IODP Proposal Cover Sheet

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Antarctic Cenozoic Paleoclimate

Title	Greenhouse to Icehouse Antarctic paleoclimate and ice history from George V Land and Adélie Land shelf sediments
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Abstract

Along the George V and Adélie Land (GVAL) shelf of Antarctica, shallowly-buried strata contain a record of Antarctica's climate and ice history from the lush forests of the Eocene greenhouse to the dynamic ice sheet margins of the Neogene. Over these times, Antarctica and the Southern Ocean have played a central role in controlling sea level, deep-water formation, ocean circulation, and exchange of carbon dioxide with the atmosphere. Yet currently there are very few direct records of Antarctic climate and ice conditions from close to the continent. On the GVAL shelf, short piston cores and dredges have recovered Cretaceous and Eocene sediment at the seabed. In 2010, IODP Expedition 318 recovered earliest Oligocene and early Pliocene subglacial and proglacial diamicts, providing direct records of ice advances across the shelf at these times, and confirming that target sediments are accessible at shallow burial depths. However, challenging ice and drilling conditions from the JOIDES Resolution resulted in poor core recovery and abandoning sites before the stratigraphic targets were reached. Here we propose to use the MeBo sea bed drill for improved core recovery and easier access to the shelf. We propose to drill two stratigraphic transects of shallow (~80m) holes to investigate Antarctica's role in icehouse and greenhouse climates, and the transitions between the two.

To investigate Oligocene to Pliocene ice sheet dynamics, we target strata above and below regional erosional and downlap surfaces to date and characterize major episodes of ice sheet advance and retreat. These direct records of ice extent on the shelf can be set in the context of Southern Ocean records of temperature, ice-rafted debris (IRD) and latitudinal fluctuations of the opal belt, and hence we can relate ice behavior to paleoclimate conditions. The ice and climate history of the GVAL margin can provide warm-world scenarios to help understand ice sheet instability in analogous future warm climates.

In the Cretaceous and Eocene greenhouse target intervals: temperature and vegetation records will provide high-latitude constraints on pole-equator temperature gradients and their evolution; the proximity of the sites to the coastal lowlands will enable us to assess the hypothesized role of thawing permafrost in Eocene hyperthermal events; and late Eocene cooling and possible pre-cursor glaciations can also be documented by drilling.

This proposal addresses the IODP science plan's challenges "How does Earth's climate respond to increased CO2?" and "How do ice sheets and sea level respond to a warming climate?"

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Scientific Objectives

Paleoclimate and ice sheet dynamics objectives:
- The timing and environmental conditions leading to major ice advances over the shelf, and how this relates to records of IRD, sea level and oxygen isotopes. We aim to sample the Eocene/Oligocene ice advance (~34 Ma), Oligocene environmental conditions, the mid-Miocene climate transition (~14 Ma), and earliest Pliocene warmth and climate fluctuations (~5 Ma).
- Climate cooling in the late Eocene in advance of main glacial inception at the Eocene/Oligocene boundary: what were the paleoenvironmental conditions, was there cyclicity, and were there precursor glaciations?
- Antarcticas climate during the early Eocene climatic optimum, including cyclicity, hyperthermals, temperatures and vegetation. This will extend the short time window obtained at distal Site U1356 (Expedition 318), at a site closer to Antarctica.

- Early Cretaceous greenhouse conditions (non-marine sediments): are they stable or cyclic, and how do conditions compare to the Eocene greenhouse?

Drilling will also address seismic-stratigraphic, glacial-isostatic, and tectonic objectives to:
- Date the major changes in shelf prograded wedge geometry and the major unconformities.
- Constrain the timing and character of rifting between the GVAL margin and Australia.
- Assess whether the predictions of glacial isostatic adjustment (GIA) models are recorded in the ice-proximal sediments (e.g., relative sea level rise adjacent to expanding ice sheets).

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

Drilling from a stable platform achieves much better recovery of glacial sediments than from a moving ship (e.g. ~98% recovery at AND-1B, drilled from the McMurdo ice shelf, compared to ~38% recovery of semi-lithified diamict at Antarctic shelf sites drilled from the JOIDES Resolution). Therefore we propose to use a sea floor drill rig (MARUMs MeBo) to provide a stable platform and improved core recovery. Additionally, the deploying vessel would be better able than the JOIDES Resolution to reach sites through moderate sea ice conditions.

