	*	2,57

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy		G. ruber (p) geochemical composition					Mg/Ca based temperature (°C)	δ ¹⁸ O _{w-ivc} (‰, SMOW)
		DM index	FDM/FCM index	δ ¹³ C (‰, VPDB)	δ ¹⁸ O (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)			
104	2788	*	*	1,76	-0,69	1,10	4,23	26,77	2,40	
106	2818	*	*	1,56	-0,64	1,69	4,23	26,78	2,46	
108	2848	*	*	1,63	-0,77	*	4,05	26,30	2,22	
110	2878	*	*	1,27	-0,63	2,26	4,00	26,16	2,33	
112	2908	*	*	1,47	-0,55	1,12	4,27	26,88	2,57	
114	2938	*	*	1,80	-0,65	1,38	3,74	25,39	2,13	
116	2968	*	*	1,55	-0,82	1,16	3,85	25,72	2,04	
118	2998	65,19	2,67	2,01	-0,80	1,64	4,07	26,34	2,20	
120	3028	47,53	1,42	1,66	-1,22	1,44	3,91	25,89	1,68	
122	3058	53,23	0,89	1,53	-0,40	1,33	4,33	27,03	2,76	
124	3089	*	*	*	*	*	*	*	*	
126	3119	*	*	1,59	-0,74	1,10	4,09	26,39	2,27	
128	3150	*	*	1,76	-0,67	1,11	3,87	25,80	2,21	
130	3181	*	*	*	*	1,37	3,90	25,86	*	
132	3212	*	*	1,87	-0,82	*	*	*	*	
134	3243	*	*	*	*	*	*	*	*	
136	3275	*	*	1,62	-0,47	1,49	3,98	26,10	2,48	
138	3307	*	*	1,70	-0,78		4,11	26,47	2,24	
140	3339	*	*	1,52	-0,45	1,33	4,20	26,69	2,63	
142	3372	*	*	1,55	-0,99	1,23	3,56	24,85	1,67	
144	3405	*	*	1,99	-1,17	*	*	*	*	
146	3439	*	*	1,41	-0,62	1,76	4,18	26,64	2,45	
148	3473	*	*	1,82	-0,71	1,34	4,10	26,42	2,30	
150	3508	68,77	2,29	1,93	-0,99	*	*	*	*	
152	3543	63,09	1,48	1,69	-0,89	1,91	4,12	26,49	2,14	
154	3579	59,53	2,23	1,82	-0,73	1,38	3,80	25,58	2,10	
156	3615	*	*	1,65	-0,69	2,15	4,51	27,49	2,56	

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy		G. ruber (p) geochemical composition					Mg/Ca based temperature (°C)	δ ¹⁸ O _{w-ivc} (‰, SMOW)
		DM index	FDM/FCM index	δ ¹³ C (‰, VPDB)	δ ¹⁸ O (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)			
158	3652	*	*	1,74	-1,15	*	*	*	*	*
160	3690	*	*	*	*	*	*	*	*	*
162	3728	*	*	1,88	-0,59	1,46	4,42	27,27	2,62	2,62
164	3767	*	*	1,78	-0,60	1,26	4,24	26,79	2,49	2,49
166	3806	*	*	1,71	-0,68	1,72	4,39	27,19	2,51	2,51
168	3846	*	*	1,70	-0,38	1,43	4,25	26,83	2,73	2,73
170	3887	*	*	1,60	-0,44	1,17	4,17	26,61	2,62	2,62
172	3928	*	*	*	*	*	*	*	*	*
174	3970	56,26	1,09	2,00	-0,79	1,77	4,31	26,98	2,35	2,35
176	4013	67,80	1,46	1,82	-0,41	1,30	3,30	24,02	2,06	2,06
178	4056	59,94	1,69	1,44	-0,35	1,80	4,10	26,42	2,66	2,66
180	4100	*	*	1,85	-0,65	1,48	3,91	25,90	2,24	2,24
182	4145	*	*	1,70	-0,86	1,05	4,06	26,32	2,13	2,13
184	4191	*	*	1,69	-0,16	1,25	4,17	26,63	2,90	2,90
186	4237	*	*	1,91	-1,06	1,44	4,03	26,23	1,91	1,91
188	4284	*	*	*	*	*	*	*	*	*
190	4332	*	*	2,09	-0,93	1,86	3,99	26,12	2,01	2,01
192	4380	*	*	1,62	-0,65	1,21	3,67	25,21	2,09	2,09
194	4430	*	*	1,81	-0,67	1,25	3,94	25,99	2,24	2,24
196	4480	51,71	0,76	1,71	-1,18	1,43	4,07	26,34	1,82	1,82
198	4531	57,27	1,59	1,63	-0,68	1,35	3,95	26,03	2,24	2,24
200	4583	66,75	1,59	1,71	-0,81	1,53	3,98	26,09	2,13	2,13
202	4635	*	*	1,74	-0,33	1,16	3,71	25,33	2,43	2,43
204	4689	*	*	1,95	-0,57	1,19	3,90	25,86	2,32	2,32
206	4743	*	*	1,59	-0,71	1,01	3,56	24,87	1,95	1,95
208	4798	*	*	1,95	-0,83	1,29	3,76	25,48	1,97	1,97
210	4854	*	*	1,87	-0,98	1,15	3,77	25,50	1,82	1,82
212	4911	*	*	1,82	-0,23	1,26	3,56	24,86	2,42	2,42

