IODP Proposal Cover Sheet

- Pre

Antarctic Cryosphere Origins

Received for:

Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Proponents	Robert McKay, Laura De Santis, Christopher Sorlien, Richard Levy, Denise Kulhanek, Amelia Shevenell, Doug Wilson, Bruce Luyendyk, Sookwan Kim, Huw Horgan, Tina van de Flierdt, Rupert Sutherland, David Harwood, Tim Naish, Robert De Conto, Jongkuk Hong, Yusuke Suganuma, Gerhard Kuhn, Karsten Gohl
Keywords	Antarctica, Cryosphere, Cenozoic, Paleoclimate, Tectonics
Area	Ross Sea

Proponent Information

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Abstract

Antarctica's ice sheets profoundly influence the global climate system and carbon cycle by impacting ocean and atmospheric circulation, biogeochemical cycles, and sea level. Large ice sheets developed in Antarctica as the Earth transitioned from the warm, high-CO2 Greenhouse world of the Paleocene and Eocene, into the moderate-CO2 world of the Oligocene to early Miocene. However, constraints regarding the timing and magnitude of Antarctica's earliest ice sheets come mostly from indirect inferences based on distant marine geochemical records rather than a direct, ice-proximal, perspective from the Antarctic continental shelf. Additionally, there are very few direct records of Eocene-Cretaceous climates at high latitudes in Antarctica, and new records will provide important constraints of the magnitude of polar amplification during greenhouse climates.

Several mechanisms exist to explain Antarctic glacial onset, including declining atmospheric CO2 and the tectonic opening of the Southern Ocean. It is also generally assumed that initial ice sheet expansion near the Eocene/Oligocene boundary was limited to terrestrial ice sheets in East Antarctica, because ice could not easily expand across a marine-inundated West Antarctica in the moderate-CO2 worlds and warmer climates of the Oligocene. However, Cretaceous-Cenozoic rifting, alongside Neogene erosion, has led to widespread subsidence in West Antarctica. A more elevated West Antarctica in the Oligocene could hold more terrestrial ice than today, even though the climate was warmer than present. Consequently, the ice sheet evolution of the Ross Sea is hypothesized to be strongly-coupled to the tectonic and subsidence history of West Antarctica, rather than climate forcings alone. Therefore,obtaining direct records of rift timing and climate/glacial history is required to understand these competing influences. A further implication of understanding the tectonic history of West Antarctica, is that active rifting in the Ross Sea is thought to be a keystone in resolving models of Cenozoic global plate motion circuits.

The Ross Sea is perfectly situated to obtain new perspectives on the tectonic influences on Antarctica's climatic and ice sheet evolution. It is located within West Antarctic Rift System, which allows for direct assessment of rift timing, but has formed large sedimentary basins that capture and preserve climatic records at high latitudes in Antarctica since Late Cretaceous times. We target four continental shelf drill sites in the Ross Sea, which form a longitudinal-transect designed to capture this integrated history of tectonic, climate and glacial influences from both East and West Antarctica.

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Scientific Objectives

Objective 1: Obtain direct evidence of the earliest ice sheets in East and West Antarctica expanding into the Ross Sea.
Objective 2: Obtain geological reconstructions of “pre-icehouse” climates at high latitudes in Antarctica during the Late Cretaceous to Eocene.
Objective 3: Constrain the timing of late rift phases in the Ross Sea to resolve mechanisms of crustal extension in the Ross Sea, in order to test hypotheses of global plate tectonic models, and understand tectonic controls on ice sheet evolution.

We will achieve these objectives by:
A) Drilling a total of four sites, as part of an East to West transect on the Ross Sea continental shelf, that will provide records of early ice sheet histories sourced from both East and West Antarctica.
B) Drill into syn-rift strata (Cretaceous- late Eocene), and post-rift strata (Eocene-early Miocene) at each site to obtain climate archives. We aim to core above and below unconformities formed near the Eocene/Oligocene boundary, when the first large-continental scale Antarctic ice sheets are proposed to have formed.
C) Date syn-rift strata in separate continental shelf basins, to provide minimum constraints of the time of active Ross Sea rift propagation.

This proposal directly address Challenges 1 and 2 of the IODP Science Plan.

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

Proposal History

Submission Type: Resubmission from declined proposal

Declined Proposal Number: 964-Full

Review Response

The SEP stated "there is a very strong scientific rationale for the proposed drilling". We were strongly encouraged to resubmit, even though it was deactivated.

SEP had several high order requests.

1) submit a pre-proposal (instead of full proposal) to allow more opportunity to nurture the proposal prior through to the peer review stage. DONE

2) remove link to undrilled IODP Exp 374 sites. That expedition terminated early, so several sites went back to JRFB. We submitted the last proposal (964) as a shorter duration expedition to allow remaining 374 sites to be drilled. This confused SEP, who found it difficult to prioritize between objectives between this new proposal and IODP 374. We also overlooked port call time that the drilling timeline to include the 374 unfeasible. This new proposal is entirely standalone in it objectives and is now a full expedition. JRFB can decide on the best procedure to prioritize the undrilled 374 sites. DONE

3) Prioritize objectives between obtaining rift history or climate/ice sheet history. It was perceived our first priority was the deepest, highest risk strata below RSU7 to obtain rift timing, and therefore we could have achieved our objectives by drilling at shallower sites. This was not intended. Our priority is the greenhouse and early icehouse records above and below RSU6 and expanded records of this period are higher priority than dating RSU7 (which highly useful, but more snapshot in nature). This prioritization is much clearer in this revised proposal. DONE

3) Add results of Exp 374 to inform on margin stratigraphy, and paleoclimate or optimum methodologies or operational strategies can be integrated.
-This was a somewhat confusing request as we had a lot of details of operation strategies/methods from 374 in this new proposal, and had several figures dedicated to this. Importantly, 374 has no bearing on margin stratigraphy relevant to this new proposal - as our targets much older than anything 374 drilled (see Figure 3). Therefore, existing published drill core studies in the Ross Sea we cited are more relevant and already published (ANDRILL, Cape Robert, CIROS-1, DSDP 28). Results from these expeditions are far more relevant than 374 (and we explain paleoclimate/methods from these in a table). These earlier projects are what guided our hypothesis development and strategy for drilling/analysis. We have made this more clear in this revised proposal, but we do point to the relevant methodological/dirlling successes from 374 proceeding volumes in this revised proposal (esp drilling recovery/risks). IMPROVED AND CLARIFIED

4) Consider relocating some sites to shallower target for RSU7, and if RSU7 is primary target we may need addition seismic lines due to the complex rifting structures. See comment 2.This request was based on the view RSU7 was our higher priority than early ice house/greenhouse records - which was not intended. If RSU7 was not the highest priority, then SEP suggested existing site are ok. We make it clear this is not our priority and expanded sequences are more important. Shallow targets are only presented as contingency if drilling window time are short due to delays etc. CLARIFIED.

Proposed Sites (Total proposed sites: 16; pri: 4; alt: 12; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
CHCS-01A (Primary)	-77.2315 172.2051	693	1200	0	1200	1) Obtain direct geological evidence of the earliest history of ice sheets in East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in East Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (medium priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority)
CHCS-02A (Alternate)	-77.31783122 171.95787093	740	1200	0	1200	1) Obtain direct geological evidence of the earliest history of ice sheets in East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in East Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (medium priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority)
CHCS-03A (Alternate)	-77.0727 171.5629	712	1300	0	1300	1) Obtain direct geological evidence of the earliest history of ice sheets in East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in East Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5 Ma). (medium priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority)
CENCS-01A (Primary)	-77.4516 -177.8407	616	1185	15	1200	1) Obtain direct geological evidence of the earliest history of ice sheets coalescing from West and East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in West Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5 Ma). (high priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority).
CENCS-02A (Alternate)	-77.6402 -179.2478	648	850	50	900	1) Obtain direct geological evidence of the earliest ice sheets coalescing from West/East Antarctica, by sampling strata above RSU6 (~34-26.5 Ma). A Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (low priority at this site, as section is condensed compared to CENCS-01A) 2) Reconstruct “pre-icehouse” climates in West Antarctica (Late Cretaceous to Eocene), by sampling material below RSU6 (thought to be ~34-26.5Ma). (high priority) 3) Constrain late rift phase timing in the Western Ross Sea, by dating RSU6 and coring syn-rift strata. (moderate priority). ALTERNATE IN CASE OF REDUCED DRILLING TIME DUE TO LOGISTIC DELAYS AT OTHER SITES.
CENCS-03A (Alternate)	-77.2200 -178.6336	645	1050	0	1050	1) Obtain direct geological evidence of the earliest history of ice sheets coalescing from West and East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in West Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (high priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority).
CENCS-04A (Primary)	-73.99148766 -177.28643477	700	1070	0	1070	1) Reconstruction “pre-icehouse” climates in West Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (high priority) 2) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (medium priority).
CENCS-05A (Alternate)	-73.99713175 177.15819239	385	1000	0	1000	1) Reconstruction “pre-icehouse” climates in West Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (high priority) 2) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (medium priority).

Proposed Sites (Continued; total proposed sites: 16; pri: 4; alt: 12; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
ERSCS-01A (Alternate)	-77.61010423 -160.84500232	620	1050	10	1060	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to Early Miocene (20 Ma) record of WAIS advance in Marie Byrd Land (high priority) 2) Reconstruction “pre-icehouse” climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-28Ma) and RSU7 (Late Cretaceous to Eocene?) (high priority) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
ERSCS-02A (Primary)	-77.9402 -160.4316	660	775	25	800	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to Early Miocene (20 Ma) record of WAIS advance in Marie Byrd Land (high priority) 2) Reconstruction “pre-icehouse” climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-28Ma) and RSU7 (Late Cretaceous to Eocene?) (high priority) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
ERSCS-03A (Alternate)	-78.3925 -164.7040	541	1200	0	1200	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica (strata above RSU6; 34-26.5 Ma). Will obtain a Oligocene-Early Miocene (~34-20 Ma) record of WAIS advance in Marie Byrd Land. (moderate priority, as top of sequence truncated by younger strata) 2) Reconstruct “pre-icehouse” climates in Eastern Ross Sea/Marie Byrd Land during the Late Cretaceous to Eocene; strata below RSU6 (~34-28Ma) and RSU7 (Late Cretaceous to Eocene?). (high priority-expanded at this site) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
ERSCS-04A (Alternate)	-78.3509 -162.5913	706	1134	20	1154	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to Early Miocene (20 Ma) record of WAIS advance in Marie Byrd Land (high priority) 2) Reconstruction “pre-icehouse” climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-28Ma) and RSU7 (Late Cretaceous to Eocene?) (high priority) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
ERSCS-05A (Alternate)	-78.2274 -161.5268	615	1200	0	1200	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene-Early Miocene (~34-20 Ma) record of WAIS advance in Marie Byrd Land (high priority) 2) Reconstruction “pre-icehouse” climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (~34-26.5Ma) and RSU7 (Late Cretaceous to Eocene?) (low priority -as strata to deep) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
ERSCS-06A (Alternate)	-77.668106299 -160.740589980	620	1300	0	1300	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene-early Miocene (~34-20 Ma) record of WAIS advance in Marie Byrd Land. (high priority) 2) Reconstruct “pre-icehouse” climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-28Ma) and RSU7 (Late Cretaceous-Eocene?) (high priority - expanded sequence at this site) 3) Constrain timing of late rift phases in Eastern Ross Sea, by dating syn-rift strata below RSU7. (moderate priority)
RSAP-01A (Alternate)	-71.3435 -164.4160	4133	1090	10	1100	1) obtain continuous record of Early Miocene to Oligocene oceanographic change relating to ice sheet variance on continent. Site complements RSCR-19A from IODP Exp 374 to obtain an older stratigraphic record links Exp 374 and this new proposals objective. It is lower priority than the continental shelf site and RSCR-19A, as it is RCB only and will obtain lower recovery than shelf site (less lithified) and RSCR-19A (APC/XCB core). alternate in case of poor sea ice year in ERSCS sites (other shelf site in CHCS and CENCS regions are always open water in summer)

