IODP Proposal Cover Sheet

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Argentine Margin Cretaceous Tectonics & Climate

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Title	Exploring South Atlantic continental breakup and transition to a passive margin and its impact on Cretaceous/ Cenozoic climate
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Keywords	SDRs, Cretaceous paleoclimate, ocean circulation
Area	Argentine Margin

Proponent Information

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Abstract

Early Cretaceous opening of the South Atlantic (SA) resulted from lithospheric extension and breakup of Pangaea, leading to major tectonic reconfiguration that significantly impacted Earth's oceanographic and climate evolution. Rifting was accompanied by extensive intrusive magmatism and extrusive flood basalts identified as seaward dipping reflectors (SDRs). Despite the wide global distribution of volcanic margins, the nature of the processes that lead to continental breakup remains controversial and SDRs have only been sampled through scientific ocean drilling in the NE Atlantic; an area impacted by hotspot volcanism. Furthermore, Early Cretaceous volcanogenic degassing contributed to the mid-Cretaceous supergreenhouse climate but the linkages are poorly constrained. The young SA formed a focal point for deposition of organic-carbon–rich sediments, sometimes during oceanic anoxic events (OAEs). Despite significant study, the causal mechanisms, links with tectonics, and Earth system feedbacks for OAEs remain debated. In addition, the progressive opening of the SA resulted in major changes to landmass configuration and ocean water mass distribution, with a change from sluggish to vigorous deepwater circulation as gateways opened and global temperatures cooled, yet timing of these changes is poorly constrained. Despite its importance for global tectonic and climate evolution, only a handful of sites have cored SA Cretaceous and basement rocks and none drilled the Argentine Continental Volcanic Margin (ACVM).

We propose to core two unique regions on the ACVM that were carefully selected based on interpretation of new seismic data. The regions represent sites where breakup volcanic deposits and well-stratified Cretaceous sediments are reachable by the JOIDES Resolution. We will sample the SDRs at two sites to determine their age and composition to better understand the chronology of SA opening and sources and magmatic processes involved during breakup to test the active vs. passive rifting hypotheses. We will investigate evidence for magma/crust interaction and the impact volcanism had on climate through delivery of gases to the ocean and atmosphere. Cretaceous and Cenozoic sediments will be cored at three sites to reconstruct SA oceanographic and climate evolution. Coring these sediments will address key questions related to the relationship between organic-carbon–rich sediment deposition, the carbon cycle, and impact on climate; global temperature evolution from the supergreenhouse climate of the mid-Cretaceous to decreasing temperatures in the Late Cretaceous; and water mass evolution as the SA widened and deepened. Coring the unsampled ACVM will revolutionize our knowledge of rifting processes and evolution of the global climate system.

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Scientific Objectives

1. Examine the nature and environmental impact of volcanic rifted margin formation in the South Atlantic (SA). Hypotheses: Active rifting (continental breakup and magmatism triggered by a deep-seated mantle plume) versus passive rifting (regional extension caused continental breakup and associated magmatism was related to decompressional melting of a fertile mantle); the influence of the Tristan plume head on rift-related magmatism decreases from north to south; rifting occurred simultaneously between the south and north; the ACVM SDRs consist of volcanic rocks emplaced through subaerial eruption.

2. Examine the change in basin architecture from a ramp-style margin to one with a clear shelf break. Hypothesis: The change in basin architecture is a consequence of regional SA tectonic breakup.

3. Examine the evolution of ACVM water masses as the SA widens and deepens. Hypothesis: The evolving SA paleogeographic framework imparted a strong control on basin hydrography in the Cretaceous and Cenozoic. Major changes in water mass composition occurred in concert with deepening sills and opening gateways in the Southern Ocean.

4. Examine SA climate evolution. Hypothesis: The regional climate was extremely warm throughout the Cretaceous with peak temperatures occurring during the late Cenomanian–Santonian, followed by gradual cooling in the Campanian.

5. Examine the relationship between organic-carbon–rich deposition, the carbon cycle, and impact on climate evolution. Hypothesis: The small restricted ACVM basins were a sink for organic carbon through stratification during the Early Cretaceous but became better ventilated as the basin became larger and better connected with the Southern Ocean and equatorial/North Atlantic.