Cont. Appendix 4 -

Core depth (cm)	Estimated age (yr cal. BP)	Mineralogy		G. ruber (p) geochemical composition					$\delta^{18}\text{O}_{\text{w-ivc}}$ (‰, SMOW)
		DM index	FDM/FCM index	$\delta^{13}\text{C}$ (‰, VPDB)	$\delta^{18}\text{O}$ (‰, VPDB)	Ba/Ca (umol/mol)	Mg/Ca (mmol/mol)	Mg/Ca based temperature (°C)	
214	4969	59,65	1,60	1,74	-0,88	1,24	3,94	26,00	2,03
216	5028	*	*	1,90	-0,55	1,26	4,26	26,86	2,56
218	5087	62,21	1,33	1,59	-0,82	1,23	3,66	25,17	1,90
220	5148	*	*	1,80	-0,99	1,78	3,81	25,61	1,84
222	5209	*	*	1,64	-0,73	1,51	3,60	24,97	1,95
224	5272	*	*	2,07	-0,80	1,51	3,69	25,25	1,94
226	5335	*	*	*	*	*	*	*	*
228	5400	*	*	2,01	-1,20	1,62	3,75	25,45	1,59
230	5465	*	*	*	*	*	*	*	*
232	5532	58,98	1,67	1,73	-0,67	1,51	3,94	25,98	2,24
234	5599	50,92	1,06	1,86	-0,78	1,57	3,85	25,73	2,07
236	5667	61,52	2,08	1,82	-0,78	1,65	3,92	25,93	2,12
238	5737	*	*	1,62	-0,49	1,30	4,20	26,70	2,57
240	5807	*	*	1,92	-0,73	1,41	3,91	25,89	2,16
242	5879	*	*	2,08	-0,81	1,24	4,22	26,76	2,27
244	5952	*	*	1,84	-0,73	1,44	4,13	26,51	2,29
246	6025	59,06	1,87	1,88	-0,72	1,34	4,16	26,58	2,32
248	6100	59,36	1,46	2,15	-0,96	1,47	4,14	26,54	2,06
250	6176	52,12	1,30	1,68	-0,65	*	*	*	*
252	6253	*	*	1,93	-0,87	*	*	*	*
254	6331	*	*	1,74	-1,10	1,14	4,07	26,35	1,88
256	6411	*	*	1,90	-0,44	1,24	3,68	25,22	2,29
258	6491	*	*	2,01	-0,84	2,26	4,11	26,45	2,16
260	6572	64,20	1,04	*	*	*	*	*	*
262	6655	54,56	1,20	1,60	-0,35	1,66	4,12	26,48	2,66
264	6738	61,92	1,75	2,07	-0,86	1,21	4,01	26,18	2,08
266	6823	*	*	1,78	-0,57	1,40	3,83	25,68	2,25
268	6908	*	*	2,16	-0,78	1,08	4,11	26,46	2,21

Appendix 5 - Core 7616 benthic foraminifera community data, identified taxa microhabitat classification and relative frequency (%), and values of total density (tests·10cc⁻¹), percentages of fragments, non-identified specimens, epifauna and infauna specimens, productivity indexes BFHP (%) and BFAR (tests·cm⁻²·kyr⁻¹) and ecological parameters richness (S), Shannon diversity (H') and equitability (J'). Where: epifauna (E) and infauna (I).

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			1037	1434	1551
			Benthic foraminifera (%)		
<i>Amphicoryna</i> spp.	I	Fontanier et al., 2004	0,00	0,00	0,20
<i>Angulogerina angulosa</i> (Williamson, 1858)	I	Corliss, 1985; Corliss e Chen, 1988	15,19	17,11	15,86
<i>Angulogerina</i> spp.	I	Corliss, 1985; Corliss e Chen, 1989	2,47	1,78	2,41
<i>Astacolus crepidulus</i>			0,00	0,00	0,00
<i>Bolivina doniezi</i> Cushman & Wickenden, 1929	I	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Bolivina pseudoplicata</i> Heron-Allen & Earland, 1930	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina pulchella</i> (d'Orbigny, 1839)	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina pulchella f. primitiva</i> Cushman, 1930	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina skagerrakensis</i> Qvale & Nigam, 1985	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,00	0,00
<i>Bolivina subspinensis</i> Cushman, 1922	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	1,06	0,22	0,60
<i>Brizalina ordinaria</i> (Phleger & Parker, 1952)	I	Murray, 1991; Fontanier et al., 2003 - genera Bolivina	0,00	0,22	0,00
<i>Bolivina</i> spp.	I	Murray, 1991; Fontanier et al., 2003	0,00	0,00	0,20
<i>Brizalina subaenariensis</i> (Cushman, 1922)	I	Corliss, 1985; Corliss e Chen, 1988	0,00	0,89	0,00
<i>Brizalina spathulata</i> (Williamson, 1858)	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	0,00	0,00	0,40
<i>Brizalina</i> sp.1	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	0,00	0,22	0,40
<i>Brizalina</i> spp.	I	Murray, 1991; Fontanier et al., 2003 - genera Brizalina	1,06	0,44	0,60
<i>Buccella peruviana</i> (d'Orbigny, 1839)	I	Murray, 1991 - genera Buccella	0,00	0,00	0,00
<i>Bulimina aculeata</i> d'Orbigny, 1826	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	0,00	0,22	0,20
<i>Bulimina elongata</i> d'Orbigny, 1846	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	0,00	0,22	0,20
<i>Bulimina gibba</i> Fornasini, 1900	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	0,00	0,00	0,00
<i>Bulimina marginata</i> d'Orbigny, 1826	I	Murray, 1991; Corliss e Chen, 1988; Fontanier et al., 2002 - genera Bulimina	15,90	11,11	10,44
<i>Bulimina mexicana</i> Cushman, 1922	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	0,00	0,00	0,00
<i>Bulimina pseudoaffinis</i> Kleinpell, 1938	I	Murray, 1991; Fontanier et al., 2002 - genera Bulimina	1,41	0,44	1,20
<i>Bulimina</i> spp.	I	Murray, 1991; Fontanier <i>et al.</i> , 2002	4,59	2,67	3,61

