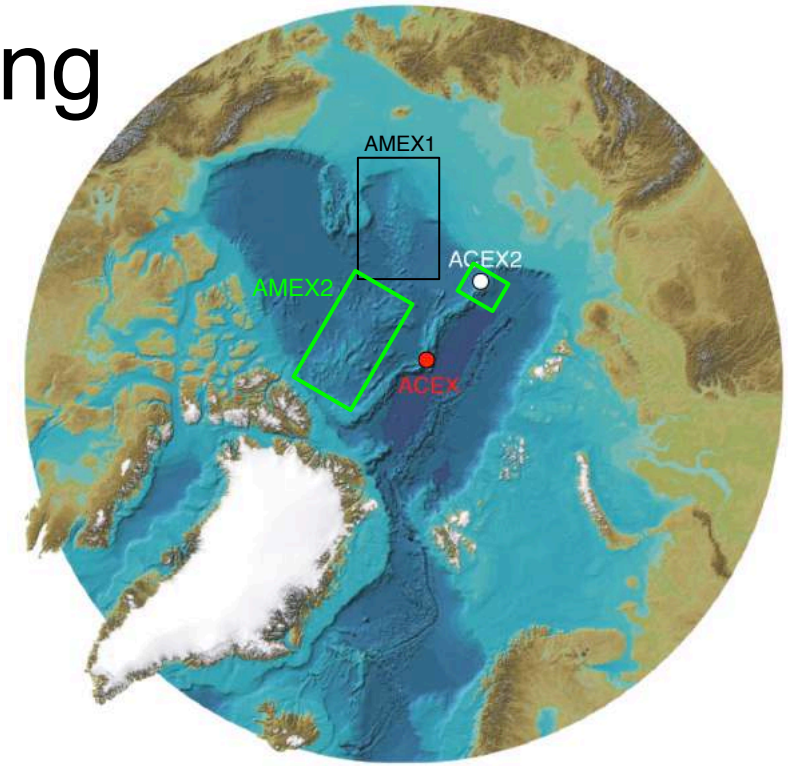
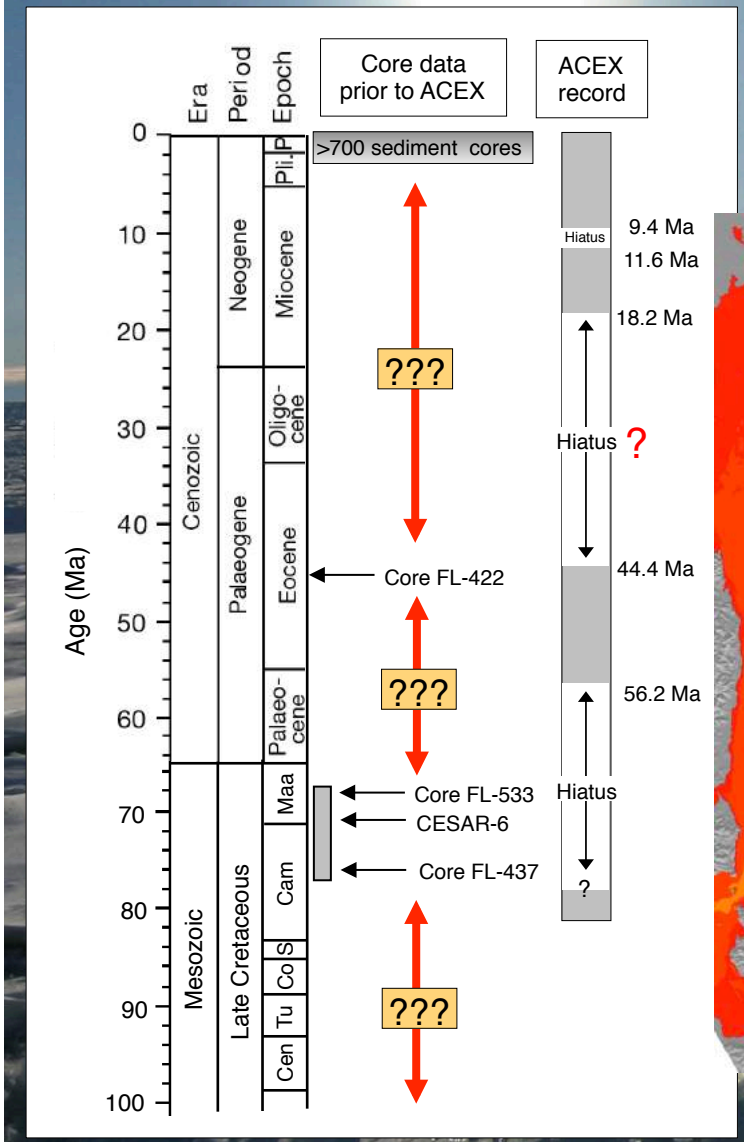
IODP: Future Arctic Drilling

