A Polar Perspective on Future MSP Drilling

View from icebreaker Oden, western Arctic Ocean, 2014. Photo: Adam Ulfsbro, Gothenburg University, Sweden

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Scientific Drilling in Polar Regions

Image: Exploring Earth by Scientific Ocean Drilling, 2050 Science Framework
"The history of Arctic climate and circulation is so poorly known that we can look at the recovery of any material as a true exploration that will, by definition, increase our knowledge and understanding of this critical region."

Larry Mayer (UNH), 1999, ACEX drilling proposal (#533)
IODP 302, *The Arctic Coring Expedition (ACEX)*, 2004

**Post-ACEX expedition planning**

1. **Arctic Ocean History: From Speculation to Reality**  
   *Consortium for Ocean Leadership (US), the ESF, AOSB, and the Nansen Arctic Drilling Program*  
   AWI Bremerhaven, Germany, November, 2008

   ![Map of the Arctic Ocean](image1.png)

   **Table 1.** Active Arctic-related IODP proposals (as of October, 2009). More details on these proposals including the list of co-proponents and involved institutions can be obtained from the IODP website (http://www.iopd.org/active-proposals).

<table>
<thead>
<tr>
<th>Number</th>
<th>Short Title</th>
<th>Contract Proponents</th>
<th>University/I nstitute</th>
<th>Country</th>
<th>Platform*</th>
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<tr>
<td>645-Full3</td>
<td>North Atlantic Gateway</td>
<td>W. Jokat</td>
<td>AWI Bremerhaven</td>
<td>ECORD/Germany</td>
<td>MSP+NR</td>
<td><a href="mailto:Wilfried.Jokat@awi.de">Wilfried.Jokat@awi.de</a></td>
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<td>680-Full</td>
<td>Bering Strait Climate Change</td>
<td>S. J. Fowell</td>
<td>University of Alaska Fairbanks</td>
<td>USA</td>
<td>MSP</td>
<td><a href="mailto:Ifsfl@ualf.edu">Ifsfl@ualf.edu</a></td>
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<td>708-Pre</td>
<td>Central Arctic Paleoceanography</td>
<td>R. Stein</td>
<td>AWI Bremerhaven</td>
<td>ECORD/Germany</td>
<td>MSP</td>
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<td>L. Polyak</td>
<td>Ohio State University</td>
<td>USA</td>
<td>MSP+NR</td>
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<td>Stockholm University</td>
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<td>NR</td>
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<td>D. Winkelmann</td>
<td>GEOMAR</td>
<td>ECORD/Germany</td>
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<td>756-Pre</td>
<td>Morris Jesup Rise: Drilling the Arctic Ocean Exit Gateway</td>
<td>M. Jakobsson</td>
<td>Stockholm University</td>
<td>ECORD/Sweden</td>
<td></td>
<td><a href="mailto:Martin.jakobsson@geo.su.se">Martin.jakobsson@geo.su.se</a></td>
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2. **Overcoming Barriers to Arctic Ocean Scientific Drilling: The site survey challenge**  
   *Magellan Workshop Series*  
   Copenhagen, Denmark, November, 2011
Expedition 377 - Arctic Ocean Paleoceanography (ArcOP)

"Recovery of a complete (composite) stratigraphic sedimentary record on the southern Lomonosov Ridge to meet our highest-priority pale oceanographic objective, the continuous long-term Cenozoic climate history of the central Arctic”

• MSP’s provide an incredible amount of flexibility in designing proposals and reaching drilling targets. What we ask for in the proposal determines the type and cost of drilling.

• Deep holes require staying on site for a long time. This is logistically challenging and very expensive in continuously moving sea ice.

• Ultimately, there is no single site that will deliver the complete history of the Arctic cryosphere (sea ice, ice sheets, glaciers and permafrost).

• To address many of the goals in the 2050 Science Framework, we need to increase scientific drilling activity in the Arctic. This can be achieved with numerous ‘smaller’ focused campaigns.
Alternate Approaches

1. Target outcropping sediments

Expedition 373 (813-Full) - George V Land, Antarctica: Cenozoic Paleoclimate: T. Williams et al.

“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.”

