IODP Proposal Cover Sheet

871 - CPP 2

Lord Howe Rise Continental Ribbon

Received for: 2016-04-01

Title	First deep stratigraphic record for the Cretaceous eastern Gondwana margin: Tectonics, paleoclimate and deep life on the Lord Howe Rise high-latitude continental ribbon
Proponents	Ron Hackney, Yasuhiro Yamada, Kliti Grice, Junichiro Kuroda, Jessica Whiteside, Marco Coolen, Fumio Inagaki, Richard Arculus, Dietmar Mueller, Saneatsu Saito, Scott Bryan, Julien Collot, Jun-Ichi Kimura, Nick Mortimer, Yoshihiko Tamura, Takehiko Hashimoto, Clinton Foster, Sean Johnson, William Orsi, Talitha Santini
Keywords	Cretaceous, rifting, paleoclimate, microbiology, Gondwana
Area	Lord Howe Rise

Proponent Information

Proponent	Ron Hackney
Affiliation	Geoscience Australia
Country	Australia

✔ Permission is granted to post the coversheet/site table on www.iodp.org

Abstract

Active plate tectonics and resulting changes in crustal architecture profoundly influence global climate, oceanic circulation, and the origin, distribution and sustainability of life. A key element of the 50-year-old theory of plate tectonics is the distinction between passive and active continental margins in both convergent and extensional tectonic settings. Yet we have been unable to fully resolve the tectonic setting and evolution of Gondwana's eastern margin because much of it is now dispersed as huge, thinned, submerged, and relatively inaccessible "ribbons" of continental crust that include the Lord Howe Rise (LHR). Continental ribbons are not easily explained by plate tectonics, but they have been a crucial characteristic of post-Archean continental dispersal, modification, and re-assembly. The tectonic and paleogeographic evolution of these ribbons is poorly understood, as the deep stratigraphy of a large, un-accreted and intact continental ribbon, like the LHR, has not previously been explored.

The Cretaceous world - of which the LHR is a part - witnessed major changes in biogeochemical cycling, climate and evolution. These changes are thought to have been initiated by increased oceanic-crust production, possibly in combination with periodic and sudden releases of methane that resulted in elevated atmospheric CO2 concentrations and a rise in global sea level. However, modelling results indicate that the very warm ocean temperatures resulted in heat-stressed organisms that mean proxy estimates of Cretaceous climate should be re-evaluated.

Drilling exploration of the deep sub-seafloor biosphere has demonstrated that a remarkable diversity of microbial life is present in deeply-buried sediments. However, the biotic-abiotic transition zone has not yet been reached despite penetrating 2.5 km (~20 Ma) below the seafloor. Depth-dependent increases in temperature are considered to pose a major constraint on life at depth. However, the thermally-assisted decomposition of organic matter present in deep, warm sediments may provide a source of energy that is sufficient to support microbial communities in repairing thermally-induced cellular damage, thereby allowing life to persist beyond the depth range previously explored.

We propose a single deep-riser drill hole through a sedimentary basin and into basement on the 1600 km long by 600 km wide LHR. The processes of LHR crustal ribbon development will be investigated using rock cores recovered from up to 3,500 m below the seafloor. These samples will also provide major breakthroughs in understanding ocean biogeochemical cycles at high southern latitudes from the Cretaceous onwards, and in extending the known limits of life beneath the ocean floor.

Scientific Objectives

Our globally-significant objectives, grouped into three broad themes, are:
• EARTH: To define the role and importance of elongate strips of continental crustal ribbons in plate tectonic cycles and continental evolution.
• OCEANS/CLIMATE: To recover new high-latitude data to better constrain the timing and nature of Cretaceous paleoclimate and linked changes in ocean biogeochemistry.
• LIFE: To test fundamental evolutionary concepts of sub-seafloor microbial life over a 100 million year timeframe.

These objectives help to address Challenges defined within each Research Theme of the IODP Science Plan for 2013-2023, and will be met by addressing the following questions:
• Are continental ribbons the key for determining the driving mechanism for plate tectonics?
• Is the LHR continental ribbon the result of upper-plate extension and rifting accompanying slab roll-back, or mantle upwelling accompanied by propagating seafloor spreading?
• The history of the eastern Gondwana margin was characterised by long-lived subduction throughout the Paleozoic, but was this subduction continuous through the Cretaceous?
• Do the LHR basins also contain a record of the paleogeographic and paleoenvironmental conditions prevailing during the transition from a relatively cool Early Cretaceous climate to a Late Cretaceous hothouse world?
• Do Ocean Anoxic Events (OAE) extend to high southern latitudes in the southwest Pacific?
• What are the limiting conditions under which life can be sustained?
• Have energy-starved conditions deep below the seafloor suppressed rates of genetic evolution, and therefore preserved correlations between deep subsurface microbial communities and their depositional environment?