Cont. Appendix 5 -

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			1037	1434	1551
			Benthic foraminifera (%)		
<i>Buliminella elegantissima</i> (d'Orbigny 1839)	I	Murray, 1991 - genera Buliminella	0,00	0,00	0,00
<i>Cancris auriculatus</i> (Fichtel & Moll, 1798)	E	Murray, 1991; Fontanier et al., 2002 - genera Cancris	0,00	0,00	0,00
<i>Cancris</i> spp.	E	Murray, 1991; Fontanier et al., 2002	0,35	0,00	0,20
<i>Cassidulina carinata</i> (Silvestri, 1896)	I	Murray, 1991 - genera Cassidulina	0,00	0,00	0,40
<i>Cassidulina laevigata</i> d'Orbigny, 1826	I	Murray, 1991 - genera Cassidulina	0,00	0,00	0,20
<i>Cassidulina</i> spp.	I	Murray, 1991	0,00	0,67	0,40
<i>Cibicides</i> spp.	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991	0,00	0,22	0,00
<i>Cibicides ungerianus</i> (d'Orbigny, 1846)	E	Murray, 1991- genera Cibicidoides	0,35	0,00	0,40
<i>Cibicidoides wuellerstorfi</i> (Schwager, 1866)	E	Murray, 1991- genera Cibicidoides	0,00	0,22	0,00
<i>Cibicidoides</i> spp.	E	Murray, 1991	0,00	0,00	0,00
<i>Clavulina humilis</i> Brady, 1884			0,00	0,00	0,20
<i>Clavulina multicamerata</i> Chapman, 1907			0,00	0,00	0,00
<i>Clavulina</i> spp.			0,35	0,00	0,60
<i>Criboelphidium incertum</i>			0,00	0,00	0,00
<i>Dentalina ariana</i> Patterson & Pettis, 1986	I	Corliss e Chen, 1988 - genera Dentalina	0,00	0,00	0,00
<i>Dentalina</i> spp.	I	Corliss e Chen, 1988	0,00	0,22	0,00
<i>Discorbinella</i> spp.			0,00	0,00	0,00
<i>Discorbis williamsoni</i> Chapman & Parr, 1932	E	Murray, 1991 - genera Discorbis	0,00	0,00	0,00
<i>Dorothia goessi</i> (Cushman, 1911)			0,00	0,67	0,00
<i>Epistominella</i> spp.			0,00	13,11	1,20
<i>Evolvocassidulina orientalis</i> (Cushman, 1922)			0,00	0,00	0,00
<i>Fissurina laevigata</i> Reuss, 1850	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Fissurina lucida</i> (Williamson, 1884)	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Fissurina marginata</i> (Montagu, 1803)	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,00
<i>Fissurina quadricostulata</i> Silvestri, 1902	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,20
<i>Fissurina</i> spp.	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,00	0,40
<i>Fissurina staphyllearia</i> Schwager, 1866	I	Corliss e Chen, 1988 - genera Fissurina	0,00	0,22	0,20
<i>Favulina hexagona</i> (Williamson, 1848)	I	Corliss e Chen, 1988 - genera Favulina	0,00	0,00	0,00

Cont. Appendix 5 -

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			1037	1434	1551
			Benthic foraminifera (%)		
<i>Favulina melo</i> (d' Orbigny, 1839)	I	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Gavelinopsis praegeri</i> (Heron-Allen & Earland, 1913)	E	Murray, 1991 - genera Gavelinopsis	0,00	0,22	0,00
<i>Gavelinopsis</i> spp.	E	Corliss, 1985; Corliss e Chen, 1988	0,00	0,00	0,00
<i>Globocassidulina</i> spp.	I	Murray, 1991	9,54	6,22	12,25
<i>Globocassidulina subglobosa</i> (Brady, 1881)	I	Murray, 1991 - genera Globocassidulina; Fontanier <i>et al.</i> , 2002	19,43	22,44	31,33
<i>Gyroidina altiformis</i> R.E. & K.C. Stewart, 1930	E	Fontanier <i>et al.</i> , 2002	0,00	0,00	0,00
<i>Gyroidina umbonata</i> (Silvestri, 1898)	E	Murray, 1991; Corliss e Chen, 1988 - genera Gyroidina; Fontanier <i>et al.</i> , 2008	4,59	6,22	5,02
<i>Gyroidina</i> spp.	E	Fontanier <i>et al.</i> , 2003	2,47	2,00	1,81
<i>Hoeglundina elegans</i> (d' Orbigny, 1826)	E	Corliss, 1985; Fontanier <i>et al.</i> , 2002	0,71	0,00	0,20
<i>Islandiella norcrossi</i> (Cushman, 1933)	I	Murray, 1991- genera Islandiella; Corliss e Chen, 1988	14,49	4,67	4,42
<i>Procerolagena gracilis</i> (Williamson, 1848)			0,00	0,22	0,40
<i>Lagena laevis</i> (Montagu, 1803)	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena laevis</i> , f. tenuis Williamson, 1848	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena laevis</i> , f. typica Williamson, 1848	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena</i> spp.	I	Corliss e Chen, 1988	0,00	0,22	0,00
<i>Lagena striata</i> (d'Orbigny, 1839)	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,00	0,00
<i>Lagena sulcata</i>	I	Corliss e Chen, 1988 - genera Lagena	0,00	0,22	0,00
<i>Lenticulina</i> sp.1	E	Murray, 1991 - genera Lenticulina	0,00	0,00	0,00
<i>Lenticulina</i> spp.	E	Murray, 1991	1,06	0,00	0,00
<i>Liesbusella</i> sp.			0,00	0,00	0,00
<i>Lobatula lobatula</i> (Walker & Jacob, 1798)			0,00	0,22	0,20
<i>Melonis barleeanus</i> (Williamson, 1858)	I	Murray, 1992; Corliss e Chen, 1988 - genera Melonis	0,00	0,00	0,00
<i>Melonis</i> spp.	I	Murray, 1992; Corliss e Chen, 1989	0,00	0,00	0,00
<i>Miliolinella subrotunda</i> (Montagu, 1803)	E	Corliss, 1991 - Miliolideos	0,00	0,00	0,00
<i>Neolenticulina variabilis</i> (Reuss, 1850)	E	Corliss, 1985; Corliss e Chen, 1988 - genera Neolenticulina	0,00	0,00	0,00
<i>Nonion</i> sp. (juvenil)	I	Murray, 1991 - genera Nonion	0,00	0,00	0,00
<i>Nonion</i> spp.	I	Murray, 1991	0,00	0,67	0,00
<i>Nonionella</i> spp.	I	Murray, 1991	0,00	0,00	0,00

