ESF Report
Workshop „Arctic Ocean History: From Speculation to Reality“
Alfred Wegener Institute Bremerhaven/Germany, November 03 to 05, 2008
(Convenor: Bernard Coakley/University of Alaska/US and Ruediger Stein/AWI Bremerhaven/Germany)

Summary

In order to discuss and plan the future of scientific drilling in the Arctic Ocean, an international workshop was held at the Alfred Wegener Institute in Bremerhaven, Germany, on November 3rd thru 5th of 2008. Convenors of the workshop were Bernard Coakley (Geophysical Institute, University of Alaska Fairbanks/US) and Ruediger Stein (Alfred Wegener Institute Bremerhaven/Germany). About 95 scientists from Europe, US, Canada, Russia, Japan, and Korea and observers from oil companies participated in the workshop. Funding of the workshop was provided by the Consortium for Ocean Leadership (US), the European Science Foundation, the Arctic Ocean Sciences Board, and the Nansen Arctic Drilling Program as well as by sponsorships from British Petroleum, ConocoPhillips, ExxonMobil, Norwegian Petroleum Directorate, Shell International, and StatoilHydro.

The first day of the meeting focused on presentations about the history of the Arctic Ocean, the legacy of high latitude ocean drilling, the existing site survey database, the possibilities of collaboration with industry and the process of developing ocean-drilling legs through IODP. The next day and a half was spent in thematic and regional break-out groups discussing the particular questions to be addressed by drilling and the particular targets for Arctic scientific drilling. Within the working groups, key scientific questions, site surveys (available and needed) as well as strategies for reaching the overall goals were discussed and – as one of the main results – core groups for further developing drilling proposals were formed. Based on discussions at this meeting, approximately ten new pre-proposals will be submitted to IODP for the April 01- 2009 deadline.

A community-wide (USA, Europe, Japan, and others), multidisciplinary and international conference – INVEST IODP New Ventures in Exploring Scientific Targets - is planned for September 2009 in Bremen/Germany to discuss future directions of scientific ocean drilling beyond 2013. We hope that the development of new scientific objectives through the pre-proposal process – as main goal of our workshop - will help reshape plans for scientific ocean drilling and direct the program north towards these critical priorities and advance exploration of the Arctic.

Reports of the workshop discussions will be published in the journals *EOS* (summary) and *Scientific Drilling* (extended version).

Introduction and background

Although major progress in Arctic Ocean research has been made during the last decades, the knowledge of its short- and long-term paleoceanographic and paleoclimatic history as well as its plate-tectonic evolution is much behind that from the other world’s oceans. That means - despite the importance of the Arctic in the climate system - the data base we have from this area is still very weak, and large parts of the climate history have not been recovered at all in sedimentary sections. This lack of knowledge is mainly caused by the major technological/ logistic problems in reaching this permanently ice-covered region with normal research vessels and in retrieving long and undisturbed sediment cores.

With the successful completion of IODP Expedition 302 ("Arctic Coring Expedition" – ACEX), the first Mission Specific Platform (MSP) expedition within the Integrated Ocean Drilling Program - IODP, a new era in Arctic research has begun. For the first time, a scientific drilling in the permanently ice-covered Arctic Ocean was carried out, penetrating about 430 meters of Quaternary, Neogene, Paleogene and Campanian sediment on the crest of Lomonosov Ridge close to the North Pole (Backman, et al., 2006; Moran et al., 2006). ACEX was an outstanding success for two reasons. First, ACEX has proven that with an intensive ice-management strategy, i.e., a three-ship approach with two powerful icebreakers (*Sovetskiy Soyuz* and *Oden*) protecting the drillship (*Vidar Viking)* by breaking upstream ice floes into small pieces, successful scientific drilling in the permanently ice-covered central Arctic Ocean is possible. Second, the first scientific results comprise a milestone in Arctic Ocean research and brought new insights into the Arctic Ocean climate history and its global significance (Backman and Moran, 2008 and further references therein). The success of ACEX has certainly opened the door for further scientific drilling in the Arctic Ocean, and will frame the next round of questions to be answered from new drill holes to be taken during next two decades.

In order to discuss and plan the future of scientific drilling in the Arctic Ocean, an international workshop was held at the Alfred Wegener Institute in Bremerhaven, Germany, on November 3rd thru 5th of 2008 (see Appendix 1, final programme). Convenors of the workshop were Bernard Coakley (Geophysical Institute, University of Alaska Fairbanks/US) and Ruediger Stein (Alfred Wegener Institute Bremerhaven/Germany). For planning, organizing, and chairing the workshop, a Steering Committee was established, composed of the two convenors and Jan Backman (Stockholm University/Sweden), Henk Brinkhuis (Utrecht University/The Netherlands), Nick Kusznir (University of Liverpool/UK), Naja Mikkelsen (Geological Survey of Denmark and Greenland Kopenhagen/Denmark), Kate Moran (University of Rhode Islands/US), and Jörn Thiede (Alfred Wegener Institute Bremerhaven/Germany).