Figure 2. Schematic composite transect along seismic lines WEGA-02 and IFP-103/107. Seaward-dipping strata mean younger sediments are found on the outer shelf, and older sediments are found in the inner shelf. Vessel and MeBo rig not to scale.
Alternate Approaches

2. Continuous Recovery of Shallow - (but critical) - Targets

Estimated Depths of Epoch Boundaries

<table>
<thead>
<tr>
<th>Epoch</th>
<th>Depth (m) at 1 cm/ka</th>
<th>Depth (m) at 2 cm/ka</th>
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<tr>
<td>Quaternary</td>
<td>25.8</td>
<td>51.6</td>
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<tr>
<td>Pliocene</td>
<td>53.5</td>
<td>106.6</td>
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</table>

Shallow sediments were not well recovered on ACEX, with complete (overlapping) recovery in the upper 19 m!!
Observed/modeled global temperature change (°C)

Observed Arctic temperature change (°C)

-7 -5 -3 -1 1 3 5

20
10
0
-10
-20
-30

MP
LIG
HTM
LGM

Perennial Seasonal

This is conceptual because we lack the required data

‘Arctic temperature change consistently exceeds the Northern Hemisphere average by a factor of 3–4’

Miller et al., 2010, QSR

Arctic amplification: can the past constrain the future?

Gifford H. Miller a,c, Richard B. Alley b, Julie Brigham-Grette c, Joan J. Fitzpatrick d, Leonid Polyak e, Mark C. Serreze f, James W.C. White a
Thresholds in the Past

Flor Vermassen, Stockholm University, in review
Maybe 50+ years of ‘age uncertainty’ is not an impediment to drilling - but the foremost scientific question.
Connections in the ‘Climate Factory’ Transcend Timescales

Recent Arctic amplification and extreme mid-latitude weather
Judah Cohen, James A. Screen, Jason C. Furtado, Mathew Barlow, David Whitleston, Dim Coumou, Jennifer Francis, Klaus Dethloff, Dara Entekhabi, James Overland & Justin Jones

The influence of Arctic amplification on mid-latitude summer circulation
D. Coumou, G. Di Capua, S. Vavrus, L. Wang & S. Wang

Midlatitudes unaffected by sea ice loss
John C. Fyfe

Asian monsoon intensity coupled to Antarctic climate during Dansgaard–Oeschger 8 and Heinrich 4 glacial intervals
Yi-Jia Liang, Shi-Tao Chen, Yong-Jin Wang, Kan Zhao, Shao-Hua Yang, Zhen-Jun Wang, Yu-Zheng Huang, Hai Cheng & R. Lawrence Edwards

Late Miocene climate cooling and intensification of southeast Asian winter monsoon
Ann E. Holbourn, Wolfgang Kuhnt, Steven C. Clemens, Karlos G. D. Kochhann, Janika Jöhnck, Julia Löbbers & Nils Andersen

Hydrological impact of Middle Miocene Antarctic ice-free areas coupled to deep ocean temperatures
Catherine D. Bradshaw, Petra M. Langebroek, Caroline H. Lear, Daniel J. Lunt, Helen K. Coxall, Sindia M. Söldner & Agatha M. de Beér

High-latitude biomes and rock weathering mediate climate–carbon cycle feedbacks on eccentricity timescales
David De Vries, Ann Joy Drury, Maximilian Vahlenkamp, Fiona Rochholz, Diederk Liebrand & Heiko Pälike
Tectonics, Paleogeography and Ocean Circulation

Late Cretaceous (ca. 70 Ma)

Middle Eocene (ca. 50 Ma)

Early Miocene (ca. 20 Ma)

Terrestrial-Marine Carbon Dynamics

Drone footage from the Beaufort Sea Coast. Image: Dustin Whalen, GSC-Atlantic/NRCan

Source: www.grida.no/resources/13519
Final Remarks . . .

- There are a lot of exciting planned (yellow) and proposed (red) drilling sites in the polar regions that address central themes in high latitude ice sheet evolution and ocean circulation.

- However achieving many of the high level goals set by the 2050 Science Framework requires increased scientific drilling activity in the Arctic. This begins with a renewed effort to develop feasible drilling proposals that acknowledge the cost and logistical challenges of working in sea ice.
End

View from CCGS Amundsen, Northern Banks Island, Canadian Beaufort Sea, September 2021.