Cont. Appendix 5 -

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			1037	1434	1551
			Benthic foraminifera (%)		
<i>Nonionoides turgida</i> (Williamson, 1858)	I	Corliss, 1985; Corliss e Chen, 1988	0,00	0,89	0,20
<i>Nonionoides grateloupi</i> (d'Orbigny, 1826)	I	Murray, 1991 - genera Nonionoides	0,00	0,00	0,20
<i>Nonionoides punctulatus</i>	I	Murray, 1991 - genera Nonionoides	0,00	0,00	0,00
<i>Nonionoides</i> spp.	I	Murray, 1991	0,00	0,00	0,00
<i>Oolina acuticosta</i>			0,00	0,00	0,00
<i>Oolina melo</i>			0,00	0,00	0,00
<i>Osanguriella umbonifera</i> (Cushman, 1933)			0,00	0,00	0,20
<i>Planulina</i> spp.	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991 - genera Planulina	0,00	0,00	0,00
<i>Polymorphinella</i> sp.			0,00	0,00	0,00
<i>Pseudogaudryna</i> sp. nov.			1,06	0,00	0,60
<i>Pseudononion atlanticum</i> (Cushman, 1936)	I	Corliss, 1985; Corliss e Chen, 1988 - genera Pseudononion	0,00	0,00	0,40
<i>Pullenia bulloides</i> (d'Orbigny, 1846)	I		0,00	0,00	0,00
<i>Pullenia osloensis</i> Feyling-Hanssen, 1954			0,00	0,00	0,00
<i>Pulenia quadriloba</i>			0,00	0,00	0,00
<i>Pullenia quinqueloba</i> (Reuss, 1851)			0,00	0,00	0,00
<i>Pyrgo depressa</i> (d' Orbigny, 1826)	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,00	0,00	0,00
<i>Pyrgo murrhina</i> (Schwager, 1866)	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,00	0,00	0,00
<i>Pyrgo nasuta</i> Cushman, 1935	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,00	0,00	0,40
<i>Pyrgo ringens</i> (Lamarck, 1804)	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,35	0,22	0,00
<i>Pyrgo</i> sp.3	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Pyrgo	0,00	0,00	0,20
<i>Pyrgo</i> spp.	E	Corliss, 1991 - Miliolideos	0,35	0,00	0,20
<i>Quinqueloculina akneriana</i> d' Orbigny, 1846	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,00	0,00	0,00
<i>Quinqueloculina atlantica</i>	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,00	0,22	0,00
<i>Quinqueloculina lamarckiana</i> d'Orbigny, 1839	E	Corliss, 1991 - Miliolideos ; Murray, 1991 - genera Quinqueloculina	0,35	0,00	0,00
<i>Quinqueloculina</i> spp.	E	Corliss, 1991 - Miliolideos ; Murray, 1991	0,35	0,00	0,40
<i>Reophax</i> sp.			0,35	0,00	0,20
<i>Rosalina globularis</i> (d' Orbigny, 1826)	E	Murray, 1991 - genera Rosalina	0,00	0,67	0,00
<i>Rosalina</i> spp.	E	Murray, 1991	0,00	0,00	0,00

Cont. Appendix 5 -

Benthic foraminifera taxa	Microhabitat	References	Estimated age (yr cal. BP)		
			1037	1434	1551
			Benthic foraminifera (%)		
<i>Saracenaria</i> sp.			0,00	0,00	0,00
<i>Seabrookia earlandi</i> Wright, 1891	E	Heinz et al., 2004	0,00	0,67	0,00
<i>Sigmollopsis schlumbergeri</i> (Silvestri, 1904)	E	Di Stefano et al., 2010; Pipper and Reichenbacher, 2010 - genera Sigmollopsis	0,00	0,67	0,00
<i>Siphonina bradyana</i> Cushman, 1927			0,00	0,67	0,20
<i>Siphotextullaria</i> sp.			0,35	0,00	0,00
<i>Spiroglutina</i> spp.	E	Corliss, 1985; Corliss e Chen, 1988; Corliss, 1991	0,35	0,22	0,20
<i>Spiroplectinella wrightii</i> (Silvestri, 1903)			0,00	0,00	0,00
<i>Stainforthia complanata</i> (Egger, 1895)	SI	Bubenshchikova et al., 2008	0,00	0,44	0,00
<i>Stainforthia</i> spp.	SI	Bubenshchikova et al., 2008	0,00	0,00	0,00
<i>Textullaria pseudogramen</i>			0,00	0,00	0,00
<i>Textullaria</i> sp.1	E	Corliss, 1985; Corliss e Chen, 1988; Murray, 1991	0,00	0,00	0,00
<i>Textullaria</i> sp.2			0,00	0,00	0,00
<i>Textullaria</i> sp.4			0,00	0,00	0,00
<i>Textullaria</i> spp.	E		1,41	0,00	0,00
<i>Triloculina</i> spp.	E	Corliss, 1991 - Miliolideos	0,00	0,44	0,00
<i>Uvigerina auberiana</i> d'Orbigny, 1839	I	Murray, 1991; Fontanier et al., 2002 - genera Uvigerina	0,00	0,00	0,00
<i>Uvigerina peregrina</i> Cushman, 1923	I	Murray, 1991; Corliss e Chen, 1988 - genera Uvigerina	0,00	0,67	0,20
<i>Uvigerina</i> spp.	I	Murray, 1991 Fontanier et al., 2002 - genera Uvigerina	0,00	0,00	0,00
total density (tests•10 cc ⁻¹)			2547	10800	14940
fragments (%)			13,07	8,00	12,45
not identified (%)			1,41	0,89	1,81
E (%)			7,42	5,78	3,82
I (%)			90,46	92,44	93,57
BFHP index (%)			24,03	18,67	18,27
BFAR index (tests•cm ⁻² •kyr ⁻¹)			127202	552455	774170
R			26	41	45
H'			2,42	2,56	2,42
J'			0,74	0,69	0,64

