IODP Proposal Cover Sheet

West Antarctic Ice Sheet Climate

751 - Full 2

Title	Ocean-ice sheet interactions and West Antarctic Ice Sheet vulnerability: clues from the Neogene and Quaternary record of the outer Ross Sea continental margin
Proponents	R. McKay, L. De Santis, P. Bart, A. Shevenell, T. Williams, R. Levy, L. Bartek, C. Sjunneskog, A. Orsi, S. Warny, R. DeConto, D. Pollard, Y. Suganuma, J. Hong,
Keywords	Antarctica, Neogene, Quaternary, cyrosphere, paleoceanography
Area	Ross Sea, Antarctica

Contact Information

Contact Person:	Robert McKay		
Department:	Antarctic Research Centre		
Organization:	Victoria University of Wellington		
Address:	Room 511, , Kelburn Campus	Wellington	
Tel.:	04 463 6836	Fax:	
E-mail:	robert.mckay@vuw.ac.nz		

Abstract

Observations from the past several decades indicate that the Southern Ocean is warming significantly (Gille, 2008; Purkey and Johnson, 2010), while Southern Hemisphere westerly winds have migrated southward and strengthened due to increasing atmospheric CO2 concentrations and/or ozone depletion (Shindell and Schmidt, 2004, Thompson et al., 2011). These changes have been linked to thinning of Antarctic ice shelves and marine terminating glaciers (Shepherd et al., 2008; Pritchard et al., 2012; Depoorter et al., 2013). Results of geologic drilling on Antarctica's continental margins indicate late Neogene marine-based ice sheet variability (Naish et al., 2009; Cook et al., 2013) and numerical modeling indicates a fundamental role for oceanic heat in controlling this variability over at least the past 20 million years (Pollard and DeConto, 2009). While ice sheet variability has been observed, sedimentologic sequences from the outer continental shelf are still required to evaluate the extent of past ice sheet variability and the role of oceanic heat flux in controlling ice sheet mass balance.

IODP 751-Full proposes a latitudinal and depth transect of 6 drill sites from the outer continental shelf and rise in the Eastern Ross Sea to resolve the relationship between climatic/oceanic change and West Antarctic Ice Sheet (WAIS) evolution through the Neogene and Quaternary. This location was selected because numerical ice sheet models indicate that it is highly sensitive to changes in ocean heat flux and sea level (Pollard and DeConto, 2009; Golledge et al., 2011). The proposed drilling is designed for optimal data-model integration, which will enable an improved understanding of the sensitivity of Antarctic Ice Sheet mass balance during warmer-than present climates (e.g. the early Pliocene and middle Miocene). Additionally, the proposed transect links ice proximal records from the inner Ross Sea continental shelf (e.g. ANDRILL sites) to deep Southwest Pacific drilling sites/targets to obtain an ice proximal to far-field view of Neogene climate and Antarctic cryosphere evolution. The proposed scientific objectives directly address Ocean and Climate Challenges 1 and 2 of the 2013-2023 IODP Science Plan.

751 - Full 2

Scientific Objectives

Proposed IODP 751-Full sites target Neogene and Quaternary strata and form a latitudinal and depth transect from the Ross Sea continental shelf to rise that is designed to achieve five scientific objectives:
1. Evaluate the contribution of West Antarctica to far-field ice volume and sea level estimates.
2. Reconstruct ice proximal atmospheric and oceanic temperatures to identify past polar amplification and assess its forcings/feedbacks.
3. Assess the role of oceanic forcing (e.g. sea level and temperature) on WAIS stability/instability.
4. Identify the sensitivity of WAIS to Earth's orbital configuration under a variety of climate boundary conditions.
5. Reconstruct Eastern Ross Sea bathymetry to examine relationships between sea-floor geometry, ice sheet stability/instability, and global climate.