Proposed Sites (Continued; total proposed sites: 16; pri: 4; alt: 12; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
RSAP-02A (Alternate)	-69.99544571 -164.67600	4075	1200	0	1200	1) obtain continuous record of Early Miocene to Oligocene oceanographic change relating to ice sheet variance on continent. Site complements RSCR-19A from IODP Exp 374 to obtain an older stratigraphic record links Exp 374 and this new proposals objective. It is lower priority than the continental shelf sites. Provides an alternate in case of poor sea ice year in ERSCS sites (other shelf site in CHCS and CENCS regions are always open water in summer)

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Contact Information

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Proponent List

First Name	Last Name	Affiliation	Country	Role	Expertise
Robert	McKay	Antarctic Research Centre, Victoria University of Wellington	New Zealand	Principal Lead	Sedimentology, Stratigraphy
Laura	De Santis	National Institute of Oceanography and Applied Geophysics - INOGS	Italy	Data Lead	Seismic Stratigraphy
Christopher	Sorlien	University of California Santa Barbara	United States	Other Proponent	Seismic Stratigraphy
Richard	Levy	GNS Science	New Zealand	Other Proponent	Paleontology, stratigraphy
Denise	Kulhanek	International Ocean Discovery Program, Texas A&M University	United States	Other Proponent	biostratigraphy, logistics
Amelia	Shevenell	University of South Florida	United States	Other Proponent	Geochemistry, sedimentology
Doug	Wilson	University of California Santa Barbara	United States	Other Proponent	Seismic Stratigraphy
Bruce	Luyendyk	University of California Santa Barbara	United States	Other Proponent	Seismic Stratigraphy
Sookwan	Kim	Korea Polar Research Institute	Korea, Republic of	Other Proponent	Seismic Stratigraphy
Huw	Horgan	Victoria University of Wellington	New Zealand	Other Proponent	Glaciology, geophysics
Tina	van de Flierdt	Imperial College London	United Kingdom	Other Proponent	Geochemistry, oceanography, provenance studies
Rupert	Sutherland	Victoria University of Wellington	New Zealand	Other Proponent	Tectonics
David	Harwood	University of Nebraska-Lincoln	United States	Other Proponent	diatom biostratigraphy, stratigraphy
Tim	Naish	Antarctic Research Centre, Victoria University of Wellington	New Zealand	Other Proponent	Sedimentology, Stratigraphy
Robert	De Conto	University of Massachusetts-Amherst	United States	Other Proponent	ice sheet/climate modelling
Jongkuk	Hong	Korea Polar Research Institute	Korea, Republic of	Other Proponent	Seismic Stratigraphy
Yusuke	Suganuma	National Institute of Polar Research	Japan	Other Proponent	Paleomagnetics and paleoclimate
Gerhard	Kuhn	Alfred-Wegener-Institut	Germany	Other Proponent	Geochemistry, physical properties
Karsten	Gohl	Alfred-Wegener-Institut	Germany	Other Proponent	Seismic Stratigraphy,

1. Introduction

The tectonic break-up of Gondwana has long been considered a fundamental control on Antarctic Ice Sheet (AIS) development, due to resultant shifts in global carbon cycling, and the thermal isolation of Antarctica as the Southern Ocean formed (Kennett *et al.*, 1974; Kennett, 1977; DeConto and Pollard, 2003). The West Antarctic Rift System (WARS) is also a critical influence on early AIS evolution as it controlled the timing and amount of West Antarctic subsidence, Transantarctic Mountain (TAM) uplift, and crustal heat flux (Behrendt et al., 1991; Cooper and Davey, 1985; LeMasurier, 1990; Luyendyk et al., 2001; Wilson and Luyendyk, 2009). It has recently become apparent that constraining West Antarctica's paleotopography, relating to WARS history and erosional processes, is critical for determining AIS contributions to eustatic sea level variance through the Cenozoic (Wilson et al., 2013). Determining past AIS contributions to sea level in a range of background climate states and boundary conditions is required to inform models used to project future scenarios and thresholds for ice sheet and global sea level change.

Paleotopographic reconstructions reveal that West Antarctica was largely above sea level at 34 Ma. Consequently, Antarctica could hold more terrestrial ice in the warmer-than-present Oligocene than it can today (Wilson et al., 2013). This is because the cooling threshold required for the development of a terrestrial-based ice sheet is lower than that of marine-based ice sheets, which are highly sensitive to changes in oceanic heat flux. Consequently, models indicate a largely terrestrial West Antarctica could potentially accommodate an extra ~13 million km^2 of grounded ice (i.e. ~30 m sea level equivalent (SLE)) during the early Oligocene, while the increased buttressing provided by a larger WAIS also leads to a larger EAIS (Bart et al., 2016; Colleoni et al., 2018; Wilson et al., 2013) (Figure 2).

Here, we plan an east-to-west drilling transect in the Ross Sea to examine high-latitude paleoclimates during early Paleogene high-CO_2 worlds (IODP challenge 1); Early Cenozoic AIS evolution (IODP challenge 2); and the rift history of the WARS (IODP challenge 9). Our continental shelf drill sites are strategically located to constrain the earliest ice sheet advances sourced from both the EAIS and WAIS

(Figures 1-2); and identify key paleotopographic, environmental and tectonic boundary conditions that influenced the earliest phases of AIS development.

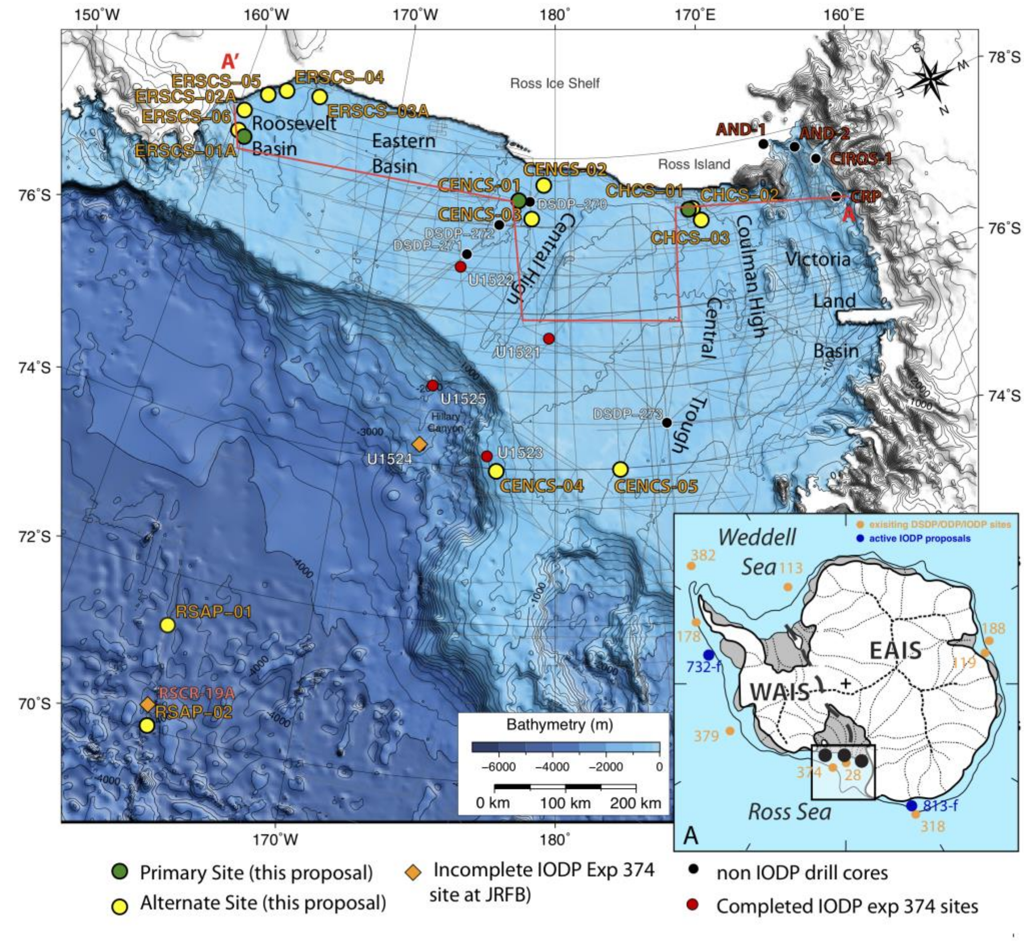


Figure 1: Ross Sea bathymetry with locations of proposed drill sites (including alternates); and existing drill sites. Insert map show major ice flow pathways of the WAIS and EAIS (dotted lines) relative to primary sites proposed herein (black dots). Sites are strategically located to capture sedimentary archives of WAIS and EAIS ice flow into the Ross Sea. Red line (A-A') show approximate location of simplified transect in Figure 5.

