

IODP Proposal Cover Sheet

902 - Full

Iceberg Alley Paleocyanography

Received for: 2016-04-01

Title	Late Neogene reconstruction of ice-sheet, atmosphere, and ocean dynamics in Iceberg Alley		
Proponents	Michael E. Weber, Simon Belt, Peter U. Clark, Marga García, Marcus Gutjahr, Ian Hall, Gerhard Kuhn, Gerrit Lohmann, Nicholas McCave, Jerry X. Mitrovica, Maureen Raymo, Ralph Schneider, Joseph Stoner, Axel Timmermann, Trevor Williams, Yasmina M. Martos, Claire Allen, Daniela Sprenk, Fernando Bohoyo		
Keywords	ice-sheet dynamics, paleocyanography, sea-level change	Area	Scotia Sea

Proponent Information

Proponent	Michael E. Weber
Affiliation	University of Cologne, Institute of Geology and Mineralogy, Cologne
Country	Germany

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

Abstract

Objectives of the Iceberg Alley proposal address IODP Challenges 1 (elevated CO₂) and 2 (ice-sheets and sea level). These can only be achieved through the first deep drilling in the Scotia Sea. Two sites should recover 600 m long Late Neogene sequences to reconstruct past variability in Antarctic Ice Sheet (AIS) mass loss, oceanic and atmospheric circulation.

We will deliver the first spatially integrated record of variability in icebergs flux from Iceberg Alley, where a substantial number of Antarctic icebergs exit into the warmer Antarctic Circumpolar Current (ACC). In particular, we will characterize the iceberg flux during key times of AIS evolution: Middle Miocene glacial intensification of the East Antarctic Ice Sheet, mid-Pliocene warm interval, Late Pliocene glacial intensification of the West Antarctic Ice Sheet, mid-Pleistocene transition, warm interglacials of the last 800 kyr, and glacial terminations. We will use the geochemical provenance of detrital material to determine regional sources of AIS mass loss, address interhemispheric phasing of ice-sheet and climate events, and the relation of AIS variability to sea level.

We will also deliver critical information on changes in Drake Passage throughflow, meridional overturning in the Southern Ocean, water-mass changes, CO₂ transfer via wind-induced upwelling, sea-ice variability, bottom water outflow from the Weddell Sea, Antarctic weathering inputs, and changes in oceanic and atmospheric fronts in the vicinity of the ACC by comparing N-S variations across the Scotia Sea.

Comparing changes in dust proxy records between the Scotia Sea and Antarctic ice cores will provide a detailed reconstruction of changes in the Southern Hemisphere westerlies on millennial and orbital time scales for the last 800 kyr. Extending this comparison beyond 800 kyr will help evaluating climate-dust couplings since the Pliocene, its potential role in iron fertilization and atmospheric CO₂ drawdown during glacials, and whether dust and changes in Antarctic ice volume played a role in the mid-Pleistocene transition.

Post-cruise analytical work will include: magneto-, bio-, and tephrostratigraphy, combined with dust tuning, stable isotopes, and relative paleointensity to establish the chronology; production of seawater-derived radiogenic isotope records, iceberg-rafted debris, physical properties, XRF scanning, and provenance studies to constrain ice dynamics; geochemistry, sortable silt, stable isotopes, biomarkers, and diatom assemblages to reconstruct ocean temperature, current strength, productivity, and sea-ice extent. Models will help investigating possible physical mechanisms causing changes in ice-sheet dynamics, ocean-atmosphere interactions, and sea-level changes.

Scientific Objectives

Scientific objectives of the Iceberg Alley proposal relate to IODP Challenges 1 (elevated CO₂) and 2 (ice-sheets and sea level). Two 600-m deep sites are requested for Dove Basin and Pirie Basin (Scotia Sea, SW Atlantic) to reconstruct, along a latitudinal transect, the evolution of the Antarctic Ice Sheet (AIS) through major Late Neogene transitions (Middle Miocene glacial intensification of the East Antarctic Ice Sheet, mid-Pliocene warm interval, Late Pliocene glacial intensification of the West Antarctic Ice Sheet, mid-Pleistocene transition, warm interglacials of the last 800 kyr, and glacial terminations).

