Proposal 732-Full2: Sediment drifts off the Antarctic Peninsula and West Antarctica

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Antarctica’s Cenozoic ice and climate history: New science and new challenges of drilling in Antarctic waters
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Antarctic and Southern Ocean science questions

IODP Science Plan challenges:
1. How does Earth’s climate system respond to elevated levels of atmospheric CO₂?
2. How do ice sheets and sea level respond to a warming climate?

PAIS ice-margin-offshore-far field transect concept and data-model comparison
What time resolution do we need in order to capture ice dynamics?


![Graph showing sea-level contribution over time](image)

DeConto & Pollard (2016) *Nature* – model incorporating marine ice cliff instability, and tuned with Pliocene and LIG sea level records

![Graph showing sea-level change over time](image)

![Map showing ice thickness](image)
Challenges of drilling in the Southern Ocean

Main challenges encountered are:
1. On the Antarctic continental shelf
   - Incomplete sequences
   - Poor core recovery
   - JOIDES Resolution not ice strengthened
2. Most areas
   - Lack of foraminiferal carbonate
   - Interpretation of ice dynamics from sedimentary record

Carbonate issue
Sites with carbonate do exist – need careful site selection
Can now complement with relative geomagnetic paleointensity (RPI) dating

Proposal 732 strategy to obtain detailed records
Target sites
1. where complete composite sections can be recovered
2. with continuous, high sed rates
3. as shallow as possible
Antarctic Peninsula continental rise drifts

Modified from Rebesco et al. (1998) Terra Antartica by F. J. Hernández-Molina

Two sites target pre-Pliocene succession

Most proposed sites target Plio-Pleistocene and are at shallowest part of drift crests (<2800 m), but Site PEN-5D targets Early Pliocene – Late Miocene section.
Previous drilling in region – Leg 178 (1998)

Sites drilled on both shelf and rise

Sites 1098 & 1099 in Palmer Deep contained expanded post-glacial record

Other shelf sites had poor recovery

Three continental rise sed. drift sites:
1095 – double APC to only 84 mbsf
1096 – double APC to only 108 mbsf
1101 – only single APC/XCB hole
All three at >3100 m water depth

Previously, DSDP Site 325 was only spot cored, with 34.4 m recovered from 718 m drilled
Bellingshausen Sea sites – recording WAIS history
PISO-1500 RPI/δ¹⁸O stack compared to LR04

RPI (with δ¹⁸O) offers potential for near-millennial-scale chronology...also in Antarctic sediments that contain high-quality palaeomagnetic records.

Channell et al., 2009
New RPI template for 0-45 ka

North Atlantic (plus two South Atlantic, one Pacific)
RPI records (19 in total) placed on their independent age models
Cruise JR298 (Jan.-March 2015) – site survey for Prop. 732

723 (BELS-1)

736 (PEN-1, Drift 4)

Reference RPI template in red

Mean sed. rate ~4.3 cm/kyr
Sed. rate range 2-17 cm/kyr

Mean sed. rate ~12 cm/kyr
Sed. rate range 5-30 cm/kyr
AF demagnetization of NRM

Venuti et al. (2011) Drift 7: “magnetically hard titanomagnetite”

- CORE SED-07 (Depth: 3.70 mbsf)
  - NRM (0 mT): 0.13 A/m
  - Decl.: 194.4°
  - Inc.: -70.6°
  - MAD: 17.2°
  - MDF: 87 mT

- CORE SED-07 (Depth: 5.3 mbsf)
  - NRM (0 mT): 0.046 A/m
  - Decl.: 300°
  - Inc.: 48.3°
  - MAD: 0.5°
  - MDF: 43.6 mT

- CORE SED-12 (Depth: 3.90 mbsf)
  - NRM (0 mT): 0.18 A/m
  - Decl.: 201°
  - Inc.: -77.9°
  - MAD: 0.6°
  - MDF: 89.6 mT

- CORE SED-13 (Depth: 2.24 mbsf)
  - NRM (0 mT): 0.135 A/m
  - Decl.: 352°
  - Inc.: -59.3°
  - MAD: 0.5°
  - MDF: 38.7 mT

- CORE SED-14 (Depth: 1.91 mbsf)
  - NRM (0 mT): 0.1 A/m
  - Decl.: 226.9°
  - Inc.: -80.8°
  - MAD: 0.7°
  - MDF: 68.3 mT

- CORE SED-14 (Depth: 5.53 mbsf)
  - NRM (0 mT): 0.13 A/m
  - Decl.: 199.7°
  - Inc.: -40.6°
  - MAD: 1.5°
  - MDF: 56.2 mT
ODP Site 1101

Site 1101 data from Guyodo et al. (2001) PISO-NARPI stack (Channell et al., 2009, 2016)
Summary

- Drift sediments contain records of ice-sheet history and Southern Ocean paleoceanography, from multi-proxy methods

- Drifts are dominated by muddy sediments that have accumulated at relatively high sedimentation rates (often ~10 cm/kyr) and apparently without major hiatuses

- Chronostratigraphic problem due to general lack of foraminiferal carbonate prevents full exploitation of existing records

- Initial RPI results of existing cores (178-1101, SEDANO cores, PC466, JR298) suggest RPI can provide age control for off-shore drifts on orbital to millennial time scales, appropriate for reconstructing even short-term ice-sheet/climate changes