Ruediger Stein
(Alfred Wegener Institute
Bremerhaven, Germany)

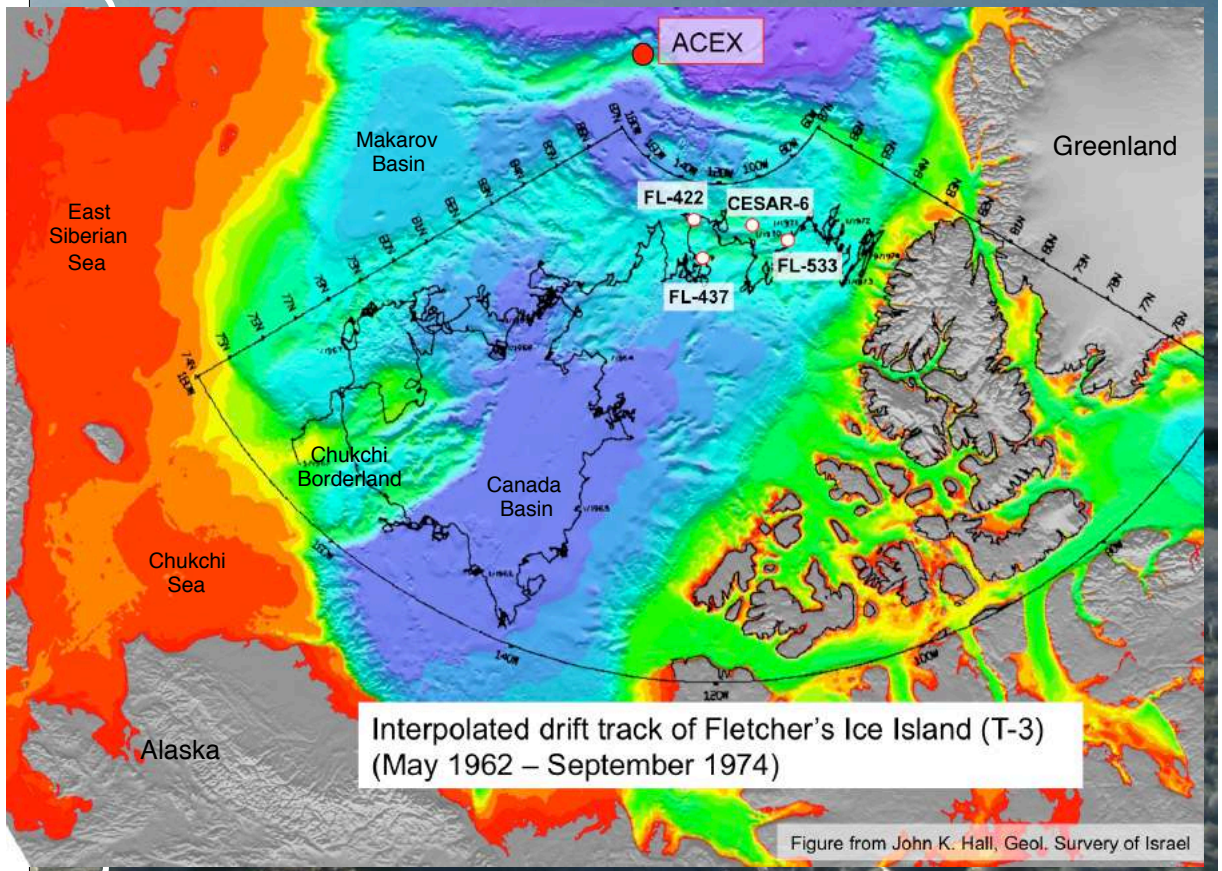


- ACEX: Background and Highlights
- ACEX2: IODP Proposal 708-Full
- AMEX2: Polarstern Expedition 2014