Specific objectives

- Establish the time frame with bio-, magneto-, and tephrostratigraphy, stable isotopes, paleointensity, and dust tuning
- Variability in and sources of AIS mass loss
- Relationship between AIS mass loss and global sea level
- Linkages between climate and AIS events and their interhemispheric phasing
- Effects of water-mass changes and ocean thermal forcing on ice-mass loss
- Dust-climate couplings and dust sources, as well as potential effect on iron fertilization and glacial CO₂ drawdown
- Glacial-to-interglacial changes in the frontal systems and associated sea-ice shifts and the carbon cycle
- Changes in sea-ice extent and interaction with the Antarctic Circumpolar Current and the Southern Hemisphere westerlies
- Paleoceanographic changes of the Drake Passage and thermal isolation of Antarctica
- Paleoceanographic evolution of the ACC and Weddell Sea Bottom Water recorded by the five seismic units.

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

Proposed Sites (Total proposed sites: 12; pri: 2; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SCO-11 (Primary)	-57.4421 -43.3578	3110	600	0	600	SCO-11 is the primary site for the northern study area Pirie Bank. Objectives are to (i) reconstruct past variability in AIS mass loss and the related sea-level history in a northerly region of the Scotia Sea closer to Patagonia, (ii) capture the northern, more CDW-dominated part of the Drake Passage throughflow and associated shifts of frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current, (iii) reconstruct changes in atmospheric circulation and dust-climate couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more proximal location relative to the source.
SCO-01 (Alternate)	-57.4333 -43.4500	3101	600	0	600	SCO-01 (core MD07-3133) is an alternate site for SCO-11 in Pirie Basin. Objectives are to (i) reconstruct past variability in AIS mass loss and the related sea-level history in a northerly region of the Scotia Sea closer to Patagonia, (ii) capture the northern, more CDW-dominated part of the Drake Passage throughflow and associated shifts of frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current, (iii) reconstruct changes in atmospheric circulation and dust-climate couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more proximal location relative to the source.
SCO-19 (Alternate)	-57.4285 -43.5000	3131	600	0	600	SCO-19 is an alternate site for SCO-11 in the northern study area Pirie Basin. Objectives are to (i) reconstruct past variability in AIS mass loss and related sea-level history in a northerly region of the Scotia Sea closer to Patagonia, (ii) capture the northern, more CDW-dominated part of the Drake Passage throughflow and associated shifts of frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current, (iii) reconstruct changes in atmospheric circulation and dust-climate couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more proximal location relative to the source.
SCO-12 (Alternate)	-57.6466 -43.5000	3092	600	0	600	SCO-12 is an alternate site for SCO-11 in the northern study area Pirie Basin. Objectives are (i) reconstruct past variability in AIS mass loss and related sea-level history in a northerly region of the Scotia Sea closer to Patagonia, (ii) capture the northern, more CDW-dominated part of the Drake Passage throughflow and associated shifts of frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current, (iii) reconstruct changes in atmospheric circulation and dust-climate couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more proximal location relative to the source.