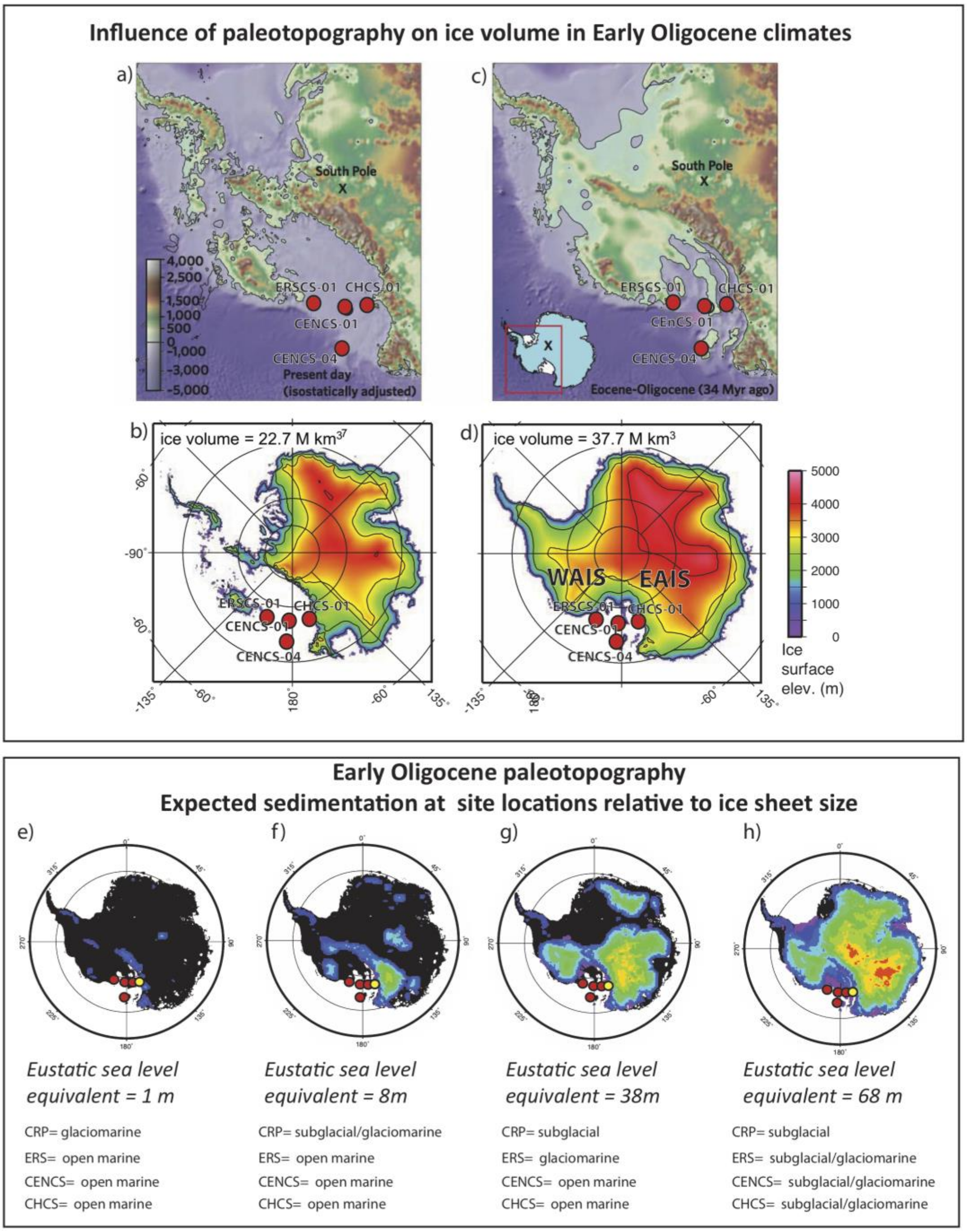


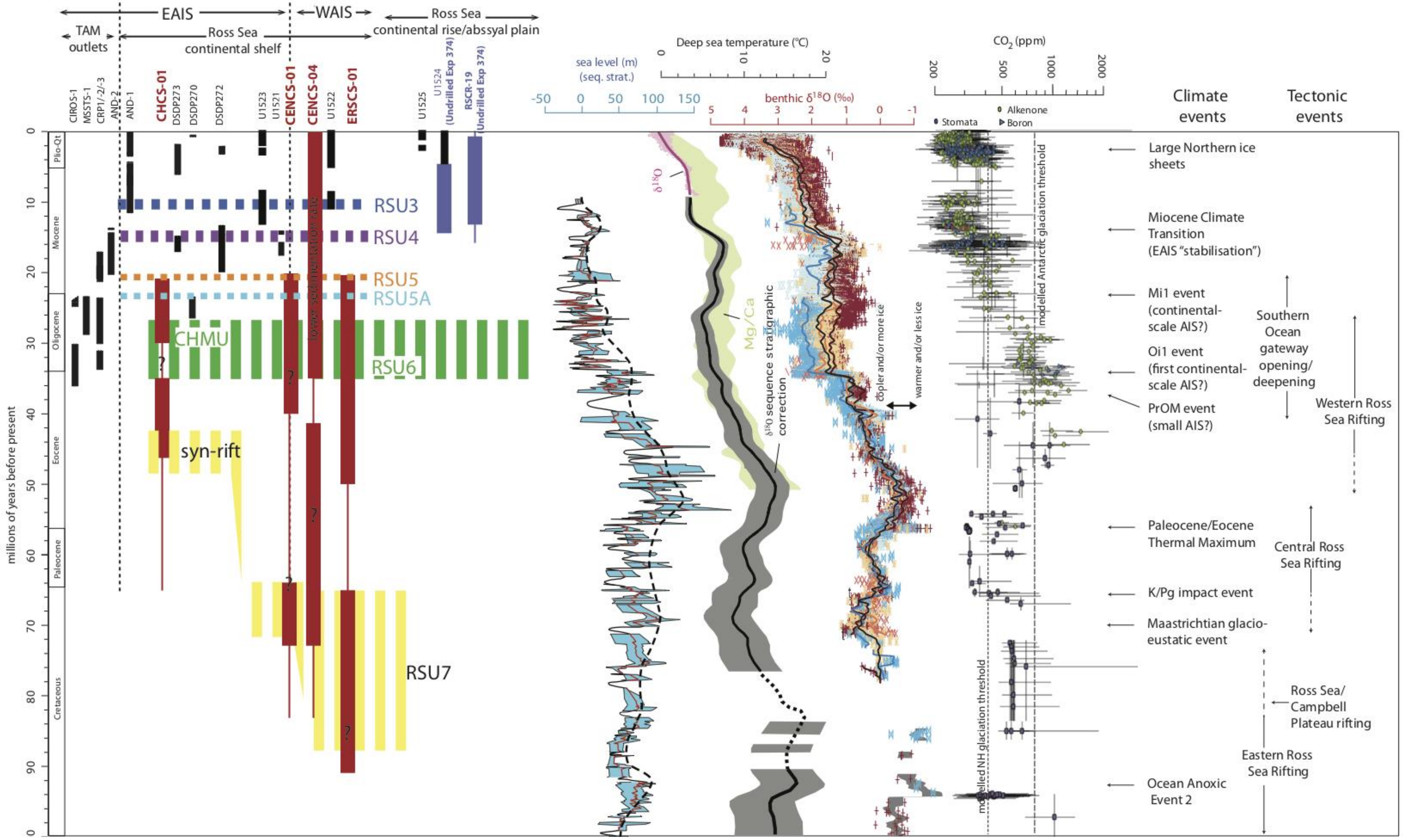
Figure 2: ***Upper panel****: a) Modern West Antarctic topography, with b) modeled AIS volume under an E/O boundary climate state (700 ppm CO_2). Note lack of AIS in West Antarctica as marine ice sheet does not form in this warmer-than-present climate. c) Reconstructed Eocene/Oligocene (E/O) West Antarctic topography, with d) modeled AIS volume run in same climate as panel c but with E/O topography. Note AIS almost doubles due to this topographic change.* ***Lower Panels:*** *Modelled AIS evolution across the E/O transition using topography in Figure 2c. (e) small alpine glaciers or (f) ice caps in TAM could result in glacial deposition at the CRP core records (yellow dot), contributing only 1-8 m eustatic SLE. Large advances from WAIS and EAIS into the Ross Sea (g, h) will be captured at the proposed sites herein (red dots)- and represent events up to 68 m in eustatic SLE (model from Stocchi et al., 2013)).*

2. Relationship to recent IODP Expedition 374 and previous drilling in Ross Sea

This new proposal is entirely standalone from IODP Expedition 374 aims, which drilled sediments post-dating 18 Ma in the Central Ross Sea (Figure 3). For strata older than 18 Ma, the western-most Victoria Land Basin (VLB) has been the focus of most previous geological drilling in the Ross Sea region (e.g. DVDP, MSSTS-1, CIROS, Cape Roberts Project (CRP) and ANDRILL), and it is the results/methods/stratigraphic framework of these legacy drilling projects (and DSDP Leg 28) that have guided our hypothesis development/drilling strategy (Figure 3).

This proposal focuses on the unsampled early Cenozoic Ross Sea sequences in the Coulman High region, Central Trough basin and Eastern Basins (EB); (Figures 3-5) (Brancolini et al., 1995; Busetti et al., 1999).

Figure 3 (NEXT PAGE): Chronostratigraphic summary of existing/proposed Ross Sea drilling (Modified from McKay et al., 2019)*. Seismic stratigraphy below RSU4 is only partially constrained in the Victoria Land and Central Basin, but not in the Eastern basins where major unconformities are likely diachronous. Seismic stratigraphy below RSU6 (26.5-34 Ma) or deeper is not constrained in any basin – and recovering these strata is the primary aim of this proposal. Red lines indicate predicted stratigraphies to be recovered. Far-field sea level records (Kominz et al., 2008), climate proxies ($\delta^{18}O$; Cramer et al., 2009)), atmospheric CO_2, (Foster et al., 2017), and relevant Cenozoic climate and tectonic events are also shown.*



EAIS
WAIS
TAM outlets
Ross Sea continental shelf
Ross Sea continental rise/abyssal plain
CIROS-1
MSSTS-1
CRP1/-2/-3
AND-2
AND-1
CHCS-01
DSDP273
DSDP270
DSDP272
U1523
U1521
CENCS-01
CENCS-04
U1522
ERSCS-01
U1525
U1524 (Undrilled Exp 374)
RSCR-19 (Undrilled Exp 374)
RSU3
RSU4
RSU5
RSU5A
CHMU
RSU6
syn-rift
RSU7
Plio-Qt
Miocene
Oligocene
Eocene
Paleocene
Cretaceous
millions of years before present
sea level (m) (seq. strat.)
Deep sea temperature (°C)
benthic δ18O (‰)
δ18O
Mg/Ca
δ18O sequence stratigraphic correction
cooler and/or more ice
warmer and/or less ice
CO2 (ppm)
Stomata
Alkenone
Boron
modelled Antarctic glaciation threshold
modelled NH glaciation threshold
Climate events
Tectonic events
Large Northern ice sheets
Miocene Climate Transition (EAIS "stabilisation")
Mi1 event (continental-scale AIS?)
Oi1 event (first continental-scale AIS?)
PrOM event (small AIS?)
Paleocene/Eocene Thermal Maximum
K/Pg impact event
Maastrichtian glacio-eustatic event
Ocean Anoxic Event 2
Southern Ocean gateway opening/deepening
Western Ross Sea Rifting
Central Ross Sea Rifting
Ross Sea/Campbell Plateau rifting
Eastern Ross Sea Rifting

3. Cretaceous to early Miocene stratigraphic framework of the Ross Sea

WARS extension likely occurred in several phases since the Late Cretaceous, and resulted in the development of three major Ross Sea sedimentary basins (Figure 4) (Cooper et al., 1991; Wilson & Luyendyk, 2009). Eight Ross Sea Seismic Sequence (RSS1-8) units and seven Ross Sea Unconformities (RSU1-7) represent steps in Antarctica's tectonic and climatic evolution (Figure 3). The oldest and deepest unit RSS-1 consists of graben-bound rift-fill strata formed by extension and continental breakup (Decesari et al., 2007; Luyendyk et al., 2001). Subdivision into early- (RSS-1 Lower) and late-rift (RSS-1 Upper) sequences are bounded by unconformity RSU7, which is probably diachronous across basins, a consequence of rifting propagating from east (Cretaceous) toward the west; or glacial erosional by the earliest ice sheets (late Eocene) (Figure 4). Unit RSS-1 Upper is a thicker sequence of flat-lying, faulted strata onlapping onto RSU7, inferred to contain strata deposited during marine transgression across thermally subsiding crust (Decesari et al., 2007).