Arctic Ocean climate history and sedimentary records

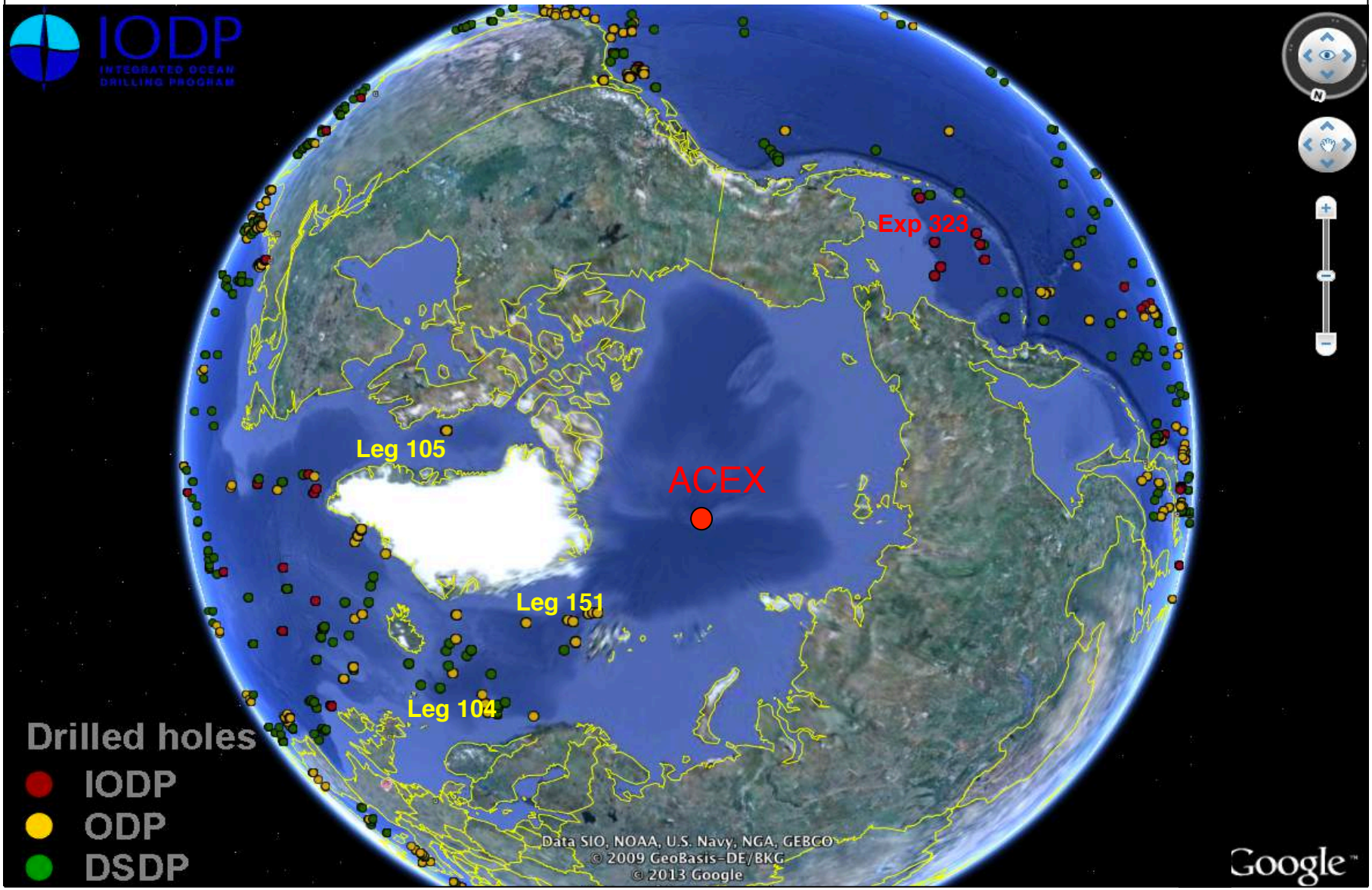