Proposed Sites

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
GVAL-01A	-66.74533, 145.59042	506	80	0	80	Late Eocene cooling, precursor interglacials? Youngest available strata along WEGA-02-01. Primary site.
GVAL-02A	-66.78851, 145.50550	563	80	0	80	Late Eocene cooling, precursor interglacials? Can Antarctica sustain any ice sheets when the atmosphere is above 1000 ppm CO2? Nature of high amplitude reflector. Primary site.
GVAL-03A	-66.87160, 145.32064	713	80	0	80	Middle/Late Eocene climate conditions, nature of paleoenvironmental change represented by underlying high-amplitude reflector. Primary site.
GVAL-04A	-66.88356, 145.29604	765	80	0	80	Middle Eocene climate conditions, nature of paleoenvironmental change represented by overlying high-amplitude reflector. Primary Site.

GVAL-05A	-66.90627, 145.26001	844	80	0	80	Middle Eocene climate and environmental conditions, nature of paleoenvironmental change (close to Dredge 1). Primary Site.
GVAL-06A	-66.91162, 145.25153	881	80	0	80	Middle Eocene climate and environmental conditions, nature of paleoenvironmental change (close to Dredge 1). Primary Site.
GVAL-07A	-66.93843, 145.20008	956	80	0	80	Early/Middle Eocene climate and environmental conditions. Pre-unconformity A. Hyperthermals? Primary Site.
GVAL-08A	-66.95185, 145.16873	1069	80	0	80	Early/Middle Eocene climate and environmental conditions. Pre-unconformity A. Hyperthermals? Primary Site.
GVAL-09A	-66.98382, 145.10865	1193	80	0	80	Early Cretaceous temperature and vegetation on Antarctica. What were the Cretaceous greenhouse conditions like compared to Eocene warmth? Alternate Site.
GVAL-10A	-66.99644, 145.08846	1200	80	0	80	Early Cretaceous temperature and vegetation on Antarctica. What were the Cretaceous greenhouse conditions like compared to Eocene warmth? Alternate Site.
GVAL-11A	-66.10396, 143.27648	540	80	0	80	Early Pliocene ice advances and warm intervals. Age of WL-U8 unconformity. Alternate Site.
GVAL-12A	-66.13133, 143.19281	570	80	0	80	l. Miocene (?) environmental conditions leading to the formation of the WL-U8 unconformity and the observed change in the geometry of the sedimentary wedge. Alternate Site.
GVAL-13A	-66.19123, 143.04521	600	80	0	80	?mid-Miocene ice expansion (~14Ma) across downlap surface following the Mid-Miocene Climate Optimum Alternate Site.
GVAL-14A	-66.21104, 142.99714	607	80	0	80	Middle Miocene (climate optimum?) and environmental conditions leading to mid-Miocene ice expansion Alternate Site.
GVAL-15A	-66.33685, 142.77142	465	80	0	80	Oligocene environmental conditions. How did the Antarctic ice sheets respond the last time Earth's atmosphere was between 600-1000ppm CO2? Alternate Site.
GVAL-16A	-66.38363, 142.72241	540	80	0	80	Earliest Oligocene environmental conditions and glacial advance leading to a continental-wide ice sheet. Alternate Site.
GVAL-17A	-66.39432, 142.70773	532	80	0	80	E/O transition. Environmental changes across the WL-U3 unconformity (in combination with proposed site GVAL-16A) Alternate Site.
GVAL-18A	-66.40869, 142.68304	518	80	0	80	Late Eocene environmental conditions leading to establishment of