RSU6 is a prominent seismic reflection/unconformity, but its origin and age is enigmatic. DSDP Site 270 indicates RSU6 is >26 Ma, but this site cored into a basement high and postdates RSU6 (Figure 5) (Kulhanek et al., 2019). An early Oligocene age (>26 Ma) is consistent with the hypothesis that RSU6 represents early Oligocene grounding of ice sheets on the continental shelf, or related eustatic sea level change, and underlying strata likely capture the Eocene/Oligocene (E/O) transition (Anderson & Bartek, 1992; Bartek et al., 1991; De Santis et al., 1995).

Overlying RSU6, glacial-influenced marine sediment provides a record of the early Oligocene to early Miocene history of the AIS, although this unit is still only sparsely sampled. The CRP and CIROS-1 sites obtained discontinuous records influenced by deposition and erosion from local TAM alpine glaciers since the earliest Oligocene (Figure 2).

Here, we aim for a more complete record of Units RSS-1 Upper and RSS-2 along an E-W transect that records a signal of both East and West Antarctic ice sheet and climate history, and the relationship to the WARS tectonic history.

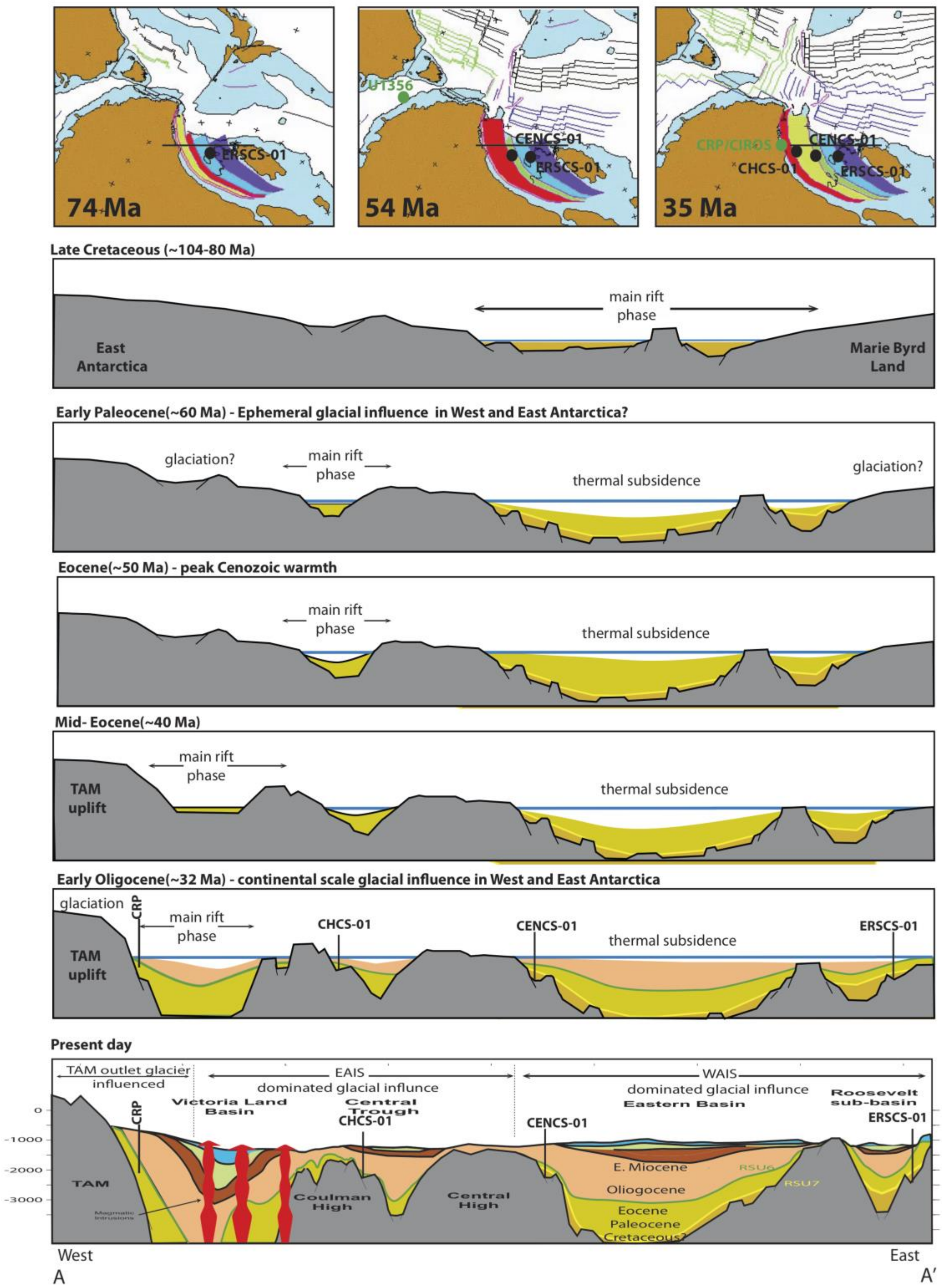


Figure 4: Rift history and relationship to basin infill and ice sheet/TAM outlet glacier influences through time (c.f. ice sheet models in Figure 2e-h). Targeted E-W drilling will assess the timing of active rift termination. In this model, ERSCS-02A will obtain the oldest rift fill/climate records (back to Cretaceous?), and site CHCS-01A will contain the youngest rift fill/paleoclimate record (back to Middle Eocene?). See red line in Figure 1 for transect location.

4. Scientific Objectives

Objective 1: Obtain direct evidence of the earliest ice sheets in East and West Antarctica.

Guiding hypothesis 1: West Antarctica accommodated terrestrial ice sheets in the latest Eocene-Oligocene, which episodically expanded across shallow regions of the Ross Sea driving sea level variations of 10s of meters.

It is generally assumed the first large ice sheets in Antarctica formed at the E/O boundary due to opening of Southern Ocean gateways and declining atmospheric CO_2 concentrations (DeConto & Pollard, 2003; Kennett, 1977). However, significant Southern Ocean cooling has been identified at ~37 Ma, and linked to an early AIS glaciation on the East Antarctic margin (Carter et al., 2017; Leg 119 shipboard scientific party, 1988; Pascher et al., 2015; Passchier et al., 2017; Scher et al., 2014). Continental shelf cores from the East Antarctic margin also suggest marine-terminating glaciers in the early to mid-Eocene - although determining the magnitude and duration of these earlier events is ambiguous owing to the lack of equivalent and longer datasets from other parts of Antarctica (Gulick et al., 2017).

The 1.0 to 1.5‰ benthic foraminiferal $\delta^{18}O$ excursion across the E/O boundary implies a significant EAIS volume increase at 34 Ma (Coxall et al., 2005; Lear et al., 2000; Zachos et al., 2001). Early Oligocene glaciation has been unequivocally identified from coastal CRP/CIROS-1 cores (Barrett, 2007; Barrett, 1989; Galeotti et al., 2016), although these may only document fluctuations of TAM glaciations at orbital-scale periods (Figure 2). However, ice only growing on East Antarctica at this time would be 25-50% too small to account for the marine benthic isotope shift (Figure 2), requiring significant northern hemisphere ice, a deep sea cooling of 4°C (Liu et al., 2009), or an Antarctic continent that was capable of storing more terrestrial ice during the Oligocene than the Last Glacial Maximum (DeConto et al., 2008). Tectonic and pre-erosional reconstructions of West Antarctica indicate it could accommodate much larger ice sheets (~20 m SLE, when compared to modern topography) in warmer-than-present climates due to its more subaerial setting (Figure 2).

Once ice sheets were established during the Oligocene, atmospheric CO_2 levels ranged between 400-800 ppm (Foster & Rohling, 2013; Pagani et al., 2011; Zhang et al., 2013) (Figure 3). Such concentrations likely precluded widespread marine-based ice sheets, except in a very shallow marine settings (e.g. terrestrial ice sheets can still have marine terminating margins, as they do today in much of East Antarctica/Greenland). Consequently, we anticipate recovering a mostly continuous Oligocene glacimarine (with ice rafted debris) sequence (or glacifluvial run-off influenced) that is largely devoid of erosional ice sheet grounding events at the four proposed sites (c.f. Figure 2). If present, regional hiatuses will be diagnostically important, as they may be associated with eustatic sea level changes or grounded marine ice sheet overriding. Indeed, constraining the transient nature of large Oligocene glaciations is important in a climate- and ice-sheet modeling context (Pollard & DeConto, 2005), as AIS hysteresis is very strong. Consequently, once a high-elevation, terrestrial ice sheet forms, orbital forcing alone cannot provide enough surface melt to drive a retreat, even at CO_2 levels >4x preindustrial levels (Huybrechts, 1994; Pollard & DeConto, 2005), much higher than Oligocene CO_2 proxies suggest (DeConto et al., 2008; Foster & Rohling, 2013; Pagani et al., 2005, 2011).

Guiding hypothesis 1 will be tested at sites influenced by past WAIS (see site ERSCS-02A) and EAIS (see site CHCS-01A) variations. We will recover late Oligocene-early Miocene strata (above RSU6) and Cretaceous-late Oligocene (below RSU6) to investigate the spatial distribution of glacimarine and subglacial sediment when the continental shelf was much shallower, and sediment was shed from glaciofluvial or marine-terminating margins of largely terrestrial ice sheets/caps (Figure 2; see Table 1 for methods).

Guiding hypothesis 2: Ephemeral ice caps were present in East and West Antarctica during cooler climate intervals of the "greenhouse" Eocene and Paleocene

The ocean gateway hypothesis proposes that widespread late Cenozoic glaciation in Antarctica was driven by thermal isolation of the Antarctic continent after the tectonic opening of the Southern Ocean "gateways" (Bijl et al., 2013; Kennett, 1977). However, ice sheet models propose declining CO_2 was a more substantive driver (DeConto & Pollard, 2003). Far-field studies provide equivocal evidence of glaciation during the Paleocene (Hollis et al., 2014; Miller et al., 2005), and obtaining direct evidence of marine-terminating glaciation at a time preceding gateway opening will help test existing models and hypotheses for AIS development.

If glacial or glacimarine lithofacies or other geochemical indicators of glacial transport/erosion from on land (Table 1) are present at any of our sites for the Cretaceous to middle Eocene, this may point towards a dominant greenhouse gas forcing for ice sheet development in Antarctica (with the caveat that tectonic changes may ultimately drive carbon cycle changes). These data will be augmented with environmental proxies for temperature, sea ice and changes in the hydrological and carbon cycles (see Table 1) that can be used to test model-based hypothesis for thresholds of ice sheet development in the Cenozoic (DeConto et al., 2008). This hypothesis will be tested by obtaining strata between RSU6 and RSU7 at all primary sites and identifying if glacimarine signals exist in different regions, hundreds of kms apart (Figure 2; Table 1).

