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Brazilian Equatorial Margin Paleoceanography

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Title	Cenozoic Paleoceanography of the Brazilian Equatorial Margin (PBEM)
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Abstract

Tropical regions are a major source of heat to mid- and high-latitudes. Therefore accomplishing accurate global climate reconstructions, documentation and implementation of tropical climates in large-scale climate models is essential. This, however has been hampered for most of the Cenozoic, particularly for time periods older than ~12 Ma, due to the lack of low-latitude sufficient sediment records suitable for the generation of high-quality reconstructions of temperature, hydrology and biotic evolution.

The Brazilian Equatorial Margin (BEM) is a passive and stable continental margin that developed following the opening of the central Atlantic Ocean in the mid-Cretaceous. A peculiar aspect of this margin is that it remained passive and approximately at the same equatorial latitude since its formation until present. Such conditions are unique and provide great potential to yield extended, continuous, and well-preserved sedimentary archives of inter-tropical environments. This project will take advantage of these unique attributes for obtaining high-quality sedimentological, paleoclimatic, and paleoceanographic data for the Cenozoic. We propose to drill transects across the BEM from the uppermost part of the continental slope to the abyssal plain near Fortaleza (Ceará and Potiguar Basins). The expected stratigraphic continuity of the sedimentary sequences along these transects will allow the detailed study of the fundamental relation between pCO2, sea-level and climate changes throughout the Cenozoic. Moreover, it will be possible to detect the low-latitude climatic response to the major Cenozoic climatic events such as the Paleogene transient global warming events, (i.e. the Paleocene-Eocene Thermal Maximum), the onset of the Antarctic glaciation during the Eocene-Oligocene, the warm Mid-Miocene and Pliocene phases, as well as the cooling during the Mid-Miocene Transition and the onset of the northern hemisphere glaciation in the Plio-Pleistocene. Sediments are expected to yield calcareous and organic fossils, which not only will allow for studying the response of tropical ecosystems to these climatic events, but also provide independent substrates for climate and carbon cycle reconstructions.

The new data will establish a landmark for high-resolution Cenozoic tropical climate reconstructions, which will provide the following outcomes: 1) a quantitative relationship between tropical climate and atmospheric pCO2 concentrations, 2) a equatorial temperature estimate which are the backbone for accurate determinations pole-to-equator temperature gradients and polar amplification of climate change, 3) an unprecedented record of sea-level changes across Cenozoic climatic transitions, and 4) detailed insights into tropical biosphere response to climate and carbon cycle perturbations.

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Scientific Objectives

We propose to investigate variations in Earths climate and its intricate relationships and forcing mechanisms (i.e. opening/closing of ocean seaways, changes in nutrients through upwelling, astronomical variations, river runoff and eolian input) across the Cenozoic transition from greenhouse to icehouse conditions in the equatorial Atlantic Ocean through the reconstructing of oceanographical (i.e. pCO2 changes, ocean acidification, sea-level, ocean circulation and temperature) and biological processes (i.e. degradation of organic matter, primary productivity, organic matter burial).
Detailed Scientific Objectives:
1.Investigate the intrinsic link between atmospheric pCO2 and sea-level during the long- and short-term climatic evolution of the Cenozoic.
2.Study the evolution of the Atlantic Meridional Overturning Circulation (AMOC) and its response to major climate events of the Cenozoic, in relation to the evolution of the Antarctic Ice Sheet and onset of the South American monsoonal system (SAMS), latitudinal shift of the Intertropical Convergence Zone (ITCZ) and its relation to the establishment and fluctuations of the oxygen minimum zone (OMZ).
3.Examine the impact of tectonic variations (e.g., opening of Drake Passage, Terminal Tethyan Event, formation of the Isthmus of Panama) on the oceanographic and environmental processes of low-latitude sedimentary system in the Atlantic Ocean.
4.Characterize marine equatorial/tropical ecosystems regarding Cenozoic climate changes over different time scales.

Non-standard measurements technology needed to achieve the proposed scientific objectives

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Proposed Sites (Total proposed sites: 13; pri: 3; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
PBEM-05A (Primary)	-2.4445006388889 -36.963564305556	3450	650	0	650	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends (e.g. EOT, MCT) and intervals of extreme climatic warmth (e.g., PETM and other hyperthermals, such as Dan-C2, LDE, MPBE or ELPE, EECO, MECO, MMCO), the mid-Pliocene warm period, and glacial-interglacial cycles. Evolution of the Atlantic Meridional Overturning Circulation (AMOC) as part of the global Thermohaline Circulation (THC), tropical/equatorial SST, changes in circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climatic phases.
PBEM-07A (Alternate)	0.1376591111 -34.9521935000	4545	583	0	583	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends (e.g. EOT, MCT) and intervals of extreme climatic warmth (e.g., PETM and other hyperthermals, such as Dan-C2, LDE, MPBE or ELPE, EECO, MECO, MMCO), the mid-Pliocene warm period, and glacial-interglacial cycles. Evolution of the Atlantic Meridional Overturning Circulation (AMOC) as part of the global Thermohaline Circulation (THC), tropical/equatorial SST, changes in circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climatic phases.
PBEM-03B (Alternate)	-3.2061111111 -37.5886111111	259	1069	0	1069	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends and intervals of extreme climatic warmth, the mid-Pliocene warm period, and glacial-interglacial cycles. Reconstruct the influences of the biogeochemical cycling of carbon and carbonate preservation in a low-latitude sedimentary system with minimal terrigenous input and test if there is a terrestrial climatic coupling with paleoceanographic variations during the long and short-term climatic evolution of the Cenozoic through changes in surface-water circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climate phases.
PBEM-12A (Primary)	-3.2294361111 -37.5611777778	253	1029	0	1029	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends and intervals of extreme climatic warmth, the mid-Pliocene warm period, and glacial-interglacial cycles. Reconstruct the influences of the biogeochemical cycling of carbon and carbonate preservation in a low-latitude sedimentary system with minimal terrigenous input and test if there is a terrestrial climatic coupling with paleoceanographic variations during the long and short-term climatic evolution of the Cenozoic through changes in surface-water circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climate phases.
PBEM-04B (Alternate)	-3.4156583333 -37.5198055556	280	997	0	997	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends and intervals of extreme climatic warmth, the mid-Pliocene warm period, and glacial-interglacial cycles. Reconstruct the influences of the biogeochemical cycling of carbon and carbonate preservation in a low-latitude sedimentary system with minimal terrigenous input and test if there is a terrestrial climatic coupling with paleoceanographic variations during the long and short-term climatic evolution of the Cenozoic through changes in surface-water circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climate phases.
PBEM-13A (Alternate)	-3.3823250000 -37.5475030000	282	1071	0	1071	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends and intervals of extreme climatic warmth, the mid-Pliocene warm period, and glacial-interglacial cycles. Reconstruct the influences of the biogeochemical cycling of carbon and carbonate preservation in a low-latitude sedimentary system with minimal terrigenous input and test if there is a terrestrial climatic coupling with paleoceanographic variations during the long and short-term climatic evolution of the Cenozoic through changes in surface-water circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climate phases.