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GVAL-19A	-66.46560, 142.57710	428	80	0	80	Late Eocene cooling, precursor interglacials? Alternate Site.
GVAL-20A	-66.51689, 142.48008	353	80	0	80	Middle Eocene climate and environmental conditions, Eocene cooling. Alternate Site.
GVAL-21A	-66.53017, 142.45635	428	80	0	80	Middle Eocene climate and environmental conditions, Eocene cooling. Alternate Site.
GVAL-22A	-65.59561, 138.56735	698	80	0	80	Early Pliocene ice advances and warm intervals. Age of downlap surface. Primary Site.
GVAL-23A	-65.61177, 138.55483	705	80	0	80	Early Pliocene ice advances and warm intervals. Age of downlap surface. Primary Site.
GVAL-24A	-65.65785, 138.51445	750	80	0	80	Early Pliocene ice advances and warm intervals. Age of WL-U8 unconformity. Primary Site.
GVAL-25A	-65.68413, 138.49526	758	80	0	80	l. Miocene (?) environmental conditions leading to the formation of the WL-U8 unconformity and the observed change in the geometry of the sedimentary wedge. Primary Site.
GVAL-26A	-65.83677, 138.38131	863	80	0	80	?mid-Miocene ice expansion (~14Ma) across downlap surface following the Mid-Miocene Climate Optimum. Age of downlap surface. Primary Site.
GVAL-27A	-65.86841, 138.35631	870	80	0	80	Environmental conditions leading to (?mid-Miocene) ice expansion. Primary Site.
GVAL-28A	-65.94511, 138.29178	900	80	0	80	Earliest Oligocene environmental conditions and glacial advance to a continental-wide ice sheet. Primary Site.
GVAL-29A	-65.96027, 138.28022	908	80	0	80	Late Eocene environmental conditions leading to establishment of continental-wide ice sheet. Age of sediments underlying unconformity WL-U3 Primary Site.
GVAL-30A	-67.73300, 146.85000	1407	80	0	80	Early Cretaceous (Aptian) temperature and vegetation on Antarctica. What were the Cretaceous greenhouse conditions like compared to Eocene warmth? Alternate site.
GVAL-31A	-66.58894, 143.35924	855	80	0	80	Early/Middle Eocene climate and environmental conditions. Hyperthermals? Alternate site.
GVAL-32A	-66.59027, 143.36556	848	80	0	80	Early/Middle Eocene climate and environmental conditions. Hyperthermals? Alternate site.

GVAL-33A	-66.81877, 144.47948	1013	80	0	80	Early Cretaceous environment and vegetation on Antarctica. Primary site.
GVAL-34A	-66.82192, 144.49311	1005	80	0	80	Early Cretaceous environment and vegetation on Antarctica. Primary site.
GVAL-35A	-66.86100, 144.63940	1050	80	0	80	Early Cretaceous environment and vegetation on Antarctica. Alternate site.
GVAL-36A	-66.86544, 144.65615	1058	80	0	80	Early Cretaceous environment and vegetation on Antarctica. Alternate site.
GVAL-37A	-66.87030, 144.67273	1065	80	0	80	Early Cretaceous environment and vegetation on Antarctica. Alternate site.
GVAL-38A	-66.85764, 144.81591	960	80	0	80	?Early Eocene climate and environmental conditions. Hyperthermals? Alternate site.
GVAL-39A	-66.85935, 144.80628	975	80	0	80	?Early Eocene climate and environmental conditions. Hyperthermals? Alternate site.
GVAL-40A	-66.86087, 144.79772	990	80	0	80	?Early Eocene climate and environmental conditions. Hyperthermals? Alternate site.
GVAL-41A	-66.81340, 144.48011	1013	80	0	80	Cretaceous or Paleogene temperature and vegetation on Antarctica. Alternate site.
GVAL-42A	-66.80577, 144.48733	954	80	0	80	Cretaceous or Paleogene (?Early Eocene) temperature and vegetation on Antarctica. Alternate site.
GVAL-43A	-66.71453, 144.56810	863	80	0	80	Middle Eocene climate conditions, nature of paleoenvironmental change represented by high-amplitude reflector. Alternate site.
GVAL-44A	-66.70213, 144.58519	870	80	0	80	Middle Eocene climate conditions, nature of paleoenvironmental change represented by high-amplitude reflector. Alternate site.
GVAL-45A	-66.67110, 144.62679	844	80	0	80	Middle/Late Eocene climate and environmental conditions Alternate site.
GVAL-46A	-66.64422, 144.65613	713	80	0	80	Middle/Late Eocene climate and environmental conditions Alternate site.
GVAL-47A	-66.62866, 144.66952	690	80	0	80	Middle/Late Eocene climate and environmental conditions Alternate site.