Guiding hypothesis 3: Tectonic subsidence and erosion of West Antarctica led to a decoupling of Antarctic ice volume to global climate state through the Cenozoic.

As noted in guiding hypothesis 1, a larger-than-present AIS can be sustained during warmer-than-present climates if West Antarctica was largely above sea level, meaning the common assumption that the deep-sea temperature and ice volume components of the foraminiferal oxygen isotopes covary in a linear manner requires reassessment (Zachos et al., 2001). Differentiating climatic versus tectonic influences on Cenozoic Antarctic climate and AIS volume may help to reconcile interpretations of the non-linear relationship between oxygen isotope-based assessments of global climate/ice volume with that of past atmospheric CO_2 (McKay et al., 2016)(Figure 3).

The integration of our new Cretaceous to lower Miocene records with existing younger records (Figure 3) will enable a more complete stratigraphic record of both WAIS and EAIS evolution through the entire Cenozoic (Figure 2).

Objective 2: Obtain geological reconstructions of "pre-icehouse" climates at high latitudes in Antarctica during Paleocene-Eocene (and Late Cretaceous?)

Guiding hypothesis 4: High atmospheric CO_2 and associated polar amplification during the early to mid-Eocene "greenhouse" maintained mostly ice-free Antarctic climates.

Modeling studies fail to produce extreme Eocene Antarctic temperatures under scenarios of high CO_2 implied by proxies, suggesting that models lack some processes critical for simulation of polar climates (Hollis et al., 2009). Temperature reconstructions (Table 1) from our E-W transect sites will directly test competing hypothesis of potential glaciation in the early Cenozoic (Hollis et al., 2014; Miller et al., 2020); climate sensitivity to greenhouse gas forcing; strength of polar amplification; and the role of global heat-transport mechanisms during past extreme greenhouse climates.

Guiding hypothesis 5: Terrestrial environments in the Cretaceous-Paleocene provided a significant carbon source for Eocene hyperthermal events.

Drilling on the Ross Sea continental shelf is anticipated to recover *in situ* Paleocene to Eocene marine strata, and maybe Cretaceous terrestrial sediments (Figures 3-5). Very little is known about the Antarctic terrestrial environment at these times, but the thawing of organic rich permafrost deposits have been implicated in Eocene hyperthermal events, including the Paleocene Eocene Thermal Maxima (DeConto et al., 2012). Consequently, assessing the Cretaceous to Eocene terrestrial and marine-marginal Antarctic paleoenvironments will help test this hypothesis. This does not require direct sampling of the hyperthermals, but only an assessment of the potential carbon source and climatic conditions (e.g. thawing permafrost) which may have contributed to them. However, there is potential some Eocene hyperthermals could be sampled *in situ*.

Objective 3 : Constrain the timing of rift phases in the Ross Sea.

Guiding hypothesis 6: WARS rifting and basin development propagated in an east to west pattern during the Late Cretaceous to Oligocene. Alternatively, extension is of Cretaceous age, except for the VLB and NB.

Several hypotheses for the timing/mechanism of the WARS rifting exist, including:

(1) Rifting across the region occurred in two phases, with diffuse extension across the entire Ross Sea beginning in the Late Cretaceous (~100 Ma), which became focused in the VLB by 60 Ma (Huerta & Harry, 2007);

(2) Initial rifting concentrated in the EB was primarily older than 83 Ma, and was a precursor to continental breakup; and Central Trough and VLB rifting largely occurred after 83 Ma (Wilson & Luyendyk, 2009) (Figure 4).

(3) The majority of rifting in the EB occurred after breakup of Marie Byrd Land from Campbell Plateau, but before 44 Ma (Sutherland, 2007).

Each hypothesis has implications for subsidence timing, and therefore climatic thresholds for early AIS evolution (Figure 2). The timing of rifting also has implications for global plate kinematic models, because Antarctica connects the Indo-Atlantic hemisphere with the Pacific hemisphere via a route that crosses no subduction systems, and hence provides the best opportunity to quantify global plate motion history (Sutherland, 2007).

To test guiding hypothesis 6, we will date syn-rift and post-rift strata at all sites in our E-W transect to assess if syn-rift strata are diachronous, and consistent with the propagating rift model presented in Figure 4.

Objective 3 requires the deepest penetration, and strata below RSU7 are likely to be a “snapshot-style” stratigraphy, compared to strata above – so although these deeper RSU7 targets are readily achievable with our drilling plan, we place a lower strategic priority on Objective 3, compared to Objectives 1 and 2, and penetrating significantly into pre-RSU7 strata is not mission critical.

4. Methods to constrain ice sheet margin variability, past Antarctica environments, and date continental margin sequences

We will follow previous Antarctic drilling (ANDRILL/CRP/IODP) methodology and analyses at all sites to enable us to identify deposition under grounded ice, glacimarine, and open marine conditions (Fielding et al., 2000; McKay et al., 2009, 2019; Naish et al., 2001; Passchier et al., 2011; Powell & Cooper, 2002). Marine transgression, and paleo-water depth estimates will be identified through sedimentology and macro- and micro-faunal assemblages (Beu & Taviani, 2014; Patterson & Ishman, 2012). Magneto-, bio-, and tephro-chronological age models have routinely been developed from Paleogene Ross Sea sequences in the Ross Sea (e.g., Barrett, 1989; Kulhanek et al., 2019; Naish et al., 2001).

Presenting an exhaustive list of proxies is not possible under this scope of the pre-proposal, but examples of key paleoenvironmental proxies relevant to achieving our objectives are given in Table 1.

Environmental reconstruction	Proxy method	Published examples from Antarctic margin drill cores	Objectives addressed
Temperature (surface to subsurface ocean)	TEX86, microfossil assemblages (diatoms, radiolaria, marine palynomorphs)	Bijl et al., 2013; Lazarus et al., 2008; Levy and Harwood, 2000; McKay et al., 2012; Scherer et al., 2000	1,2
Temperature (bottom water)	Bottom Water Temperature (clumped isotope on molluscs), Mg/Ca on benthic foraminifera (if suitable species)	Hillenbrand et al., 2017; Levy et al., 2016	1,2
Land temperature (terrestrial runoff)	Terrestrial temperatures (pollen, MBT/CBT, leaf wax isotopes), clay weathering	Bijl et al., 2013; Duncan et al., 2019; Feakins et al., 2012, 2014; Passchier et al., 2017; Prebble et al., 2006	1,2
Sea ice/surface stratification/glacial meltwater and terrestrial hydrology	marine algal biomarkers (δ2H isotopes, IPSO25), microfossil assemblages (diatoms, radiolarian, foraminifera, palynomorphs)	Ashley et al., 2020; McKay et al., 2012a; Sangiorgi et al., 2018; Whitehead et al., 2005	1,2
Bottom Water oxygenation	Redox sensitive metals from XRF and ICP-MS/ICP-OES	Jaccard et al., 2016; Jimenez-Espejo et al., 2020	1,2
Paleobathymetry (water depth)	Grainsize, foraminifera/mollusc assemblages,	Beu and Taviani, 2014; Dunbar et al., 2008; Leckie and Webb, 1983; Patterson and Ishman, 2012	1,3
Carbon cycling	Carbon isotopes on bulk sediment, foraminifera, and pollen; and compound specific isotopes on leaf wax and marine algae biomarkers	Ashley et al., 2020; Duncan, 2017; Griener et al., 2013; McKay et al., 2012; Shevenell and Kennett, 2004	1,2
AIS extent and catchments	facies analysis , geochemistry provenance of clay and IRD, seismic stratigraphy, quartz microtextures, numerical modelling	Brancolini et al., 1995; Cook et al., 2014, 2013; Gasson et al., 2016; Levy et al., 2016; McKay et al., 2009; 2012b; Naish et al., 2009, 2001; Passchier, 2011; Patterson et al., 2014; Pierce et al., 2011; Sorlien et al., 2007; Stocchi et al., 2013; Williams et al., 2010; Wilson et al., 2013	1
Paleotopography (erosion, rift history, sub ice geology)	Seismic stratigraphy (age constrained by drilling), thermochronology, radiometric dating of detrital grains	Cook et al., 2013; Cox et al., 2010; Fitzgerald, 2002; Jacobs et al., 2017; Jordan et al., 2020; Paxman et al., 2019; Pierce et al., 2011; Pollard and DeConto, 2020; Siddoway et al., 2004; Thomson et al., 2013; Wilson and Luyendyk, 2009	1,3
Age model	Biostratigraphy - diatoms/radiolarian (above opal CT-transition) - palynology, nannofossils foraminifera, molluscs (below opal CT-transition) Tephrostratigraphy - WARS volcanism is active during Early Cenozoic Magnetostratigraphy Strontium Isotopes (carbonate shells) Astrochronology	Acton et al., 2008; Bijl et al., 2013; Cody et al., 2012, 2008; Florindo, 2003; Gulick et al., 2017; Kulhanek et al., 2019; Naish et al., 2001; Roberts, 2003; Scherer et al., 2000; Tauxe et al., 2012; Wilson et al., 2012; Wilch & McIntosh, 2000.	1,2,3

Table 1: Examples of proxies used to reconstruct past environments in previous high-latitude studies, and relevance to objectives. This list is non-exhaustive, and will be expanded in a full proposal.

5. Logistical considerations

5.1. Drilling plan overview

The four continental shelf sites will penetrate between 775 and 1200 m to obtain strata that pre- and post-date RSU6 (and RSU7). The key objective (penetrating RSU6) can be reached at depths between ~400-815 mbsf at our primary sites, and all objectives can be achieved at ~1000 mbsf. Alternates are provided with shallower penetrations if time is restricted due to weather/ice delays (e.g. RSU6 is penetrated at ~300 mbsf at CENCS-02A, but this is at the expense of a more condensed and less continuous record of post-RSU6 strata). Where feasible, basement rocks will be sampled at all continental shelf sites (informing objective 3).

5.2 Seismic coverage

Seismic data is available for all sites (with crossing lines at site or nearby), with a dense network of coverage that allows high confidence in the regional stratigraphic architecture and allows appropriate site selection to meet our objectives (Figure 1).

Site	# of holes	Water depth (m)	Penetration (mbsf)	Time to core one hole and trip pipe (days)	time logging (days)	Priority	Alternates (in order of priority)	
CHCS-01A	1	693	1200	9.1	1.8	1	CHCS-02A ,CHCS-03A	
ERSCS-02A	1	660	775	4.5	1.5	2	ERSCS-01A, ERSCS-06A,ERSCS-03A, ERSCS-04A, ERSC-05A	
CENCS-01A	1	616	1200	9	1.8	3	CENCS-02A CENCS-03A	
CENCS-04A	1	700	1070	6	1.8	4	CENCS-05A, RSAP-01A, RSAP-02A	
Drilling/logging DAYS:				28.6	6.9			
Transit days (including between sites)	19	Port call (days)	5	Total Expedtion Time (days)	59.5			

Table 1: Proposed primary drill sites and drilling plan (number of holes; time). We have prioritized the continental shelf sites (1=highest) based on importance of site in achieving the science objectives, and objective priority.