Cont. Appendix 5 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)												
	1742	2035	2209	2540	2603	2998	3119	3307	3439	3615	3846	4013	4531
	Benthic foraminifera (%)												
<i>Amphicoryna</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Angulogerina angulosa</i> (Williamson, 1858)	11,52	8,43	12,50	16,05	8,06	14,57	3,89	10,88	11,04	5,00	8,19	12,24	16,80
<i>Angulogerina</i> spp.	2,42	3,19	2,50	0,86	2,09	1,76	1,95	1,36	2,99	1,80	1,26	1,53	4,34
<i>Astacolus crepidulus</i>	0,00	0,00	0,00	0,29	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina donjezi</i> Cushman & Wickenden, 1929	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,27
<i>Bolivina pseudoplicata</i> Heron-Allen & Earland, 1930	0,00	0,00	0,25	0,00	0,60	0,00	0,00	0,00	0,00	1,20	0,21	0,38	0,00
<i>Bolivina pulchella</i> (d'Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,00
<i>Bolivina pulchella f. primitiva</i> Cushman, 1930	0,56	0,00	0,00	0,00	0,00	0,50	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina skagerakensis</i> Qvale & Nigam, 1985	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bolivina subspinsensis</i> Cushman, 1922	0,56	0,68	1,00	1,15	0,90	1,76	0,39	0,00	1,19	0,00	0,84	1,72	2,98
<i>Brizalina ordinaria</i> (Phleger & Parker, 1952)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,80	0,21	0,00	0,27
<i>Bolivina</i> spp.	0,19	0,00	0,25	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Brizalina subaenariensis</i> (Cushman, 1922)	0,00	0,00	0,00	0,29	0,00	0,25	0,00	0,00	0,00	0,00	0,21	0,76	0,81
<i>Brizalina spathulata</i> (Williamson, 1858)	0,56	0,23	0,00	0,29	0,00	0,25	0,00	0,00	0,30	0,00	0,00	0,76	0,27
<i>Brizalina</i> sp.1	0,56	0,46	0,25	0,29	0,30	0,50	0,00	0,68	0,00	0,40	0,21	0,38	0,00
<i>Brizalina</i> spp.	1,30	0,68	1,25	0,86	2,09	1,01	2,33	0,68	0,30	0,80	1,26	1,15	1,36
<i>Buccella peruviana</i> (d'Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,19	0,00
<i>Bulimina aculeata</i> d'Orbigny, 1826	0,37	0,46	0,00	0,29	0,00	0,25	0,00	0,34	0,90	0,00	0,00	0,38	0,54
<i>Bulimina elongata</i> d' Orbigny, 1846	0,19	0,00	0,25	0,00	0,00	0,00	0,78	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina gibba</i> Fornasini, 1900	0,19	0,00	0,25	0,00	0,90	0,00	0,39	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina marginata</i> d' Orbibny, 1826	9,29	14,58	12,75	10,89	6,57	16,58	5,84	7,48	12,54	3,60	6,30	8,41	11,65
<i>Bulimina mexicana</i> Cushman, 1922	0,00	0,00	0,00	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Bulimina pseudoaffinis</i> Kleinpell, 1938	0,93	2,28	0,50	0,86	0,60	0,75	0,39	0,34	0,60	0,20	0,63	0,76	0,27
<i>Bulimina</i> spp.	2,23	2,28	4,00	3,44	0,90	2,26	0,78	1,70	1,79	1,20	1,47	2,10	2,44

Cont. Appendix 5 -

	Benthic foraminifera taxa													
	Estimated age (yr cal. BP)													
	1742	2035	2209	2540	2603	2998	3119	3307	3439	3615	3846	4013	4531	
	Benthic foraminifera (%)													
<i>Buliminella elegantissima</i> (d' Orbigny 1839)	0,00	0,23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,19	0,00	
<i>Cancris auriculus</i> (Fichtel & Moll, 1798)	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Cancris</i> spp.	0,19	0,00	0,00	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Cassidulina carinata</i> (Silvestri, 1896)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,00	
<i>Cassidulina laevigata</i> d'Orbigny, 1826	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Cassidulina</i> spp.	0,37	0,00	0,75	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Cibicides</i> spp.	0,00	0,00	0,00	0,00	0,00	0,25	0,00	0,00	0,00	0,40	0,00	0,00	0,00	
<i>Cibicides ungerianus</i> (d' Orbigny, 1846)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,00	0,63	0,19	0,00	
<i>Cibicoides wuellerstorfi</i> (Schwager, 1866)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Cibicoides</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,27	
<i>Clavulina humilis</i> Brady, 1884	0,37	0,00	0,25	0,29	0,00	0,25	0,39	0,00	0,00	0,20	0,21	0,19	0,00	
<i>Clavulina multicamerata</i> Chapman, 1907	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Clavulina</i> spp.	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Criboelphidium incertum</i>	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,40	0,21	0,00	0,00	
<i>Dentalina ariena</i> Patterson & Pettis, 1986	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Dentalina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Discorbinella</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,00	
<i>Discorbis williamsoni</i> Chapman & Parr, 1932	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Dorothia goessi</i> (Cushman, 1911)	0,19	0,00	0,75	0,00	0,00	0,00	0,00	0,34	0,00	0,00	0,00	0,00	0,00	
<i>Epistominella</i> spp.	16,54	2,05	14,50	13,76	37,91	0,00	23,74	11,56	0,00	25,00	23,53	12,04	0,27	
<i>Evolvocassidulina orientalis</i> (Cushman, 1922)	0,00	0,23	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Fissurina laevigata</i> Reuss, 1850	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,19	0,27	
<i>Fissurina lucida</i> (Williamson, 1884)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,19	0,00	
<i>Fissurina marginata</i> (Montagu, 1803)	0,37	0,23	0,00	0,00	0,00	0,00	0,00	0,34	0,00	0,00	0,00	0,38	0,00	
<i>Fissurina quadricostulata</i> Silvestri, 1902	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	
<i>Fissurina</i> spp.	0,19	0,00	0,25	0,29	0,00	0,00	0,00	0,00	0,00	0,20	0,21	0,00	0,00	
<i>Fissurina staphyllearia</i> Schwager, 1866	0,19	0,00	0,00	0,29	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,19	0,00	
<i>Favulina hexagona</i> (Williamson, 1848)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,19	0,00	