To achieve these objectives, we will:
a) Use data and models to reconcile intervals of maximum Neogene annd Quatenary Antarctic ice advance with far-field records of eustatic sea-level change.
b) Reconstruct past changes in oceanic and atmospheric temperatures using a multi-proxy approach.
c) Reconstruct Neogene and Quaternary ice margin fluctuations in datable marine continental slope and rise records and correlate these records to existing inner continental shelf records (e.g. ANDRILL).
d) Examine relationships between WAIS stability/instability, Earth's orbital configuration, oceanic temperature and circulation, and atmospheric pCO2
e) Constrain the timing of Ross Sea continental shelf over-deepening and assess its impact on Neogene and Quaternary ice dynamics.

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

Proposed Sites

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
EBOCS-01B	-75.6666666666188, -179.800000000073	560	706	0	706	1) Establish the timing of the first expansion of marine based ice streams into the Ross Sea (RSU4) - addressing Objectives 1,3,4,5. 2) Determine if glacial advance associated with RSU4 was from localised ice caps or shelf-wide ice sheet advance (i.e. WAIS) – addressing Objectives 1 and 4. 3) Recover a Mid to Late Miocene climate, oceanic and ice sheet record from glacimarine deposits and subglacial till above RSU4 - addressing Objectives 1,2,3,4. 4) recover a climatic, oceanic (and ice sheet?) record (at 75 degrees S) of the Middle Miocene Climatic Optimum (below RSU4) - addressing Objectives 1,2,3,4.
EBOCS-05A	-75.5498555638864, 179.205987458374	520	1120	0	1120	1) Establish the timing of the first expansion of marine based ice streams into the Ross Sea (RSU4) -

-	-	-	-	-	-	addressing Objectives 1,3,4,5. 2) Determine if glacial advance associated with RSU4 was from localised ice caps or shelf-wide ice sheet advance (i.e. WAIS) – addressing Objectives 1 and 4. 3) Recover a Mid to Late Miocene climate, oceanic and ice sheet record from glacimarine deposits and subglacial till above RSU4 - addressing Objectives 1,2,3,4. 4) recover a climatic, oceanic (and ice sheet?) record (at 75 degrees S) of the Middle Miocene Climatic Optimum (below RSU4) - addressing Objectives 1,2,3,4.
EBOCS-02A	-76.0833333333465, -178.096666666801	675	340	0	340	1) Recover a mid(?) to Late Miocene climate, oceanic and ice sheet record from glacimarine deposits and subglacial till above RSU4 - addressing Objectives 1,2,3,4. 2) Establish the timing of the first expansion of marine based ice streams into the Ross Sea (RSU4) - addressing Objectives 1,3,4,5. 3) Determine if glacial advance associated with RSU4 was from localised ice caps or shelf-wide ice sheet advance (i.e. WAIS) – addressing Objectives 1 and 4. - this is the lowest priority of the shelf sites, but provides a (third) alternate to meet a the key objectives of EBOCS-01A (constrain RSU4 age).
EBOCS-03B	-76.578514647768, -174.609241366544	555	545	0	545	1) constrain the age of the first shelf-wide advance of the WAIS (i.e. RSU3) - addressing Objectives 1,4,5 2) Recover a post RSU4 paleoclimate, glacimarine and ice sheet stratigraphic record that spans the MMCT to present - addressing Objectives 1,2,3,4. 3) Constrain an age for the overdeepening event associated with RSU2, and assess response of ice sheet variability - addressing objectives 1,3, 5
EBOCS-06A	-75.9144821972222, -175.3495817	500	420	0	420	1) constrain the age of the first shelf-wide advance of the WAIS (i.e. RSU3) - addressing Objectives 1,4,5 2) Recover a post RSU4 paleoclimate, glacimarine and ice sheet stratigraphic record that spans the MMCT to present - addressing Objectives 1,2,3,4. 3) Constrain an age for the overdeepening event associated with RSU2, and assess response of ice sheet variability - addressing objectives 1,3, 5
EBOCS-04B	-76.1765109583333, -172.883982977778	480	520	0	520	1) Constrain an age for the overdeepening event associated with RSU2, and assess response of ice sheet variability - addressing objectives 1,3, 5 2) Recover a post RSU3 paleoclimate, glacimarine and ice sheet stratigraphic