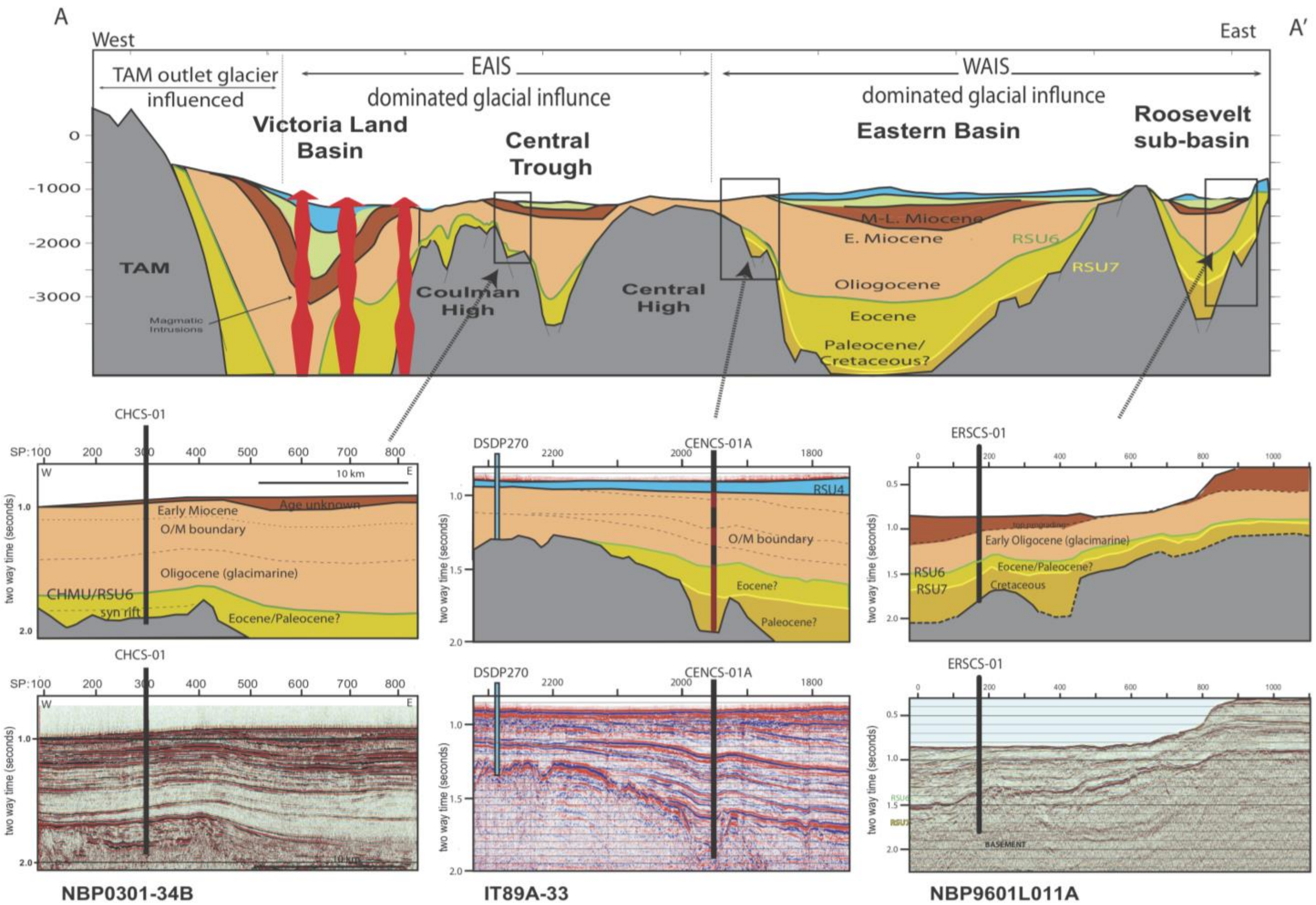


Figure 5: Simplified seismic stratigraphy of the Ross Sea (cross section lines shown as red line in Figure 1), with detailed inserts of site locations. Note proposed diachronous nature of rifting is likely to have resulted in different rift fill ages within each basin, and all sites capture thick sequences of pre- and post-RSU6 sediment.

Sites

Site CHCS-01A: Coulman High

This site will sample an expanded EAIS-influenced glacimarine sequence above the RSU6 reflector (i.e. strata of late Oligocene to early Miocene age), and earliest glacial and syn-rift material below RSU6 for a snapshot record of latest Oligocene/early Eocene climate and paleoenvironment in the western Ross Sea. This site differs from earlier drilling at CIROS-1 and CRP as: 1) it is likely to penetrate into strata older than 36 Ma; 2) the presence of glacial sediments infers larger ice sheet responses, rather than potential TAM alpine glaciations recorded in CIROS/CRP (Figure 2); and 3) ice sheet models indicate it is close to the ice sheet margin during EAIS advances, but may not be overridden regularly by a grounded ice sheets, and thus will provide a more continuous stratigraphic sequence of glacially influenced-marine environments than the highly truncated, glacially-eroded CIROS/CRP records more directly influenced by smaller scale alpine/ice cap glaciations (Figure 2e-f).

The top of the sequence can be correlated to DSDP Site 272 and IODP Site U1521 which has an age of ~18 Ma (McKay et al., 2019). Consequently, we anticipate a snapshot climate record of pre- and early icehouse climates prior to 26 (34?) Ma below RSU6 (likely to be earliest Oligocene to mid-Eocene; Figure 5) and a semi-continuous record of glacimarine sedimentation between 26 (34?) and 18 Ma, punctuated by likely hiatuses during only the largest ice sheet advance events.

Sites CENCS-01 and CENCS-04: Central Ross Sea.

Site CENCS-01 is located in the same sedimentary basin as DSDP Site 270 (~15 km to the west), which allows for high confidence in determining the age of the target strata. However, this site is designed to target both younger and older sediments than recovered at DSDP Site 270, which contain strata between 26 to 20 Ma and also had two long-duration hiatuses between 23.8-23 Ma and 22.9-20.6 Ma (Kulhanek et al., 2019). Seismic mapping indicates thick packages of sediment associated with these hiatuses are deposited at CENCS-01A, in particular across the Oligocene/Miocene (O/M) boundary (Figure 5), when the EAIS is known to have advanced across the CRP sites (Naish et al., 2001). Although the deep-sea oxygen isotope records reveal a substantial $\delta^{18}O$ increase at the O/M boundary, we have not yet constrained the extent of glacial advance during this event in the circum-Antarctic.

This site is expected to recover a semi-continuous expanded Late Eocene to Early Miocene record (pre and post-RSU6 strata) that documents ice sheet dynamics in the central Ross Sea (Objectives 1 and 2). Glacial sediments may be associated with either local ice caps on the Central High, or reflect coalescing WAIS and EAIS advances (Figure 2e-h). If present, hiatuses are likely to be diagnostically important as they may reflect ice sheet advances, either through direct erosion by grounded ice or changing sea levels. These scenarios can be constrained through seismic stratigraphy and sediment provenance studies. The base of the site will penetrate a relatively-thin (<200m) rift-fill sequence (Figure 5), providing a snapshot assessment of pre-icehouse Paleogene climates and constraining the final phase of active rifting in this sector of the Ross Sea (lower priority target, as site CENCS-01 will capture a longer record of this).

Site CENCS-04 is located on the Iselin Bank, on the outer Ross Sea continental shelf in the central Ross Sea. This site differs from CENCS-01A in that it aims to capture a more expanded syn-rift sequence (~670m thick) below RSU6, and therefore an expanded Paleocene(?) to early Oligocene sequence to address objective 2 (i.e., greenhouse climates). Strata above RSU6 (at ~400 mbsf depth) are lower priority at this site, as this sequence will be better recovered at the more ice proximal CENCS-01A.

Site ERSCS-02A: Eastern Ross Sea.

Site ERSCS-02A targets a ~430 m thick early to mid-Oligocene glacimarine influenced sequence (above RSU6) overlying early and late rift-fill sediments. Beneath RSU6, we aim to penetrate Units RSS1 Upper (between RSU6 and RSU7), to capture the dynamics of ice caps nucleating on Marie Byrd Land (Figure 2g-h). Seismic evidence infers glacial expansion in this region sometime prior to 25 Ma (Sorlien et al., 2007), which requires validation by drilling. The site also targets a ~120 m thick sequence that may have been deposited during the greenhouse (and icehouse transition) climates of the Paleocene/Eocene below RSU7; and if time/drilling conditions allows, strata beneath RSU7 (~230m thick) may allow for sampling of *in situ* Paleogene to late Cretaceous early rift fill deposits that will enable us to constrain timing of early phase rift termination in this region, and climates at that time.

5.2. Risks and logistical considerations

5.2.1 Alternate sites.

We provide a wide spatial coverage of primary and alternates that achieve objectives in this proposal and mitigates against variable sea ice conditions (Figure 6). We also identify two abyssal plain sites (RSAP-01A and RSAP-02A) as alternates directly relating to this proposal - in case of an extreme sea ice year that affects any of the continental shelf sites (CENCS-01A and CHCS-01A sites are consistently ice free each year; Figure 6). These deep-water sites will provide continuous records of offshore oceanographic change during early icehouse time intervals (more details will be provided in full proposal).

Hydrocarbon risk assessment was previously undertaken for the Ross Sea with a comprehensive 258-page EPSP safety assessment report for IODP Expedition 374. Ross Sea has very low sea ice risks (Figure 6) and detailed ice navigation and risk mitigation procedures will be provided in the full proposal – following IODP Expedition 374 procedures, which only lost one day to ice/weather delays due to extensive pre-expedition risk assessment and planning.

5.2.2. Recovering glacial sediments in the Ross Sea.

Low heave is anticipated in the Ross Sea, (e.g., DSDP Leg 28, IODP Exp 374, and annual international vessel experience) relative to other Antarctic regions. Both previous expeditions to the Ross Sea (DSDP Leg 28 and IODP Expedition 374) demonstrated that excellent core recovery is expected in pre-Miocene lithified glacial diamictite and glacimarine mudstones sediments at depth (Figure 6). However, even with low recovery rates, “snapshot” glimpses into Cretaceous to early Cenozoic Antarctic environment will prove invaluable and achieve the objectives of this expedition, as was the case for the highly-successful IODP Site 1356 in Wilkes Land, which only had 35% recovery. Where material is not recovered, downhole logging will enable completion of the stratigraphy (Figure 6).