Cont. Appendix 5 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)												
	1742	2035	2209	2540	2603	2998	3119	3307	3439	3615	3846	4013	4531
	Benthic foraminifera (%)												
<i>Favulina melo</i> (d' Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,21	0,00	0,00
<i>Gavelinopsis praegeri</i> (Heron-Allen & Earland, 1913)	0,37	0,46	1,00	2,01	0,00	0,25	0,00	0,00	0,30	0,00	0,21	0,19	1,08
<i>Gavelinopsis</i> spp.	0,00	0,00	0,00	0,00	0,00	0,25	0,00	0,34	0,00	0,00	0,00	0,00	0,00
<i>Globocassidulina</i> spp.	6,88	9,57	4,00	6,88	4,78	9,30	7,00	14,97	8,66	8,80	2,31	3,25	8,13
<i>Globocassidulina subglobosa</i> (Brady, 1881)	27,32	30,07	19,00	24,36	25,67	28,64	37,35	35,37	42,39	36,80	37,61	36,14	20,60
<i>Gyroidina altiformis</i> R.E. & K.C. Stewart, 1930	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,34	0,00	0,00	0,00	0,00	0,00
<i>Gyroidina umbonata</i> (Silvestri, 1898)	4,46	6,83	5,25	4,87	3,58	8,29	3,11	2,72	5,67	2,20	5,88	4,40	5,96
<i>Gyroidina</i> spp.	1,67	3,19	3,00	1,15	1,79	1,51	0,78	0,68	2,69	0,60	1,05	1,15	1,90
<i>Hoeglundina elegans</i> (d' Orbigny, 1826)	0,19	0,23	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,21	0,00	0,00
<i>Islandiella norcrossi</i> (Cushman, 1933)	4,46	8,88	8,25	5,73	1,79	6,53	5,06	2,72	6,27	4,60	3,78	4,97	10,30
<i>Procerolagena gracilis</i> (Williamson, 1848)	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena laevis</i> (Montagu, 1803)	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena laevis</i> , f. tenuis Williamson, 1848	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lagena laevis</i> , f. typica Williamson, 1848	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,19	0,00
<i>Lagena</i> spp.	0,19	0,00	0,00	0,57	0,00	0,00	0,00	0,34	0,00	0,00	0,00	0,19	0,27
<i>Lagena striata</i> (d'Orbigny, 1839)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,60	0,20	0,00	0,00	0,00
<i>Lagena sulcata</i>	0,56	0,23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lenticulina</i> spp.	0,00	0,00	0,25	0,00	0,00	0,25	0,78	0,34	0,00	0,00	0,21	0,00	0,00
<i>Liesbusella</i> sp.	0,00	0,00	0,00	0,29	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Lobatula lobatula</i> (Walker & Jacob, 1798)	0,56	0,46	0,25	0,00	0,00	0,00	0,00	0,34	0,30	1,00	0,21	0,00	0,00
<i>Melonis barleeanus</i> (Williamson, 1858)	0,00	0,23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Melonis</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,34	0,00	0,00	0,00	0,00	0,00
<i>Miliolinella subrotunda</i> (Montagu, 1803)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,34	0,00	0,00	0,00	0,00	0,00
<i>Neolenticulina variabilis</i> (Reuss, 1850)	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,34	0,00	0,00	0,00	0,00	0,00
<i>Nonion</i> sp. (juvenil)	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,00
<i>Nonion</i> spp.	0,19	0,00	0,00	0,29	0,00	0,00	0,00	0,00	0,30	0,20	0,21	0,19	0,00
<i>Nonionella</i> spp.	0,19	0,00	0,00	0,00	0,00	0,00	0,00	0,68	0,00	0,60	0,21	0,38	0,00

Cont. Appendix 5 -

[illegible]

Cont. Appendix 5 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)												
	1742	2035	2209	2540	2603	2998	3119	3307	3439	3615	3846	4013	4531
	Benthic foraminifera (%)												
<i>Saracenaria</i> sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,19	0,00
<i>Seabrookia earlandi</i> Wright, 1891	0,74	0,00	1,00	0,29	0,60	0,00	2,33	1,36	0,00	1,20	0,84	1,15	0,27
<i>Sigmoilopsis schlumbergeri</i> (Silvestri, 1904)	0,00	0,00	0,00	0,00	0,00	0,00	0,39	0,00	0,00	0,00	0,00	0,19	1,08
<i>Siphonina bradyana</i> Cushman, 1927	0,00	0,23	0,00	1,43	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,19	0,27
<i>Siphotextullaria</i> sp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Spiroglutina</i> spp.	0,19	0,00	0,00	0,00	0,00	1,01	0,00	0,34	0,00	0,00	0,21	0,19	0,27
<i>Spiroplectinella wrightii</i> (Silvestri, 1903)	0,00	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Stainforthia complanata</i> (Egger, 1895)	0,56	0,00	0,25	0,29	0,00	0,00	0,00	0,34	0,00	0,20	0,42	0,76	0,00
<i>Stainforthia</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,34	0,00	0,00	0,00	0,00	0,27
<i>Textullaria pseudogramen</i>	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Textullaria</i> sp.1	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,27
<i>Textullaria</i> sp.2	0,00	0,23	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Textullaria</i> sp.4	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,00	0,00	0,00	0,00
<i>Textullaria</i> spp.	0,00	0,00	0,25	0,00	0,00	0,00	0,39	0,34	0,00	0,20	0,00	0,00	1,08
<i>Triloculina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
<i>Uvigerina auberiana</i> d'Orbigny, 1839	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,30	0,00	0,00	0,00	0,00
<i>Uvigerina peregrina</i> Cushman, 1923	0,00	0,46	0,00	0,00	0,00	0,25	0,00	0,34	0,00	0,00	0,00	0,00	0,27
<i>Uvigerina</i> spp.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,54
total density (tests•10 cc ⁻¹)	19368	10536	19200	8376	30150	13930	31097	29400	16415	78000	62832	37656	22140
fragments (%)	7,62	13,44	9,75	9,17	3,88	16,08	11,28	10,88	10,45	14,20	10,92	5,16	12,20
not identified (%)	2,42	1,14	1,00	1,15	0,30	4,02	0,39	1,36	3,58	1,00	1,05	3,06	3,79
E (%)	4,09	5,01	7,75	4,30	3,28	5,28	5,45	4,08	3,28	2,60	3,36	3,44	10,03
I (%)	94,24	92,94	90,00	93,12	96,72	93,97	93,77	94,90	96,12	95,40	95,59	95,03	88,89
BFHP index (%)	17,84	22,55	22,00	18,91	12,84	24,87	11,28	13,27	18,21	9,20	12,18	19,12	21,95
BFAR index (tests•cm ⁻² •kyr ⁻¹)	1031962	595168	1125483	527163	1923659	926731	2029979	1814731	960558	4220973	3088333	1735250	855161
R	49	37	43	33	20	35	25	34	22	37	35	44	40
H'	2,55	2,43	2,68	2,47	1,96	2,32	2,09	2,26	2,00	2,13	2,10	2,42	2,63
J'	0,66	0,67	0,71	0,71	0,65	0,65	0,65	0,64	0,65	0,59	0,59	0,64	0,71