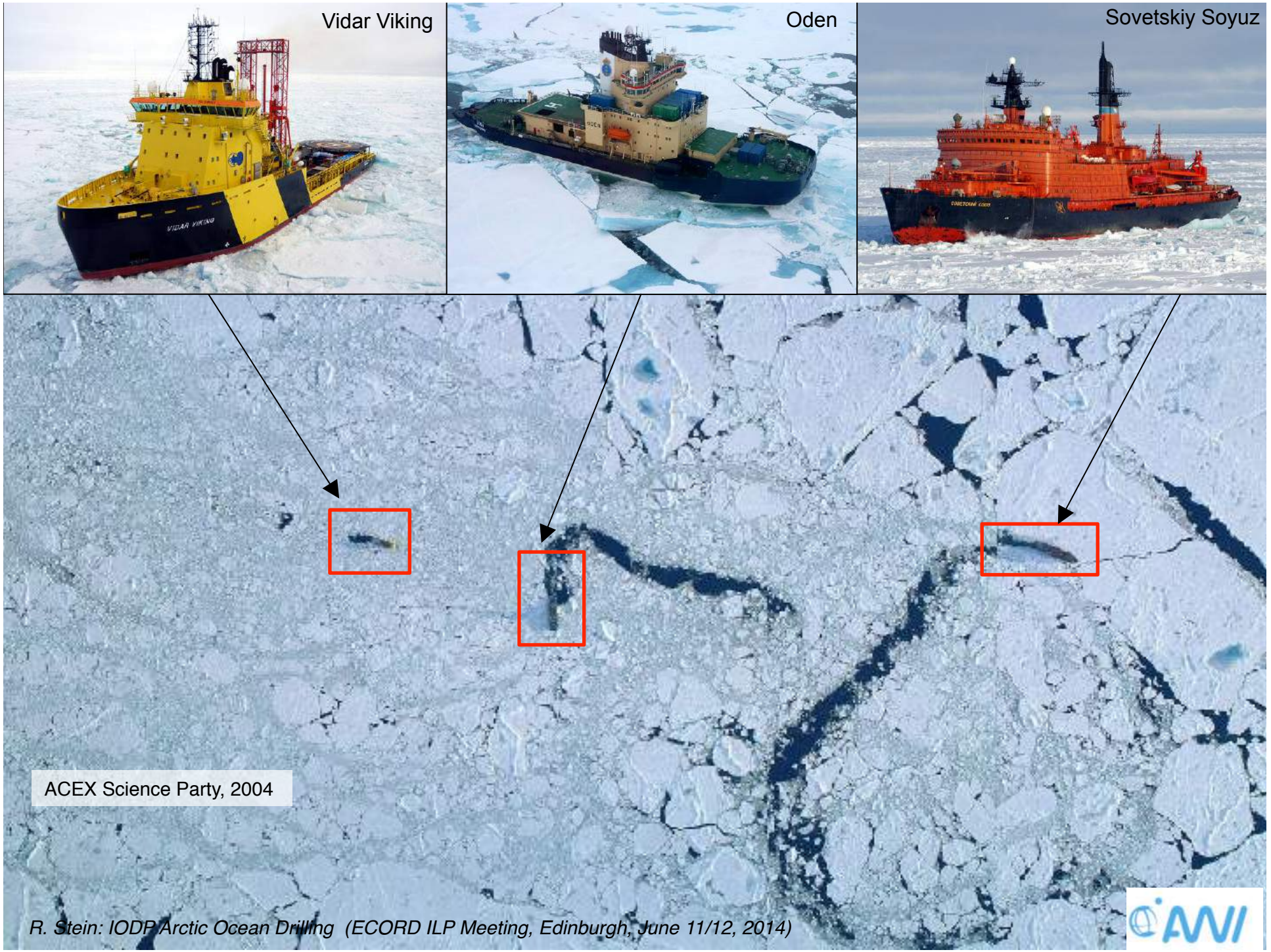
>700 sediment cores

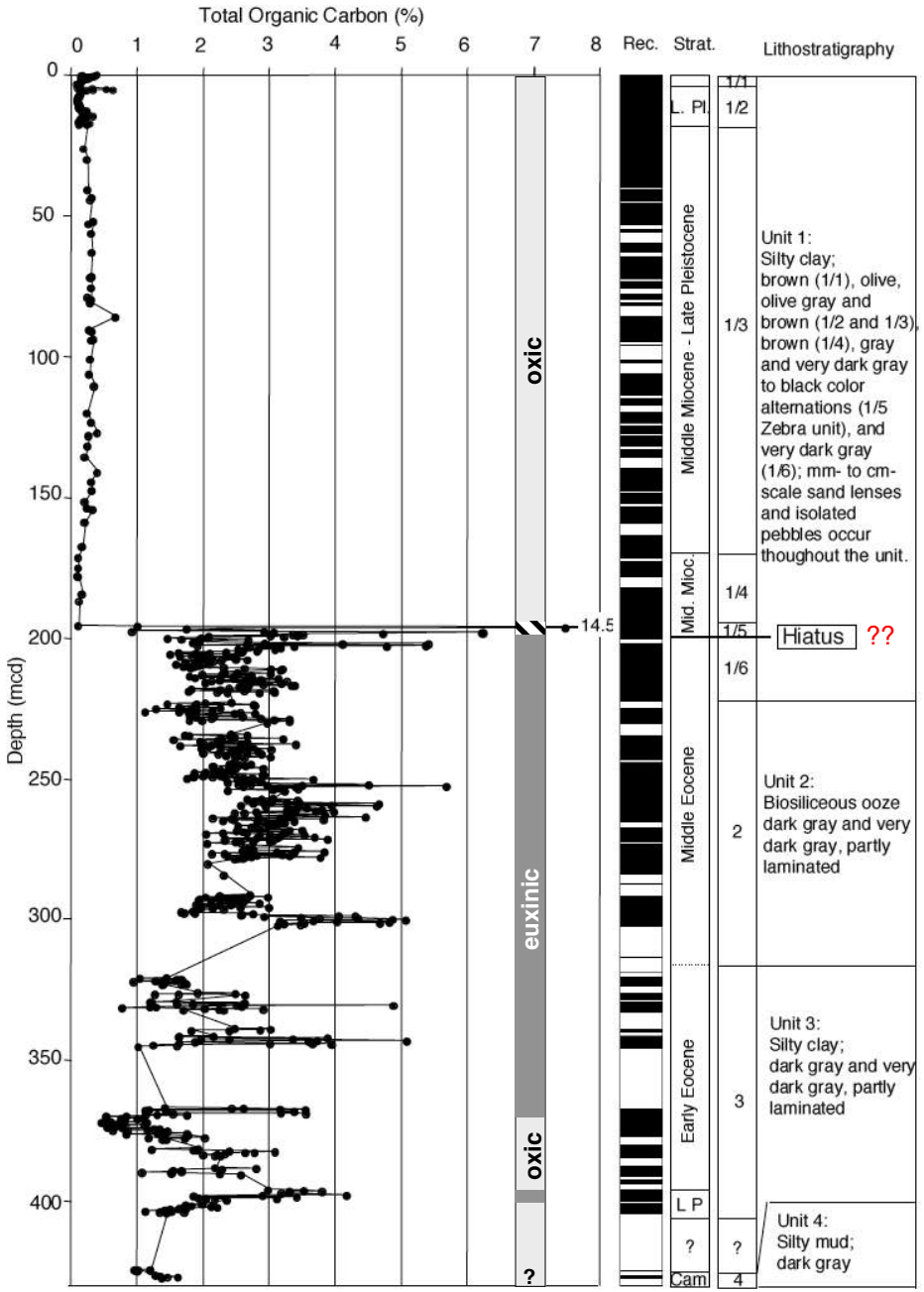


(Stein et al., 2014 - based on Thiede et al., 1990; Backman et al., 2008; Stein, 2008)