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

Request use of the ultrasonic borehole imager (UBI) for downhole logging of basement sections

Have you contacted the appropriate IODP Science Operator about this proposal to discuss drilling platform capabilities, the feasibility of your proposed drilling plan and strategies, and the required overall timetable for transiting, drilling, coring, logging, and other downhole measurements?

yes

Proposal History

Submission Type	Resubmission from declined proposal	Declined Proposal Number	903-Full2

Review Response

We thank the watchdogs for helpful feedback provided for 903-Full2 and appreciate the encouragement to submit a new proposal. Here we outline how we have addressed specific points from the 903-Full2 review.

(1) Dedicated section on why the Argentine margin is the place to drill: We have added a section called “Scientific Rationale: Why drill the Argentine margin”, which includes two sub-sections to address tectonic and oceanographic/climatic questions.

(2) Basement penetration: We increased planned basement penetration to 200–250m to ensure enough fresh material (and flow units) will be cored. We added more information about recovery and alteration of basalt cores collected from similar sites on the Greenland margin.

(3) Conjugate margin industry wells: We updated our table to indicate the types of material available from conjugate margin industry wells, noting that only cuttings are available for most wells (three collected small amounts of core but not from SDRs). We address why this material is not sufficient to achieve our objectives on the ACVM.

(4) Distinguishing a combined model for SDR emplacement: Confirming that breakup volcanic successions were emplaced in response to the combined model is challenging but remains a proposal goal. The model testing requires careful integration of seismic observations of basement structures with borehole-derived indications for lava emplacement, environment/processes, structural deformation, and geochemistry-derived magma production rates/processes constrained by numerical melt models. Comparing the possible range of models for both the northern and southern sites will show to what extent the observations can be explained by either of the end-members or a hybrid model, and if there are differences along the margin.

(5) Clearly testable hypotheses/ability to achieve objectives: We have revised our objectives to include hypotheses that can be tested by coring at our sites, as well as specific questions to be addressed. We carefully revised the objectives to ensure that our objectives/hypotheses can be met through coring the anticipated sediment/rock section at the proposed sites. We looked for additional sites; however, based on currently available seismic data we were not able to locate new sites, with water depth and total sediment overburden the largest limiting factors. However, we did shift one site from 903-Full2 to a location more clearly underlain by SDRs. We also added a new primary site where sediment overburden is thinnest. The new site has a thicker SDR wedge than the previous site (which we retain as an alternate) to ensure there is a thick sequence to core. If time is an issue, the alternate site offers an option with less sediment overburden.

(6) Continuity of sediment section: We have addressed this in the revised proposal to indicate that hiatuses actually help us to address scientific questions related to ocean circulation evolution (and therefore a continuous section is not required to test our hypotheses or answer our questions).

(7) SEG-Y files: We have provided a file indicating the location of the headers (which is allowable in the Guidelines for Site Characterization) and ask the site survey WDs to refer to that to avoid confusion.

Proposed Sites (Total proposed sites: 9; pri: 3; alt: 6; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
ACVM-01A (Primary)	-42.873746 -57.551379	2163	1555	200	1755	1–5
ACVM-18A (Primary)	-38.556546 -53.607367	3721	548	250	798	1, 3, 4
ACVM-15A (Primary)	-38.801334 -53.985308	2475	1000	10	1010	2–5
ACVM-02A (Alternate)	-42.919556 -57.551662	2285	1727	200	1927	Alternate for ACVM-01A 1–5
ACVM-06A (Alternate)	-43.001827 -57.696239	2155	1620	200	1820	Alternate for ACVM-01A 1–5
ACVM-16A (Alternate)	-38.835476 -53.912300	3000	890	200	1090	Alternate for ACVM-18A 1–5
ACVM-17A (Alternate)	-38.551860 -53.617363	3736	386	250	636	Alternate for ACVM-18A 1, 3, 4
ACVM-14A (Alternate)	-38.782687 -54.025303	2167	1200	10	1210	Alternate for ACVM-15A Objectives: 2–5
ACVM-13A (Alternate)	-39.407611 -54.032757	3640	1573	200	1773	Alternate for both Sites ACVM-18A and ACVM-15A Objectives: 1-5