The major targets of the workshop were:

(1) to bring together an international group of Arctic scientists, young scientists and ocean drilling scientists to learn and exchange ideas, experience and enthusiasm about the Arctic Ocean;
(2) to develop a scientific drilling strategy to investigate the tectonic and paleoceanographic history of the Arctic Ocean and its role in influencing the global climate system;
(3) to summarize the technical needs, opportunities, and limitations of drilling in the Arctic;
(4) to define scientific and drilling targets for specific IODP-type campaigns in Arctic Ocean key areas to be finalized in the development of drilling proposals.

About 140 applications were received for the 95 seats available at the meeting (see Appendix 2, list of participants). The European Science Foundation enabled support of about 40 European participants, and the Consortium for Ocean Leadership provided support of about 30 US participants through the U.S. Science Support Program associated with the Integrated Ocean Drilling Program and through the Nansen Arctic Drilling Program. The Arctic Ocean Sciences Board and contributions from six oil companies (British Petroleum, ConocoPhillips, ExxonMobil, Norwegian Petroleum Directorate, Shell International, and StatoilHydro) made it possible to extend travel support to Canadian, Russian, Japanese and Korean participants (12 in total). In addition, 10 observers from the sponsoring oil companies participated in the workshop. Concerning the participants, we tried to broaden the participation of young scientists in IODP/Arctic drilling. Recruiting „new blood", the leaders of the next decade, will give them the opportunity to build their careers as they create the program. Given the time

line for developing Arctic drilling legs (5-10 years), a particular focus on early career scientists (post-docs and graduate students) is desirable.

Content and structure

In planning this meeting, the conveners were acutely aware of the need to mesh the arctic science and the ocean drilling communities. As a result, the first day of the meeting focused on presentations about the history of the Arctic Ocean, the legacy of high latitude ocean drilling, the existing site survey database, the possibilities of collaboration with industry and the process of developing ocean-drilling legs through IODP. For these presentations, leading scientists in the different fields were invited to give overviews of the state of the art. Starting with an overall introduction about the history of Arctic geoscientific research (J.Thiede/Germany), presentations about the current status of Quaternary research based on coring (L. Polyak/US, R. Spielhagen/Germany), about the long-term Cenozoic history based on DSDP-ODP-IODP drilling in the High Northern Latitudes (K. Moran/US), and the knowledge from arctic shelf drilling (P. Rekant/Russia, C. Paull/US) followed. The second block of presentations concentrated on the tectonic history of circum-Arctic shelves and basins (J. Omma/UK, E. Miller/US), bathymetry (M. Jakobsson/Sweden), and seismic reflection data (Y. Kristoffersen/Norway, W.Jokat/Germany). In the afternoon, presentations dealing with organizational and technical needs (J. Schuffert/US, L. Lembke-Jene/Germany, F. Rack/US) and with collaboration between academia and industry (H. Brekke/Norwegian Petroleum Directorate, S. Paulson/British Petroleum) were scheduled. Finally, time was given to workshop participants to give short statements about unsolicited ideas, information, and speculation related to Arctic Ocean drilling.

The next day and a half was spent in break-out groups discussing the particular questions to be addressed by drilling and the particular targets for arctic scientific drilling.

In the discussions, we had two sets of break-out groups. The first was based on discipline: Paleoceanography (chaired by N. Koc/Norway and J. Zachos/US), plate tectonics (chaired by W. Jokat/Germany and V. Pease/Sweden), petrology/geochemistry (chaired by P. Michael/US), and gas hydrates (chaired by M. Torres/US). The objective of these groups was to frame important questions in a pan-arctic context. The product from these groups was a list of important questions that can be addressed by drilling in various locations across the Arctic. Major topics (hypotheses to be tested by drilling) are summarized by the following key words:

(1) Paleoceanography
Cyclicity between oxic, sub-oxic, and/or euxinic/anxoic conditions during the Cretaceous and Paleocene-Eocene; greenhouse vs. icehouse climate; polar amplification of greenhouse warming; hydrological cycle during greenhouse warming; onset of Eocene cooling; impact of Eocene-Oligocene transition in global pCO_2 and sea level on the Arctic; onset and variability of sea-ice cover (seasonal vs. perennial ice cover); circum-Arctic ice-sheet/ice-shelf history and dynamics; opening of Bering Strait/FramSrait and its paleoceanographic consequences; causes of extended mid-Cenozoic unconformities; nature of Arctic environment during periods of extreme events (warm/cold); test bipolar synchronous vs. asynchronous climate variability

(2) Tectonics
Mode of crustal extension in the Laptev Sea shelf; development of FramStrait gateway (mode

of extension); identification of plate boundaries (Chukchi Plateau); age of magnetic anomalies (Canada Basin); age and evolution of Alpha Ridge, Mendeleev Ridge, Makarov Basin, and Chukchi Plateau; correlation of on-shore and off-shore geology (Paleozoic sediments, Mesozoic magmatism); understanding the 'Amerasia' side of Lomonosov Ridge; along strike geologic variation of Lomonosov Ridge and consequences for Mesozoic evolution

(3) Petrology/Geochemistry
Gakkel ridge mantle melting and geochemistry: western vs. eastern Gakkel Ridge (Global problem: how does continental lithospheric mantle contribute to melting of the asthenosphere? How does extent of melting change as spreading rate goes to zero?); nature and origin of the Chukchi Borderland volcanism; origin of Alpha Mendeleev Ridge (hotspot track? Part of a large LIP? Connection of volcanism between America and Asia?

(4) Gas hydrates
Pan-Arctic objective: Multiple sections that lie at different end-members and represent different aspects of gas hydrate (GH) questions and its relationship to climate and geologic history of the Arctic. MacKenzie shelf (most mature, representative of a deltaic end-member) vs. Russian shelf (Laptev Sea, excellent location, wide shelf, but not as mature; Siberia excellent candidate for GH aspect); deep-water observations of pockmarks and other seismic evidence for GH presence in Mendeleev Ridge area; role of GH in these areas (e.g., carbon cycle); operational issues (GH drilling requires pressure coring and other tools that are routinely used for GH programs, i.e., P-T measurements, lab acilities etc.; need for circulating mud systems); difficulty of achieving new surveys; compilation of existing data.

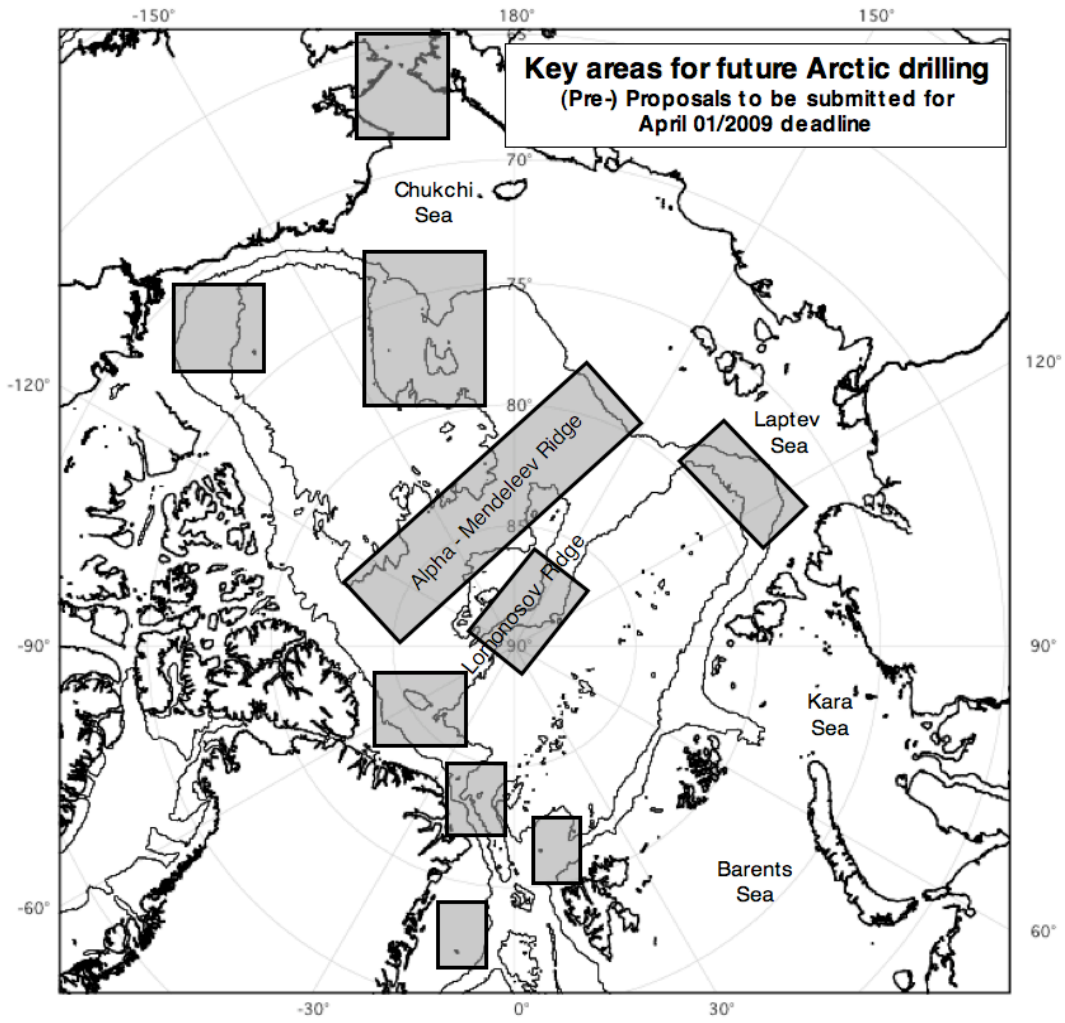
The second set of break-out groups had a geographic focus. Based on the thoughts of the conveners and the comments of the meeting applicants, we have selected these regions for break-out groups:
Lomonosov Ridge (chaired by K. St. John/US, Y. Kristoffersen/Norway)
Alpha-Mendeleev Ridge (chaired by H. Jenkyns/UK, L. Lawver/US)
Chukchi Plateau (chaired by L. Polyak/US, J. Hopper/Denmark)
Morris Jessup Rise and Yermak Plateau (chaired by S. Neben/Germany, F. Rack/US)
Eurasian Shelf Seas (chaired by H. Kassens/Germany, P. Rekant/Russia)
MacKenzie Delta (chaired by D. Schmitt/Canada)