Arctic Ocean drilling: Emerging fields / new topics / unknown areas

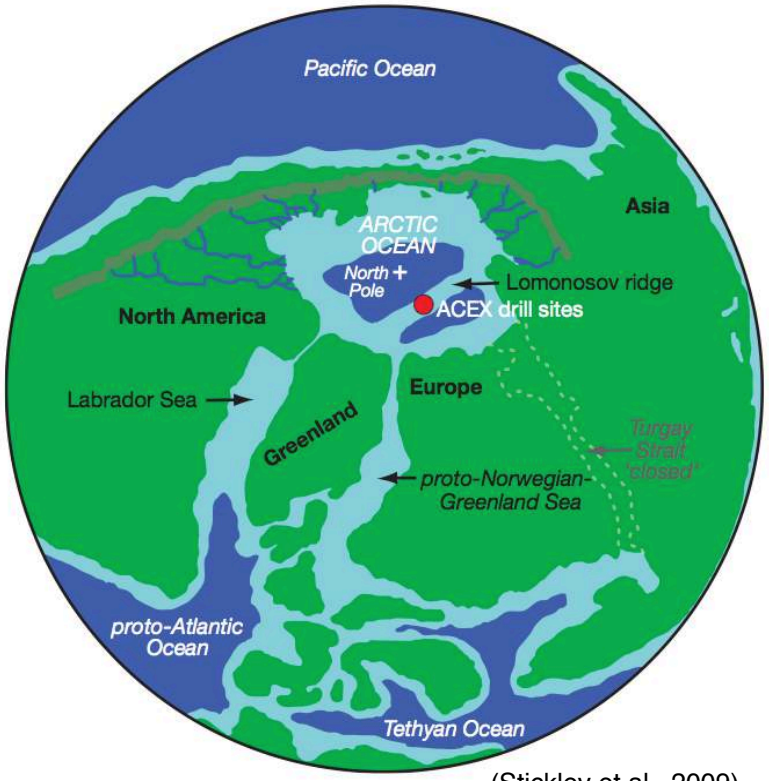



Vidar Viking
Oden
Sovetskiy Soyuz
ACEX Science Party, 2004