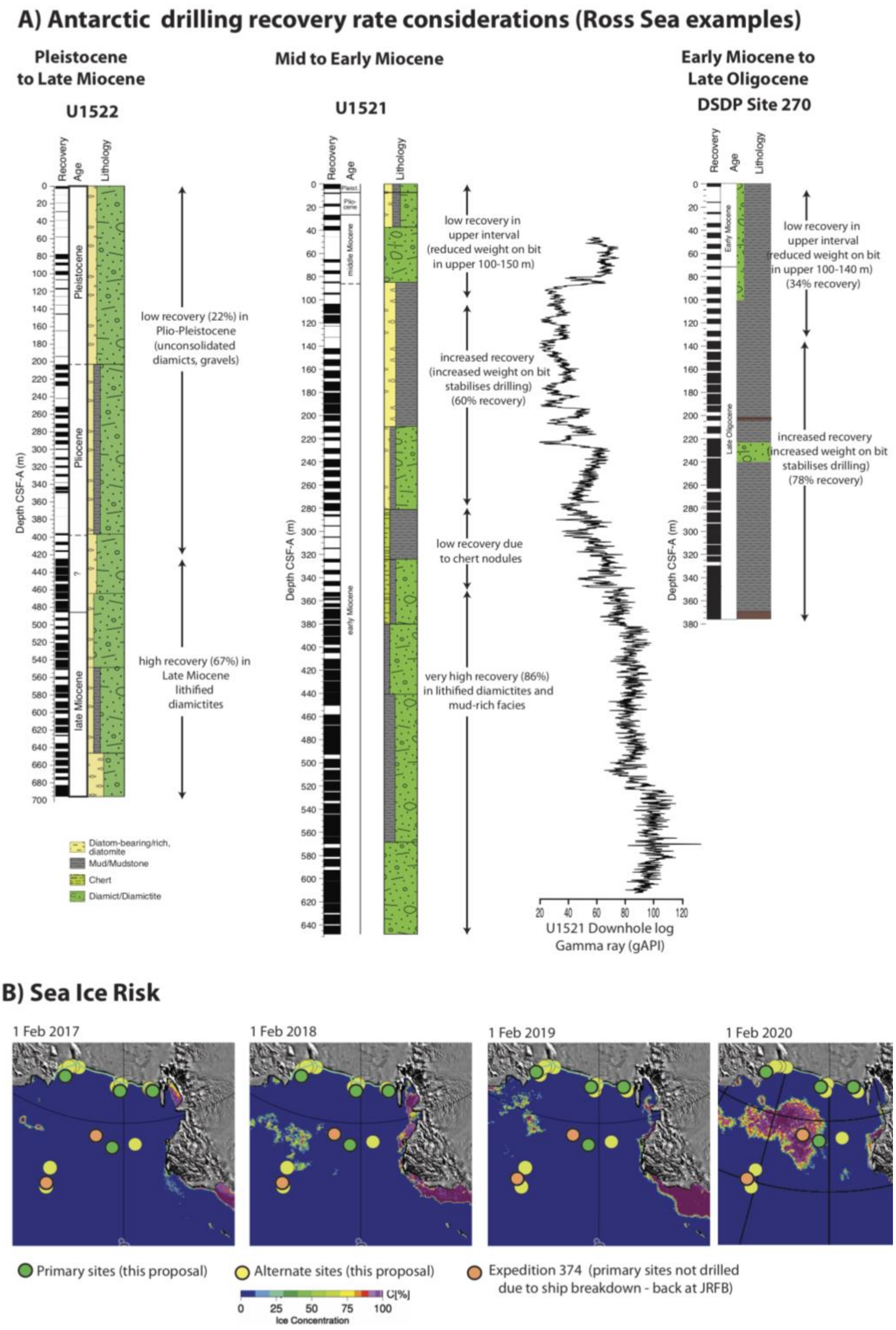


Figure 6: Logistical considerations. ***Upper panels.*** *Previous Ross Sea continental shelf drilling shows high recovery in Late Miocene and older glacimarine strata. Recovery improves >150 mbsf as weight placed on bit stabilizes drilling. Poor recovery from previous Antarctic drilling was consequence of rarely penetrating to depths below 150 mbsf (due to ice/weather delays, which are minimal in Ross Sea compared to other Antarctic sectors), and targeting soft Plio-Pleistocene targets. Continuous high quality down-hole logs can complete missing stratigraphy (see U1521 example). We anticipate lithologies similar to (more consolidated than) DSDP site 270 and U1521.* ***Lower Panels****: Sea ice concentrations on 1 February (middle of drilling window) for past 4 years (more years can be shown in full proposal). Sites CHCS-01A and CENCS-01A are open from late November and are consistently ice free. In only 2020 is one site (CENCS-04A) difficult to access (despite being in open water). In such a year, we would drill an alternate CENCS-05A. For site numbers refer to Figure 1.*

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IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in East Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (medium priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority)
List Previous Drilling in Area	Cape Roberts Project, CIROS-1, AND-1B, AND-2A

Section B: General Site Information

Site Name:	CHCS-01A	Area or Location:	SW Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.2315	Jurisdiction:	Antarctica
Longitude:	Deg: 172.2051	Distance to Land: (km)	78
Coordinate System:	WGS 84		
Priority of Site:	Primary: ✓ Alternate: ☐	Water Depth (m):	693

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Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1200	0
	Total Sediment Thickness (m): 1500	
		Total Penetration (m): 1200
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		Other tools:
WL	☑	Magnetic Susceptibility	☐	
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days:

Drilling/Coring:	Logging:	Total On-site:
9.1	1.8	10.9

Observatory Plan:

Longterm Borehole Observation Plan/Re-entry Plan

Potential Hazards/ Weather:

Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑
CO_2	☐				

Sensitive marine habitat (e.g., reefs, vents)

Preferred weather window: Jan to Feb is best ice free window (this site is open water from November).

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

	- Pre	

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in East Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (medium priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority)
List Previous Drilling in Area	Cape Roberts Project, CIROS-1, AND-1B, AND-2A

Section B: General Site Information

Site Name:	CHCS-02A	Area or Location:	SW Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.31783122	Jurisdiction:	Antarctica
Longitude:	Deg: 171.95787093	Distance to Land: (km)	64
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	740

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Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1200	0
	Total Sediment Thickness (m) 1774	
		Total Penetration (m): 1200
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		
WL	☑	Magnetic Susceptibility	☐	Other tools:
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 9 | Logging: 1.8 | Total On-site: 10.8

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

						Preferred weather window
Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Jan to Feb is best ice free window (this site is open water from November).
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑	
CO_2	☐					
Sensitive marine habitat (e.g., reefs, vents)						

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

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IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction "pre-icehouse" climates in East Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5 Ma). (medium priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority)
List Previous Drilling in Area	Cape Roberts Project, CIROS-1, AND-1B, AND-2A

Section B: General Site Information

Site Name:	CHCS-03A	Area or Location:	SW Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.0727	Jurisdiction:	Antarctica
Longitude:	Deg: 171.5629	Distance to Land: (km)	69
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	712

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Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1300	0
	Total Sediment Thickness (m): 1588	
		Total Penetration (m): 1300
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		
WL	☑	Magnetic Susceptibility	☐	Other tools:
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 10 | Logging: 2 | Total On-site: 12

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑
CO_2	☐				

Sensitive marine habitat (e.g., reefs, vents):

Preferred weather window: Jan to Feb is best ice free window (this site is open water from November).

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets coalescing from West and East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in West Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5 Ma). (high priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority).
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	CENCS-01A	Area or Location:	Central Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.4516	Jurisdiction:	Antarctica
Longitude:	Deg: -177.8407	Distance to Land: (km)	616
Coordinate System:	WGS 84		
Priority of Site:	Primary: ✓ Alternate: ☐	Water Depth (m):	616

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1185	15
	Total Sediment Thickness (m) 1185	
		Total Penetration (m): 1200
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan:
(Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		Other tools:
WL	☑	Magnetic Susceptibility	☐	
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 9 | Logging: 1.8 | Total On-site: 10.8

Observatory Plan:

Longterm Borehole Observation Plan/Re-entry Plan

Potential Hazards/ Weather:

						Preferred weather window
Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Jan to Feb is best ice free window.
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑	
CO_2	☐					
Sensitive marine habitat (e.g., reefs, vents)						

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest ice sheets coalescing from West/East Antarctica, by sampling strata above RSU6 (~34-26.5 Ma). A Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (low priority at this site, as section is condensed compared to CENCS-01A) 2) Reconstruct “pre-icehouse” climates in West Antarctica (Late Cretaceous to Eocene), by sampling material below RSU6 (thought to be ~34-26.5Ma). (high priority) 3) Constrain late rift phase timing in the Western Ross Sea, by dating RSU6 and coring syn-rift strata. (moderate priority). ALTERNATE IN CASE OF REDUCED DRILLING TIME DUE TO LOGISTIC DELAYS AT OTHER SITES.
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	CENCS-02A	Area or Location:	Central Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.6402	Jurisdiction:	Antarctica
Longitude:	Deg: -179.2478	Distance to Land: (km)	300
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	648

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	850	50
	Total Sediment Thickness (m) 850	
		Total Penetration (m): 900
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		
WL	☑	Magnetic Susceptibility	☐	Other tools:
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 5.1 | Logging: 1.5 | Total On-site: 6.6

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

						Preferred weather window
Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Jan to Feb is best ice free window (this site is open water from November).
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑	
CO_2	☐					
Sensitive marine habitat (e.g., reefs, vents)						

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets coalescing from West and East Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to mid Miocene (~16 Ma) record of EAIS advance. (high priority) 2) Reconstruction “pre-icehouse” climates in West Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (high priority) 3) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (lower priority).
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	CENCS-03A	Area or Location:	Central Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.2200	Jurisdiction:	Antarctica
Longitude:	Deg: -178.6336	Distance to Land: (km)	288
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	645

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1050	0
	Total Sediment Thickness (m) 1050	
		Total Penetration (m): 1050
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		
WL	☑	Magnetic Susceptibility	☐	Other tools:
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 7 | Logging: 1.8 | Total On-site: 8.8

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑
CO_2	☐				

Sensitive marine habitat (e.g., reefs, vents):

Preferred weather window: Jan to Feb is best ice free window.

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Reconstruction “pre-icehouse” climates in West Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (high priority) 2) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (medium priority).
List Previous Drilling in Area	IODP site 1523

Section B: General Site Information

Site Name:	CENCS-04A	Area or Location:	Central Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -73.99148766	Jurisdiction:	Antarctica
Longitude:	Deg: -177.28643477	Distance to Land: (km)	288
Coordinate System:	WGS 84		
Priority of Site:	Primary: ✓ Alternate: ☐	Water Depth (m):	700

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1070	0
	Total Sediment Thickness (m) 1070	
		Total Penetration (m): 1070
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		Other tools:
WL	☑	Magnetic Susceptibility	☐	
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days:

Drilling/Coring:	Logging:	Total On-site:
6	1.8	7.8

Observatory Plan:

Longterm Borehole Observation Plan/Re-entry Plan

Potential Hazards/ Weather:

Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑
CO_2	☐				

Sensitive marine habitat (e.g., reefs, vents)

Preferred weather window: Jan to Feb is best ice free window.