Within these regional working groups, key scientific questions, site surveys (available and needed) as well as strategies for reaching the overall goals were discussed and – as one of the main results – core groups for further developing drilling proposals were formed (see below).

Summaries of the working group discussions were presented finally in a plenary session, followed by a joint discussion about future drilling activities in the Arctic Ocean.

Results and impact of the event on the future direction of the field

The participants committed to develop new IODP pre-proposals for Arctic Ocean drilling. Based on discussions at this meeting, we believe approximately ten new pre-proposals will be submitted to IODP for the April 01- 2009 deadline (Fig. 1 for key areas). These proposals will be submitted at a critical time, both for the future of Arctic Ocean science and the future of scientific ocean drilling. Only in the last few years, through dedicated efforts of a number of research groups, sufficient data to pose specific testable hypotheses about much of the basin and to select drill sites on most of the significant bathymetric features, became available.



A community-wide (USA, Europe, Japan, and others), multidisciplinary and international conference – INVEST IODP New Ventures in Exploring Scientific Targets - is planned for September 2009 in Bremen/Germany (More information at http://www.iodp.org) to discuss future directions of scientific ocean drilling beyond 2013. The results of our workshop will contribute to develop new scientific objectives through the pre-proposal process. We hope that these plans will help reshape plans for scientific ocean drilling and direct the program north towards these critical priorities and advance exploration of the Arctic.

Reports of the workshop discussions will be published in the journals *EOS* (summary) and *Scientific Drilling* (extended version).

References

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Appendix

Appendix 1: Final programme of workshop

Appendix 2: List of participants

Workshop Agenda

(all events are in AWI Building D unless otherwise noted)

Sunday, 2 November 2008

17:00-18:00 **Registration**

18:00-21:00 **Icebreaker**
(drinks and snacks will be served)

Monday, 3 November 2008

Opening

08:30-08:35	Introduction	R. Stein
08:35-08:40	Welcome	H. Miller
08:40-08:45	Logistics	R. Stein
08:45-09:00	Workshop goals	B. Coakley

Results (1): History, Stratigraphy, and Paleoenvironment
Plenary Session Chair: R. Stein

09:00-09:30	History and mystery of the Arctic Ocean	J. Thiede

Coring

09:30-09:45	Current status of Quaternary research in the Amerasian Basin	L. Polyak
09:45-10:00	Quaternary history of the Eurasian Arctic Ocean from sediment cores	R. Spielhagen
10:00-10:30	Drilling in high northern latitudes from DSDP/ODP to IODP/ACEX	K. Moran