Proposed Sites (Continued; total proposed sites: 12; pri: 2; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SCO-16 (Alternate)	-57.7055 -43.5001	3134	600	0	600	SCO-16 is an alternate site for SCO-11 in the northern study area Pirie Basin. Objectives are (i) reconstruct past variability in AIS mass loss and related sea-level history in a northerly region of the Scotia Sea closer to Patagonia, (ii) capture the northern, more CDW-dominated part of the Drake Passage throughflow and associated shifts of frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current, (iii) reconstruct changes in atmospheric circulation and dust-climate couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more proximal location relative to the source.
SCO-17 (Alternate)	-57.7055 -43.3620	3253	600	0	600	SCO-17 is an alternate site for SCO-11 in the northern study area Pirie Basin. Objectives are (i) reconstruct past variability in AIS mass loss and related sea-level history in a northerly region of the Scotia Sea closer to Patagonia, (ii) capture the northern, more CDW-dominated part of the Drake Passage throughflow and associated shifts of frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current, (iii) reconstruct changes in atmospheric circulation and dust-climate couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more proximal location relative to the source.
SCO-15 (Primary)	-59.8520 -41.4530	3486	600	0	600	SCO-15 is the one primary site for the southern study area Dove Basin. Objectives are to (i) reconstruct past variability in AIS mass loss and the related sea-level history in a southerly region of the Scotia Sea closer to Antarctica, (ii) capture the Drake Passage throughflow and WSBW inflow and associated shifts in frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current (ACC), (iii) reconstruct changes in atmospheric circulation and dust-climate-dust couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more distal location relative to the source.
SCO-02 (Alternate)	-59.4170 -41.4670	3676	600	0	600	SCO-02 (core MD07-3134) is an alternate site for SCO-15 in the southern study area Dove Basin. Objectives are (i) reconstruct past variability in AIS mass loss and related sea-level history in a southerly region of the Scotia Sea closer to Antarctica, (ii) capture the Drake Passage throughflow and WSBW inflow and associated shifts in frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current (ACC), (iii) reconstruct changes in atmospheric circulation and dust-climate-dust couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more distal location relative to the source.

Proposed Sites (Continued; total proposed sites: 12; pri: 2; alt: 10; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SCO-13 (Alternate)	-59.4410 -41.0610	3255	600	0	600	SCO-13 is an alternate site for SCO-15 in the southern study area Dove Basin. Objectives are to (i) reconstruct past variability in AIS mass loss and the related sea-level history in a southerly region of the Scotia Sea closer to Antarctica, (ii) capture the Drake Passage throughflow and WSBW inflow and associated shifts in frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current (ACC), (iii) reconstruct changes in atmospheric circulation and dust-climate-dust couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more distal location relative to the source.
SCO-14 (Alternate)	-59.8000 -41.7600	3833	600	0	600	SCO-14 is an alternate site for SCO-15 in the southern study area Dove Basin. Objectives are to (i) reconstruct past variability in AIS mass loss and the related sea-level history in a southerly region of the Scotia Sea closer to Antarctica, (ii) capture the Drake Passage throughflow and WSBW inflow and associated shifts in frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current (ACC), (iii) reconstruct changes in atmospheric circulation and dust-climate-dust couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more distal location relative to the source.
SCO-18 (Alternate)	-59.1108 -40.9062	3734	600	0	600	SCO-18 is an alternate site for SCO-15 in the southern study area Dove Basin. Objectives are to (i) reconstruct past variability in AIS mass loss and the related sea-level history in a southerly region of the Scotia Sea closer to Antarctica, (ii) capture the Drake Passage throughflow and WSBW inflow and associated shifts in frontal systems, watermass properties, ocean temperature, and sea-ice extent within the Antarctic Circumpolar Current (ACC), (iii) reconstruct changes in atmospheric circulation and dust-climate-dust couplings between Patagonia and Antarctica and related atmospheric circulation throughout the Plio-Pleistocene in a more distal location relative to the source.
SCO-21 (Alternate)	-61.8106 -40.2878	3480	600	0	600	Site SCO-21 is an alternate site as contingency in Jane Basin if drilling will not be possible in the Scotia Sea. This site is not far to the south, in similar water depth, with good magnetostratigraphy, and Pliocene material at APC-able depths (Pudsey, 1990). Sedimentation rates are lower (~4 cm/kyr for the Quaternary; ~7 cm/kyr for the Upper Pliocene; ~15 cm/kyr for the Lower Pliocene) and would allow us to better address the long-term topics of our proposal. The site was single-cored in 1987 with moderate recovery, which can certainly be improved nowadays with APC/HLAPC technology, triple coring, and deeper drilling.