Cont. Appendix 5 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)		
	5028	6025	7083
	Benthic foraminifera (%)		
<i>Amphicoryna</i> spp.	0,00	0,00	0,00
<i>Angulogerina angulosa</i> (Williamson, 1858)	11,22	10,22	9,07
<i>Angulogerina</i> spp.	0,33	1,50	2,55
<i>Astacolus crepidulus</i>	0,00	0,00	0,00
<i>Bolivina doniezi</i> Cushman & Wickenden, 1929	0,00	0,00	0,00
<i>Bolivina pseudoplicata</i> Heron-Allen & Earland, 1930	0,00	0,75	0,00
<i>Bolivina pulchella</i> (d'Orbigny, 1839)	0,00	0,00	0,00
<i>Bolivina pulchella</i> f. <i>primitiva</i> Cushman, 1930	0,00	0,00	0,00
<i>Bolivina skagerrakensis</i> Qvale & Nigam, 1985	0,00	0,00	0,00
<i>Bolivina subspinensis</i> Cushman, 1922	1,65	0,50	0,57
<i>Brizalina ordinaria</i> (Phleger & Parker, 1952)	0,00	0,00	0,00
<i>Bolivina</i> spp.	0,00	0,00	0,00
<i>Brizalina subaenariensis</i> (Cushman, 1922)	0,66	0,00	0,85
<i>Brizalina spathulata</i> (Williamson, 1858)	0,00	0,75	0,28
<i>Brizalina</i> sp.1	0,00	0,25	0,00
<i>Brizalina</i> spp.	0,99	0,25	2,55
<i>Buccella peruviana</i> (d'Orbigny, 1839)	0,00	0,00	0,28
<i>Bulimina aculeata</i> d'Orbigny, 1826	0,00	0,25	0,00
<i>Bulimina elongata</i> d'Orbigny, 1846	0,00	0,50	0,85
<i>Bulimina gibba</i> Fornasini, 1900	0,33	0,00	0,28
<i>Bulimina marginata</i> d'Orbigny, 1826	8,58	8,98	11,33
<i>Bulimina mexicana</i> Cushman, 1922	0,00	0,00	0,00
<i>Bulimina pseudoaffinis</i> Kleinpell, 1938	0,99	0,25	1,42
<i>Bulimina</i> spp.	1,32	1,75	1,42

Cont. Appendix 5 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)		
	5028	6025	7083
	Benthic foraminifera (%)		
<i>Buliminella elegantissima</i> (d' Orbigny 1839)	0,00	0,25	0,00
<i>Cancris auriculatus</i> (Fichtel & Moll, 1798)	0,33	0,00	0,00
<i>Cancris</i> spp.	0,00	0,00	0,00
<i>Cassidulina carinata</i> (Silvestri, 1896)	0,00	0,50	0,00
<i>Cassidulina laevigata</i> d'Orbigny, 1826	0,00	0,00	0,00
<i>Cassidulina</i> spp.	0,00	0,50	0,28
<i>Cibicides</i> spp.	0,00	0,25	0,28
<i>Cibicides ungerianus</i> (d' Orbigny, 1846)	0,66	0,50	1,42
<i>Cibicidoides wuellerstorfi</i> (Schwager, 1866)	0,00	0,00	0,00
<i>Cibicidoides</i> spp.	0,33	0,50	0,57
<i>Clavulina humilis</i> Brady, 1884	0,00	0,75	0,28
<i>Clavulina multicamerata</i> Chapman, 1907	0,00	0,00	0,00
<i>Clavulina</i> spp.	0,00	0,00	0,28
<i>Criboelphidium incertum</i>	0,66	0,25	0,28
<i>Dentalina ariena</i> Patterson & Pettis, 1986	0,33	0,00	0,00
<i>Dentalina</i> spp.	0,00	0,00	0,00
<i>Discorbinella</i> spp.	0,00	0,00	0,00
<i>Discorbis williamsoni</i> Chapman & Parr, 1932	0,00	0,25	0,00
<i>Dorothia goessi</i> (Cushman, 1911)	0,00	0,00	0,00
<i>Epistominella</i> spp.	8,91	15,21	6,80
<i>Evolvocassidulina orientalis</i> (Cushman, 1922)	0,00	0,00	0,00
<i>Fissurina laevigata</i> Reuss, 1850	0,33	0,00	0,00
<i>Fissurina lucida</i> (Williamson, 1884)	0,00	0,00	0,00
<i>Fissurina marginata</i> (Montagu, 1803)	0,33	0,00	0,00
<i>Fissurina quadricostulata</i> Silvestri, 1902	0,00	0,00	0,00
<i>Fissurina</i> spp.	0,00	0,00	0,00
<i>Fissurina staphyllearia</i> Schwager, 1866	0,66	0,00	0,00
<i>Favulina hexagona</i> (Williamson, 1848)	0,00	0,00	0,00