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

Proposed Sites (Total proposed sites: 7; pri: 3; alt: 4; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
DLHR-1B (Alternate)	-26.394283 160.989760	1643	1344	300	1644	Recover a complete Early–Late Cretaceous record to: constrain the location and timing of Cretaceous subduction and magmatism along the eastern Gondwana margin, and the timing and drivers of subduction–rifting transition; obtain a Cretaceous high-latitude southern hemisphere climate record; identify effects of Cretaceous atmospheric and carbon cycle perturbations on Cretaceous terrestrial environments; identify effects of continental fragmentation and large-scale continental magmatism on terrestrial and marine environments of eastern Gondwana (including the development of Late Cretaceous marine anoxia and oceanographic circulation in southwest Pacific); constrain the limits of deep microbial life. Determine nature and age of underlying pre-rift basement.
DLHR-2A (Alternate)	-26.759528 161.197392	1670	2757	300	3057	Recover a complete Early–Late Cretaceous record to: constrain the location and timing of Cretaceous subduction and magmatism along the eastern Gondwana margin, and the timing and drivers of subduction–rifting transition; obtain a Cretaceous high-latitude southern hemisphere climate record; identify effects of Cretaceous atmospheric and carbon cycle perturbations on Cretaceous terrestrial environments; identify effects of continental fragmentation and large-scale continental magmatism on terrestrial and marine environments of eastern Gondwana (including the development of Late Cretaceous marine anoxia and oceanographic circulation in southwest Pacific); constrain the limits of deep microbial life. Determine nature and age of underlying pre-rift basement.
DLHR-3A (Primary)	-27.384797 161.663069	1530	1915	300	2215	Recover a complete Early–Late Cretaceous record to: constrain the location and timing of Cretaceous subduction and magmatism along the eastern Gondwana margin, and the timing and drivers of subduction–rifting transition; obtain a Cretaceous high-latitude southern hemisphere climate record; identify effects of Cretaceous atmospheric and carbon cycle perturbations on Cretaceous terrestrial environments; identify effects of continental fragmentation and large-scale continental magmatism on terrestrial and marine environments of eastern Gondwana (including the development of Late Cretaceous marine anoxia and oceanographic circulation in southwest Pacific); constrain the limits of deep microbial life. Determine nature and age of underlying pre-rift basement.
BLHRV-1B (Primary)	-27.564559 163.139748	1215	293	300	593	Determine nature and age of the ‘volcanic’ pre-rift basement to provide additional constraints on the location and timing of Cretaceous subduction and magmatism along the eastern Gondwana margin, and the timing and drivers of subduction–rifting transition. Complements the results of proposed deep drilling at site DLHR-1B, DLHR-2A or DLHR-3A.
BLHRV-2A (Alternate)	-27.895908 160.870635	2018	200	300	500	Determine nature and age of the ‘volcanic’ pre-rift basement to provide additional constraints on the location and timing of Cretaceous subduction and magmatism along the eastern Gondwana margin, and the timing and drivers of subduction–rifting transition. Complements the results of proposed deep drilling at site DLHR-1B, DLHR-2A or DLHR-3A.

871 - CPP 2

Proposed Sites (Continued; total proposed sites: 7; pri: 3; alt: 4; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
BLHRB-1B (Primary)	-27.552905 162.918633	1208	258	300	558	Determine nature and age of the ‘bland’ pre-rift basement to provide additional constraints on the location and timing of Cretaceous subduction and magmatism along the eastern Gondwana margin, and the timing and drivers of subduction–rifting transition. Complements the results of deep proposed drilling at site DLHR-1B, DLHR-2A or DLHR-3A.
BLHRB-2B (Alternate)	-27.251973 162.820968	1193	263	300	563	Determine nature and age of the ‘bland’ pre-rift basement to provide additional constraints on the location and timing of Cretaceous subduction and magmatism along the eastern Gondwana margin, and the timing and drivers of subduction–rifting transition. Complements the results of proposed deep drilling at site DLHR-1B, DLHR-2A or DLHR-3A.