Knowledge from arctic shelf drilling

10:30-10:45	Shallow coring and drilling activity on the Eurasian continental margin	P. Rekant
10:45-11:00	Fate of methane released on the Arctic shelf from thawing permafrost and decomposing gas hydrate (co-authors: S. Dallimore and T. Collett)	C. Paull

11:00-11:30 **Coffee Break**

Results (2): Tectonics
Plenary Session Chair: B. Coakley

11:30-11:50	Tectonic history of the circum-Arctic shelves: Observations and assumptions (co-author: R. Scott)	J. Omma
11:50-12:10	Outstanding questions about the origin and evolution of the Amerasian Basin	E. Miller

Database (Site Survey)
Plenary Session Chair: B. Coakley

12:10-12:30	Bathymetry	M. Jakobsson
12:30-13:10	Seismic Reflections	Y. Kristoffersen and W. Jokat

13:10-14:10 **Lunch**

Organizational and Technical Needs
Plenary Session Chair: N. Kusznir

14:10-14:40	How to navigate the waters of IODP	J. Schuffert
14:40-14:55	AURORA BOREALIS - European research icebreaker with drilling capability	N. Biebow
14:55-15:10	Scientific drilling in remote polar environments: Preparing for successful outcomes	F. Rack

Collaboration Between Academia and Industry
Plenary Session Chair: K. Moran

15:10-15:25	EUREKA/EUROGIA development	G. Marquette
15:25-15:40	Arctic Ocean drilling in the context of resource assessment	H. Brekke
15:40-15:55	Understanding crustal inheritance: the key to Arctic hydrocarbon prospectivity (co-authors: L. Mackay and S. Matthews)	S. Paulson

15:55-16:25 **Coffee Break**

Unsolicited Ideas, Information, and Speculations
Plenary Session Chair: H. Brinkhuis

16:25-18:00 Participant Presentations

19:00-22:00 **Joint Dinner at Alfred´s (AWI Building E)**

Tuesday, 4 November 2008

Working Group Discussion (I: Thematic Working Groups)

08:30-08:45	Scientific key questions, key hypotheses, where to go?	B. Coakley
08:45-11:00	Thematic Working Groups:	
	1. Paleoceanography	N. Koç and J. Zachos
	2. Plate Tectonics	W. Jokat and V. Pease
	3. Gakkel Ridge Petrology/Geochemistry	P. Michael
	4. Methane Hydrates	M. Torres

11:00-12:00 **Coffee Break and Poster Session**

Working Group Reports (I: Thematic Working Groups)
Plenary Session Chair: L. Mayer

12:00-12:30	1. Paleoceanography	N. Koç and J. Zachos
12:30-13:00	2. Plate Tectonics	W. Jokat and V. Pease
13:00-13:15	3. Gakkel Ridge Petrology/Geochemistry	P. Michael
13:15-13:30	4. Methane Hydrates	M. Torres

13:30-14:30 **Lunch**

Working Group Discussion (II: Regional Working Groups)

14:30-14:45	Purpose/outcome of afternoon´s group discussions	K. Moran and R. Stein
14:45-18:00	Regional Working Groups	
	1. Lomonosov Ridge	K. St. John and Y. Kristoffersen
	2. Alpha-Mendeleev Ridge	H. Jenkyns and L. Lawver

	3. Chukchi Plateau	L. Polyak and J. Hopper
	4. Morris Jessup Rise	N. Mikkelsen and S. Neben
	5. Yermak Plateau	F. Rack and M. Jakobbson
	6. Eurasian Shelf Seas	H. Kassens and P. Rekant
	7. Mackenzie	D. Schmitt
	Coffee Break (any time)	
19:00-22:00	**Conference Dinner at Atlantic Hotel Sail City (19th floor)**	

Wednesday, 5 November 2008

Working Group Reports (II: Regional Working Groups)
Plenary Session Chairs: B. Coakley and R. Stein

09:00-09:30	1. Lomonosov Ridge	K. St. John and Y. Kristoffersen
09:30-10:00	2. Alpha-Mendeleev Ridge	H. Jenkyns and L. Lawver
10:00-10:30	3. Chukchi Plateau	L. Polyak and J. Hopper
10:30-11:00	4. Morris Jessup Rise	N. Mikkelsen and S. Neben
11:00-11:30	**Coffee break**	
11:30-12:00	5. Yermak Plateau	F. Rack and M. Jakobbson
12:00-12:30	6. Eurasian Shelf Seas	H. Kassens and P. Rekant
12:30-13:00	7. Mackenzie	D. Schmitt
13:00-14:00	**Lunch**	
15:00-17:00	**Meeting of Organizing Committee**	

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