Cont. Appendix 5 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)		
	5028	6025	7083
	Benthic foraminifera (%)		
<i>Favulina melo</i> (d' Orbigny, 1839)	0,00	0,00	0,00
<i>Gavelinopsis praegeri</i> (Heron-Allen & Earland, 1913)	0,66	1,25	0,85
<i>Gavelinopsis</i> spp.	0,00	0,00	0,28
<i>Globocassidulina</i> spp.	3,96	3,99	1,98
<i>Globocassidulina subglobosa</i> (Brady, 1881)	30,03	32,92	24,08
<i>Gyroidina altiformis</i> R.E. & K.C. Stewart, 1930	0,00	0,00	0,00
<i>Gyroidina umbonata</i> (Silvestri, 1898)	6,27	3,24	5,10
<i>Gyroidina</i> spp.	0,99	1,50	2,83
<i>Hoeglundina elegans</i> (d' Orbigny, 1826)	0,00	0,00	0,00
<i>Islandiella norcrossi</i> (Cushman, 1933)	10,56	6,73	9,63
<i>Procerolagena gracilis</i> (Williamson, 1848)	0,00	0,00	0,00
<i>Lagena laevis</i> (Montagu, 1803)	0,00	0,00	0,00
<i>Lagena laevis</i> , f. tenuis Williamson, 1848	0,00	0,00	0,28
<i>Lagena laevis</i> , f. typica Williamson, 1848	0,00	0,00	0,00
<i>Lagena</i> spp.	0,00	0,00	0,00
<i>Lagena striata</i> (d'Orbigny, 1839)	0,00	0,00	0,28
<i>Lagena sulcata</i>	0,00	0,00	0,00
<i>Lenticulina</i> sp.1	0,00	0,00	0,57
<i>Lenticulina</i> spp.	0,33	0,25	0,00
<i>Liesbusella</i> sp.	0,00	0,00	0,00
<i>Lobatula lobatula</i> (Walker & Jacob, 1798)	0,00	0,00	0,57
<i>Melonis barleeanus</i> (Williamson, 1858)	0,00	0,00	0,00
<i>Melonis</i> spp.	0,00	0,00	0,00
<i>Miliolinella subrotunda</i> (Montagu, 1803)	0,00	0,00	0,00
<i>Neolenticulina variabilis</i> (Reuss, 1850)	0,00	0,00	0,00
<i>Nonion</i> sp. (juvenil)	0,00	0,00	0,00
<i>Nonion</i> spp.	0,00	0,00	0,28
<i>Nonionella</i> spp.	0,00	0,00	0,57

Cont. Appendix 5 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)		
	5028	6025	7083
	Benthic foraminifera (%)		
<i>Nonionoides turgida</i> (Williamson, 1858)	0,33	0,00	1,42
<i>Nonionoides grateloupi</i> (d'Orbigny, 1826)	0,00	0,00	0,00
<i>Nonionoides punctulatus</i>	0,33	0,50	0,28
<i>Nonionoides</i> spp.	0,33	0,00	0,28
<i>Oolina acuticosta</i>	0,00	0,00	0,28
<i>Oolina melo</i>	0,00	0,00	0,00
<i>Osanguriella umbonifera</i> (Cushman, 1933)	0,66	0,00	0,28
<i>Planulina</i> spp.	0,00	0,25	0,28
<i>Polymorphinella</i> sp.	0,00	0,00	0,00
<i>Pseudogaudryna</i> sp. nov.	0,66	0,25	0,28
<i>Pseudononion atlanticum</i> (Cushman, 1936)	0,00	0,00	0,00
<i>Pullenia bulloides</i> (d'Orbigny, 1846)	0,00	0,00	0,00
<i>Pullenia osloensis</i> Feyling-Hanssen, 1954	0,00	0,00	0,00
<i>Pullenia quadriloba</i>	0,00	0,00	0,00
<i>Pullenia quinqueloba</i> (Reuss, 1851)	0,00	0,00	0,00
<i>Pyrgo depressa</i> (d'Orbigny, 1826)	0,33	0,00	0,00
<i>Pyrgo murrhina</i> (Schwager, 1866)	0,00	0,00	0,00
<i>Pyrgo nasuta</i> Cushman, 1935	0,00	0,25	0,00
<i>Pyrgo ringens</i> (Lamarck, 1804)	0,00	0,00	0,00
<i>Pyrgo</i> sp.3	0,00	0,00	0,00
<i>Pyrgo</i> spp.	0,00	0,00	0,00
<i>Quinqueloculina akneriana</i> d'Orbigny, 1846	0,33	0,50	0,85
<i>Quinqueloculina atlantica</i>	0,33	0,00	0,00
<i>Quinqueloculina lamarckiana</i> d'Orbigny, 1839	0,33	0,00	0,00
<i>Quinqueloculina</i> spp.	0,00	0,00	0,28
<i>Reophax</i> sp.	0,00	0,00	0,00
<i>Rosalina globularis</i> (d'Orbigny, 1826)	0,33	1,25	1,42
<i>Rosalina</i> spp.	0,00	0,00	0,00

Cont. Appendix 5 -

Benthic foraminifera taxa	Estimated age (yr cal. BP)		
	5028	6025	7083
	Benthic foraminifera (%)		
<i>Saracenaria</i> sp.	0,00	0,00	0,00
<i>Seabrookia earlandi</i> Wright, 1891	1,98	0,75	2,83
<i>Sigmoilopsis schlumbergeri</i> (Silvestri, 1904)	0,00	0,25	0,00
<i>Siphonina bradyana</i> Cushman, 1927	0,33	0,25	0,00
<i>Siphotextullaria</i> sp.	0,00	0,00	0,00
<i>Spiroglutina</i> spp.	0,99	0,25	0,28
<i>Spiroplectinella wrightii</i> (Silvestri, 1903)	0,00	0,00	0,00
<i>Stainforthia complanata</i> (Egger, 1895)	0,00	0,00	0,85
<i>Stainforthia</i> spp.	0,00	0,00	0,00
<i>Textullaria pseudogramen</i>	0,33	0,00	0,00
<i>Textullaria</i> sp.1	0,33	0,25	0,28
<i>Textullaria</i> sp.2	0,00	0,00	0,00
<i>Textullaria</i> sp.4	0,00	0,00	0,00
<i>Textullaria</i> spp.	0,00	0,00	0,85
<i>Triloculina</i> spp.	0,00	0,00	0,00
<i>Uvigerina auberiana</i> d'Orbigny, 1839	0,33	0,00	0,00
<i>Uvigerina peregrina</i> Cushman, 1923	0,33	0,25	0,28
<i>Uvigerina</i> spp.	0,00	0,25	0,00
total density (tests•10 cc ⁻¹)	36360	41704	44831
fragments (%)	9,24	5,74	6,23
not identified (%)	1,32	0,50	1,42
E (%)	8,25	8,23	13,88
I (%)	89,11	90,27	83,57
BFHP index (%)	15,51	14,96	22,66
BFAR index (tests•cm ⁻² •kyr ⁻¹)	1219128	1114806	1011536
R	42	42	50
H'	2,59	2,46	2,90
J'	0,69	0,66	0,74