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Reconstruction “pre-icehouse” climates in West Antarctica during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-26.5Ma). (high priority) 2) Constrain timing of late rift phases in the Western Ross Sea. This will be achieved by dating RSU6 and coring syn-rift strata. (medium priority).
List Previous Drilling in Area	IODP site 1523

Section B: General Site Information

Site Name:	CENCS-05A	Area or Location:	Central Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -73.99713175	Jurisdiction:	Antarctica
Longitude:	Deg: 177.15819239	Distance to Land: (km)	265
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	385

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1000	0
	Total Sediment Thickness (m): 1650	
		Total Penetration (m): 1000
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		Other tools:
WL	☑	Magnetic Susceptibility	☐	
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 5.5 Logging: 1.8 Total On-site: 7.3

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑
CO_2	☐				

Sensitive marine habitat (e.g., reefs, vents):

Preferred weather window: Jan to Feb is best ice free window.

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to Early Miocene (20 Ma) record of WAIS advance in Marie Byrd Land (high priority) 2) Reconstruction "pre-icehouse" climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-28Ma) and RSU7 (Late Cretaceous to Eocene?) (high priority) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	ERSCS-01A	Area or Location:	Eastern Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.61010423	Jurisdiction:	Antarctica
Longitude:	Deg: -160.84500232	Distance to Land: (km)	70
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	620

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Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1050	10
	Total Sediment Thickness (m): 0	
		Total Penetration (m): 1060
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		
WL	☑	Magnetic Susceptibility	☐	Other tools:
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 7 | Logging: 1.8 | Total On-site: 8.8

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

						Preferred weather window
Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Jan to Feb is best ice free window.
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑	
CO_2	☐					

Sensitive marine habitat (e.g., reefs, vents)

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to Early Miocene (20 Ma) record of WAIS advance in Marie Byrd Land (high priority) 2) Reconstruction “pre-icehouse” climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-28Ma) and RSU7 (Late Cretaceous to Eocene?) (high priority) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	ERSCS-02A	Area or Location:	Eastern Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.9402	Jurisdiction:	Antarctica
Longitude:	Deg: -160.4316	Distance to Land: (km)	65
Coordinate System:	WGS 84		
Priority of Site:	Primary: ✓ Alternate: ☐	Water Depth (m):	660

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Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	775	25
	Total Sediment Thickness (m): 775	
		Total Penetration (m): 800
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		Other tools:
WL	☑	Magnetic Susceptibility	☐	
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 4.5 | Logging: 1.5 | Total On-site: 6

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑
CO_2	☐				

Sensitive marine habitat (e.g., reefs, vents)

Preferred weather window: Jan to Feb is best ice free window.

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

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IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica (strata above RSU6; 34-26.5 Ma). Will obtain a Oligocene-Early Miocene (~34-20 Ma) record of WAIS advance in Marie Byrd Land. (moderate priority, as top of sequence truncated by younger strata) 2) Reconstruct “pre-icehouse” climates in Eastern Ross Sea/Marie Byrd Land during the Late Cretaceous to Eocene; strata below RSU6 (~34-28Ma) and RSU7 (Late Cretaceous to Eocene?). (high priority-expanded at this site) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	ERSCS-03A	Area or Location:	Eastern Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -78.3925	Jurisdiction:	Antarctica
Longitude:	Deg: -164.7040	Distance to Land: (km)	84
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	541

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1200	0
	Total Sediment Thickness (m) 1550	
		Total Penetration (m): 1200
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		Other tools:
WL	☑	Magnetic Susceptibility	☐	
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 9 | Logging: 1.8 | Total On-site: 10.8

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑
CO_2	☐				

Sensitive marine habitat (e.g., reefs, vents)

Preferred weather window: Jan to Feb is best ice free window (this site is open water from November).

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

	- Pre	

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene (~34 Ma) to Early Miocene (20 Ma) record of WAIS advance in Marie Byrd Land (high priority) 2) Reconstruction "pre-icehouse" climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-28Ma) and RSU7 (Late Cretaceous to Eocene?) (high priority) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	ERSCS-04A	Area or Location:	Eastern Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -78.3509	Jurisdiction:	Antarctica
Longitude:	Deg: -162.5913	Distance to Land: (km)	90
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	706

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Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1134	20
	Total Sediment Thickness (m) 1134	
		Total Penetration (m): 1154
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		Other tools:
WL	☑	Magnetic Susceptibility	☐	
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 9.1 | Logging: 1.8 | Total On-site: 10.9

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

						Preferred weather window
Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Jan to Feb is best ice free window (this site is open water from November).
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑	
CO_2	☐					
Sensitive marine habitat (e.g., reefs, vents)						

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene-Early Miocene (~34-20 Ma) record of WAIS advance in Marie Byrd Land (high priority) 2) Reconstruction "pre-icehouse" climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (~34-26.5Ma) and RSU7 (Late Cretaceous to Eocene?) (low priority -as strata to deep) 3) Constrain timing of late rift phases in the Eastern Ross Sea. This will be achieved by dating syn-rift strata below RSU7. (lowest priority)
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	ERSCS-05A	Area or Location:	Eastern Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -78.2274	Jurisdiction:	Antarctica
Longitude:	Deg: -161.5268	Distance to Land: (km)	57
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	615

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1200	0
	Total Sediment Thickness (m) 2500	
		Total Penetration (m): 1200
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan:
(Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		
WL	☑	Magnetic Susceptibility	☐	Other tools:
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days:

Drilling/Coring:	Logging:	Total On-site:
9	1.8	10.8

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

						Preferred weather window
Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Jan to Feb is best ice free window.
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑	
CO_2	☐					
Sensitive marine habitat (e.g., reefs, vents)						

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) Obtain direct geological evidence of the earliest history of ice sheets in West Antarctica, by sampling strata above RSU6 (thought to be 34-26.5 Ma). Will obtain a Oligocene-early Miocene (~34-20 Ma) record of WAIS advance in Marie Byrd Land. (high priority) 2) Reconstruct “pre-icehouse” climates in Eastern Ross Sea/ Marie Byrd Land during the Late Cretaceous to Eocene, by sampling material below RSU6 (thought to be ~34-28Ma) and RSU7 (Late Cretaceous-Eocene?) (high priority - expanded sequence at this site) 3) Constrain timing of late rift phases in Eastern Ross Sea, by dating syn-rift strata below RSU7. (moderate priority)
List Previous Drilling in Area	DSDP Site 270

Section B: General Site Information

Site Name:	ERSCS-06A	Area or Location:	Eastern Ross Sea continental shelf
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -77.668106299	Jurisdiction:	Antarctica
Longitude:	Deg: -160.740589980	Distance to Land: (km)	65
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	620

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1300	0
	Total Sediment Thickness (m) 1500	
		Total Penetration (m): 1300
General Lithologies:	Diamictite, mudstone, cemented sandstones	unknown (schist, granite, marble, sandstone)

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		
WL	☑	Magnetic Susceptibility	☐	Other tools:
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 10 Logging: 2.5 Total On-site: 12.5

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

						Preferred weather window
Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Jan to Feb is best ice free window.
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑	
CO_2	☐					
Sensitive marine habitat (e.g., reefs, vents)						

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

	- Pre	

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) obtain continuous record of Early Miocene to Oligocene oceanographic change relating to ice sheet variance on continent. Site complements RSCR-19A from IODP Exp 374 to obtain an older stratigraphic record links Exp 374 and this new proposals objective. It is lower priority than the continental shelf site and RSCR-19A, as it is RCB only and will obtain lower recovery than shelf site (less lithified) and RSCR-19A (APC/XCB core). alternate in case of poor sea ice year in ERSCS sites (other shelf site in CHCS and CENCS regions are always open water in summer)
List Previous Drilling in Area	none

Section B: General Site Information

Site Name:	RSAP-01A	Area or Location:	Ross Sea abyssal plain
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#			
Latitude:	Deg: -71.3435	Jurisdiction:	Antarctica
Longitude:	Deg: -164.4160	Distance to Land: (km)	860
Coordinate System:	WGS 84		
Priority of Site:	Primary: ☐ Alternate: ☑	Water Depth (m):	4133

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1090	10
	Total Sediment Thickness (m) 1090	
		Total Penetration (m): 1100
General Lithologies:	diatom ooze (diatomite and mudstone	basalt

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		Other tools:
WL	☑	Magnetic Susceptibility	☐	
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days:

Drilling/Coring:	Logging:	Total On-site:
16	2.4	18.4

Observatory Plan:

Longterm Borehole Observation Plan/Re-entry Plan

Potential Hazards/ Weather:

Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑
CO_2	☐				

Sensitive marine habitat (e.g., reefs, vents)

Preferred weather window: Jan to Feb is best ice free window.

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374

IODP Site Forms

Form 1 – General Site Information

- Pre

Section A: Proposal Information

Proposal Title	Tracing Antarctic Cryosphere Origins to Climate And Tectonics
Date Form Submitted	
Site-Specific Objectives with Priority (Must include general objectives in proposal)	1) obtain continuous record of Early Miocene to Oligocene oceanographic change relating to ice sheet variance on continent. Site complements RSCR-19A from IODP Exp 374 to obtain an older stratigraphic record links Exp 374 and this new proposals objective. It is lower priority than the continental shelf sites. Provides an alternate in case of poor sea ice year in ERSCS sites (other shelf site in CHCS and CENCS regions are always open water in summer)
List Previous Drilling in Area	none

Section B: General Site Information

Site Name:	RSAP-02A
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#	
Latitude:	Deg: -69.99544571
Longitude:	Deg: -164.67600
Coordinate System:	WGS 84
Priority of Site:	Primary: ☐ Alternate: ☑
Area or Location:	Ross Sea abyssal plain
Jurisdiction:	Antarctica
Distance to Land: (km)	920
Water Depth (m):	4075

Section C: Operational Information

	Sediments	Basement
Proposed Penetration (m):	1200	0
	Total Sediment Thickness (m): 1420	
		Total Penetration (m): 1200
General Lithologies:	diatom ooze (diatomite) and mudstone	basalt

Coring Plan: (Specify or check)

Single RCB to total depth, followed by downhole logging with the TC, FMS-sonic, and VSI.

APC ☐ XCB ☐ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurements		Special Tools		
WL	☑	Magnetic Susceptibility	☐	Other tools:
Porosity	☑	Borehole Temperature	☐	
Density	☑	Formation Image (Acoustic)	☐	
Gamma Ray	☑	VSP (walkaway)	☐	
Resistivity	☑	LWD	☐	
Sonic (Δt)	☑			
Formation Image (Res)	☑			
VSP (zero offset)	☑			
Formation Temperature & Pressure	☑			

Other Measurements:

Estimated Days: Drilling/Coring: 15 Logging: 2.4 Total On-site: 17.4

Observatory Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Potential Hazards/ Weather:

						Preferred weather window
Shallow Gas	☑	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Jan to Feb is best ice free window.
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g., sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H_2S	☐	High Dip Angle	☐	Ice Conditions	☑	
CO_2	☐					
Sensitive marine habitat (e.g., reefs, vents)						

Other: Full hydrocarbon and ice risk assessment have previously been conducted in these basins for IODP Exp 374