Proposed Sites (Continued; total proposed sites: 13; pri: 3; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
PBEM-11A (Primary)	-2.8891271111 -38.3038514444	2280	1096	0	1096	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends (e.g. EOT, MCT) and intervals of extreme climatic warmth (e.g., PETM and other hyperthermals, such as Dan-C2, LDE, MPBE or ELPE, EECO, MECO, MMCO), the mid-Pliocene warm period, and glacial-interglacial cycles. Evolution of the Atlantic Meridional Overturning Circulation (AMOC) as part of the global Thermohaline Circulation (THC), tropical/equatorial SST, changes in circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climatic phases.
PBEM-08B (Alternate)	-2.003676 -39.066337	2302	1326	0	1326	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends (e.g. EOT, MCT) and intervals of extreme climatic warmth (e.g., PETM and other hyperthermals, such as Dan-C2, LDE, MPBE or ELPE, EECO, MECO, MMCO), the mid-Pliocene warm period, and glacial-interglacial cycles. Evolution of the Atlantic Meridional Overturning Circulation (AMOC) as part of the global Thermohaline Circulation (THC), tropical/equatorial SST, changes in circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climatic phases.
PBEM-01B (Alternate)	-0.8407644444 -37.7896324444	4373	1414	0	1414	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends (e.g. EOT, MCT) and intervals of extreme climatic warmth (e.g., PETM and other hyperthermals, such as Dan-C2, LDE, MPBE or ELPE, EECO, MECO, MMCO), the mid-Pliocene warm period, and glacial-interglacial cycles. Evolution of the Atlantic Meridional Overturning Circulation (AMOC) as part of the global Thermohaline Circulation (THC), tropical/equatorial SST, changes in circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climatic phases.
PBEM-06A (Alternate)	0.1214523056 -37.0647670833	4493	603	0	603	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends (e.g. EOT, MCT) and intervals of extreme climatic warmth (e.g., PETM and other hyperthermals, such as Dan-C2, LDE, MPBE or ELPE, EECO, MECO, MMCO), the mid-Pliocene warm period, and glacial-interglacial cycles. Evolution of the Atlantic Meridional Overturning Circulation (AMOC) as part of the global Thermohaline Circulation (THC), tropical/equatorial SST, changes in circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climatic phases.
PBEM-09B (Alternate)	-2.9345267222 -38.6218721666666	1189	1364	0	1364	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends and intervals of extreme climatic warmth, the mid-Pliocene warm period, and glacial-interglacial cycles. Reconstruct the influences of the biogeochemical cycling of carbon and carbonate preservation in a low-latitude sedimentary system with minimal terrigenous input and test if there is a terrestrial climatic coupling with paleoceanographic variations during the long and short-term climatic evolution of the Cenozoic through changes in circulation related to gateway changes and major climate events during the Cenozoic. Characteriation of marine equatorial/tropical ecosystems during Cenozoic climatic phases.
PBEM-10B (Alternate)	-3.0512381666 -38.54260375	1316	1408	0	1408	Record of the paleoceanographic variations occurred in relation to Cenozoic cooling trends and intervals of extreme climatic warmth, the mid-Pliocene warm period, and glacial-interglacial cycles. Reconstruct the influences of the biogeochemical cycling of carbon and carbonate preservation in a low-latitude sedimentary system with minimal terrigenous input and test if there is a terrestrial climatic coupling with paleoceanographic variations during the long and short-term climatic evolution of the Cenozoic through changes in surface-water circulation related to gateway changes and major climate events during the Cenozoic. Characterisation of marine equatorial/tropical ecosystems during Cenozoic climate phases.

Proposed Sites (Continued; total proposed sites: 13; pri: 3; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
PBEM-02B (Alternate)	-3.0284343611 -38.5236795000	1065	1789	0	1789	Record of the paleoceanographic variations occurred in relation to Neogene cooling trends and intervals of extreme climatic warmth, the mid-Pliocene warm period, and glacial-interglacial cycles. Reconstruct the influences of the biogeochemical cycling of carbon and carbonate preservation in a low-latitude sedimentary system with minimal terrigenous input and test if there is a terrestrial climatic coupling with paleoceanographic variations during the long and short-term climatic evolution of the Neogene through changes in surface-water circulation related to gateway changes and major climate events during the Neogene. Characterisation of marine equatorial/tropical ecosystems during Neogene climate phases.