-	-	-	-	-	-	record that spans the Pliocene (Late Miocene?) to present - addressing Objectives 1,2,3,4.
EBOCS-07A	-76.2277206027918, -173.551744833229	550	390	0	390	1) Constrain an age for the overdeepening event associated with RSU2, and assess response of ice sheet variability - addressing objectives 1,3, 5 2) Recover a post RSU3 paleoclimate, glacimarine and ice sheet stratigraphic record that spans the Pliocene (Late Miocene?) to present - addressing Objectives 1,2,3,4.
RSCR-01B	-75.2465988944006, -175.005823086257	1400	954	0	954	1. Obtain a near-continuous pre-RSU3 (mid Miocene-Pliocene(?)) sediment sequence (capped by a post-RSU2 sequence) to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production - addressing Objective 3.
RSCR-03A	-75.0009986388656, -173.920116730618	1824	794	0	794	1. Obtain a near-continuous pre-RSU3 (mid Miocene-Pliocene(?)) sediment sequence (capped by a post-RSU2 sequence) to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production - addressing Objective 3.
RSCR-04A	-75.499688561103, -173.192107130541	1360	998	0	998	1. Obtain a near-continuous pre-RSU3 (mid Miocene-Pliocene(?)) sediment sequence (capped by a post-RSU2 sequence) to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production - addressing Objective 3.
RSCR-05A	-75.2947106713889, -171.765336044444	1995	1053	0	1053	1. Obtain a near-continuous pre-RSU3 (mid Miocene-Pliocene(?)) sediment

-	-	-	-	-	-	sequence (capped by a post-RSU2 sequence) to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production - addressing Objective 3.
RSCR-07A	-75.3528008999886, -172.606901424953	1747	1088	0	1088	1. Obtain a near-continuous pre-RSU3 (mid Miocene-Pliocene(?)) sediment sequence (capped by a post-RSU2 sequence) to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production - addressing Objective 3.
RSCR-08A	-73.3869716055212, 178.92084033875	506	862	0	862	1. Obtain a near-continuous Miocene-Pliocene(to quaternary?)) sediment sequence to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production - addressing Objective 3.
RSCR-06A	-74.6825222888828, -170.97270744709	2718	790	0	790	1. Obtain a near-continuous pre-RSU3 (mid Miocene-Pliocene(?)) sediment sequence (capped by a post-RSU2 sequence) to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production - addressing Objective 3.
RSCR-02B	-74.5059184444211, -172.85451913905	2400	963	0	963	1. Obtain a near-continuous pre-RSU3 to present (Mid/Late Miocene to

-	-	-	-	-	-	Quaternary) sediment sequence to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production during the Neogene and Quaternary - addressing Objective 3.
RSCR-09A	-74.38, -173.775	2266	900	0	900	1. Obtain a near-continuous post-RSU3 to present (Mid/Late Miocene to Quaternary) sediment sequence to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2.Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production during the Neogene and Quaternary - addressing Objective 3. 3.Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4.
RSCR-10A	-74.2173888888586, -173.633722222356	2500	505	0	505	1. Obtain a near-continuous pre-RSU3 to present (Mid/Late Miocene to Quaternary) sediment sequence to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production during the Neogene and Quaternary - addressing Objective 3.
RSCR-11A	-71.8460272138889, -175.679039766667	1650	414	0	414	1. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production during the Neogene and Quaternary - addressing Objective 3. 2. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 3. Obtain a near-continuous Pliocene to present sediment sequence to provide a high resolution chronology, and an ice-distal record of

-	-	-	-	-	-	glacial/interglacial cycles -addressing Objectives 2,3,4.
RSCR-12A	-71.8494471194444, 178.0393065	1970	588	0	588	1. Recover a high-resolution record that can be correlated to inner and outer shelf records as well as mid and high latitude deep-sea records of glacial and environmental changes -addressing Objectives 3,4. 2. Reconstruction of Antarctic Slope Current vigor and Ross Sea Bottom Water production during the Neogene and Quaternary - addressing Objective 3. 3. Obtain a near-continuous Pliocene/Late Miocene(?) to Quaternary) sediment sequence to provide a high resolution chronology, and an ice-distal record of glacial/interglacial cycles -addressing Objectives 2,3,4.