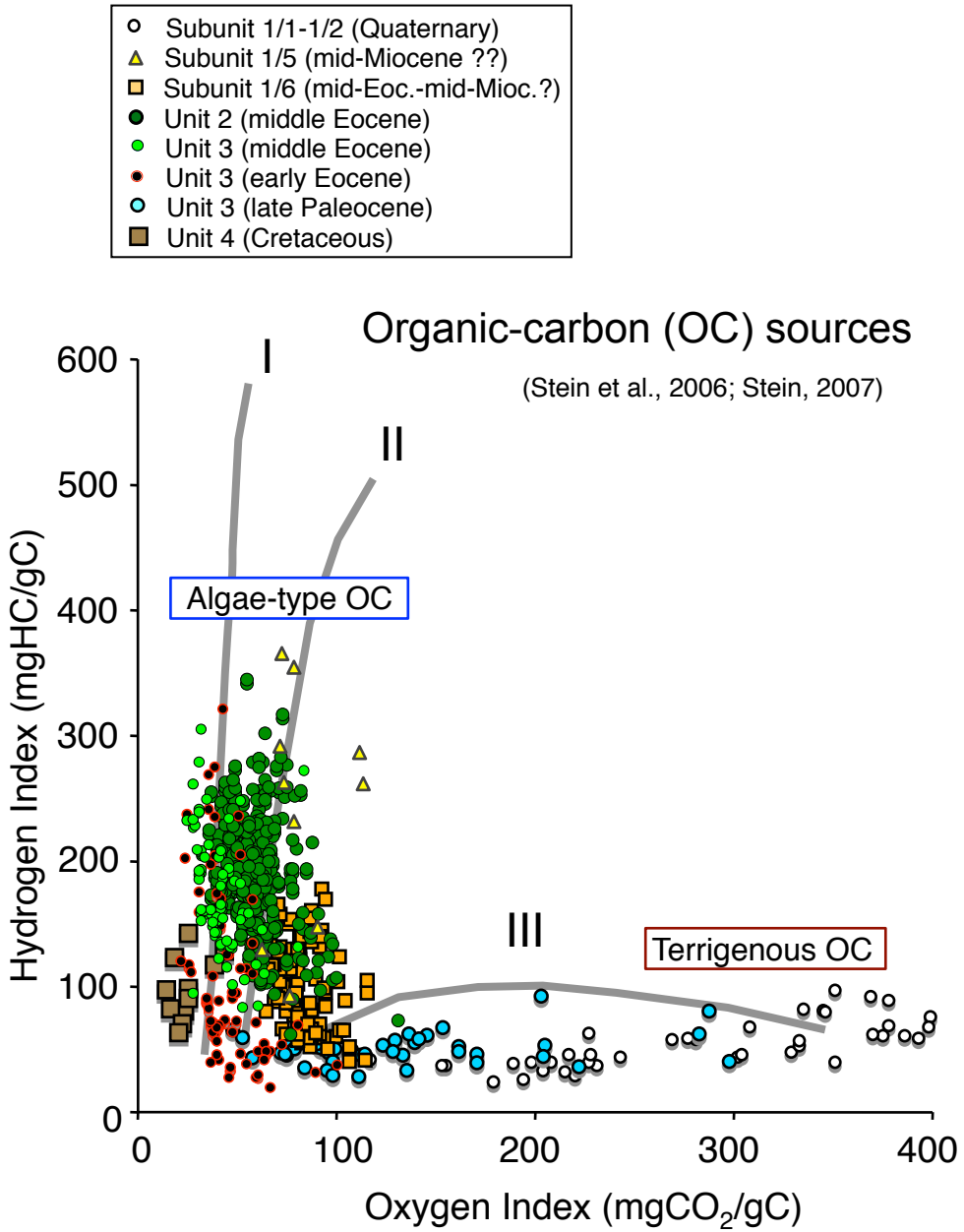
(Stein, 2007)

Early Eocene Paleogeography

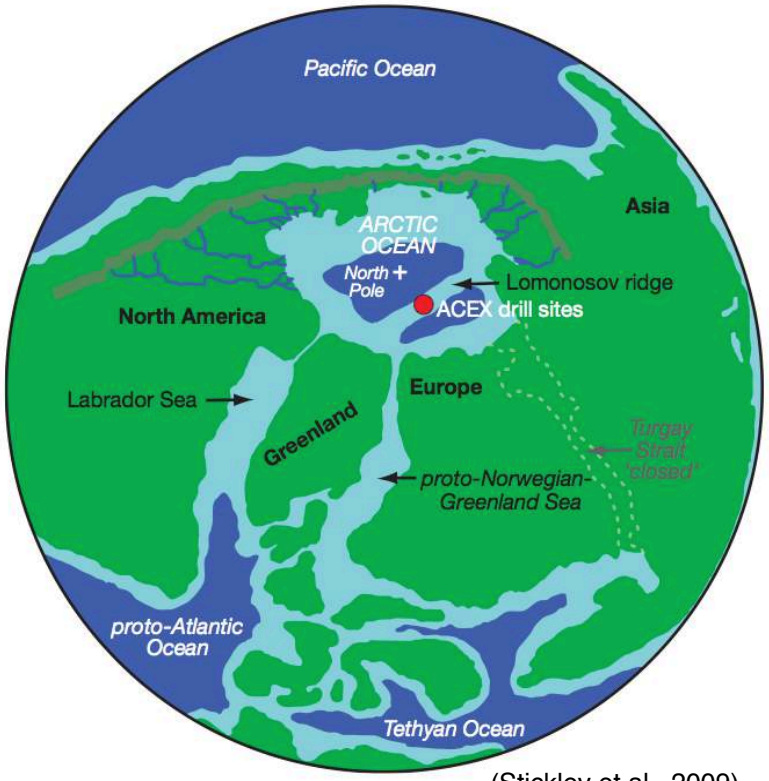


(Stickley et al., 2009)

Black shales near the North Pole



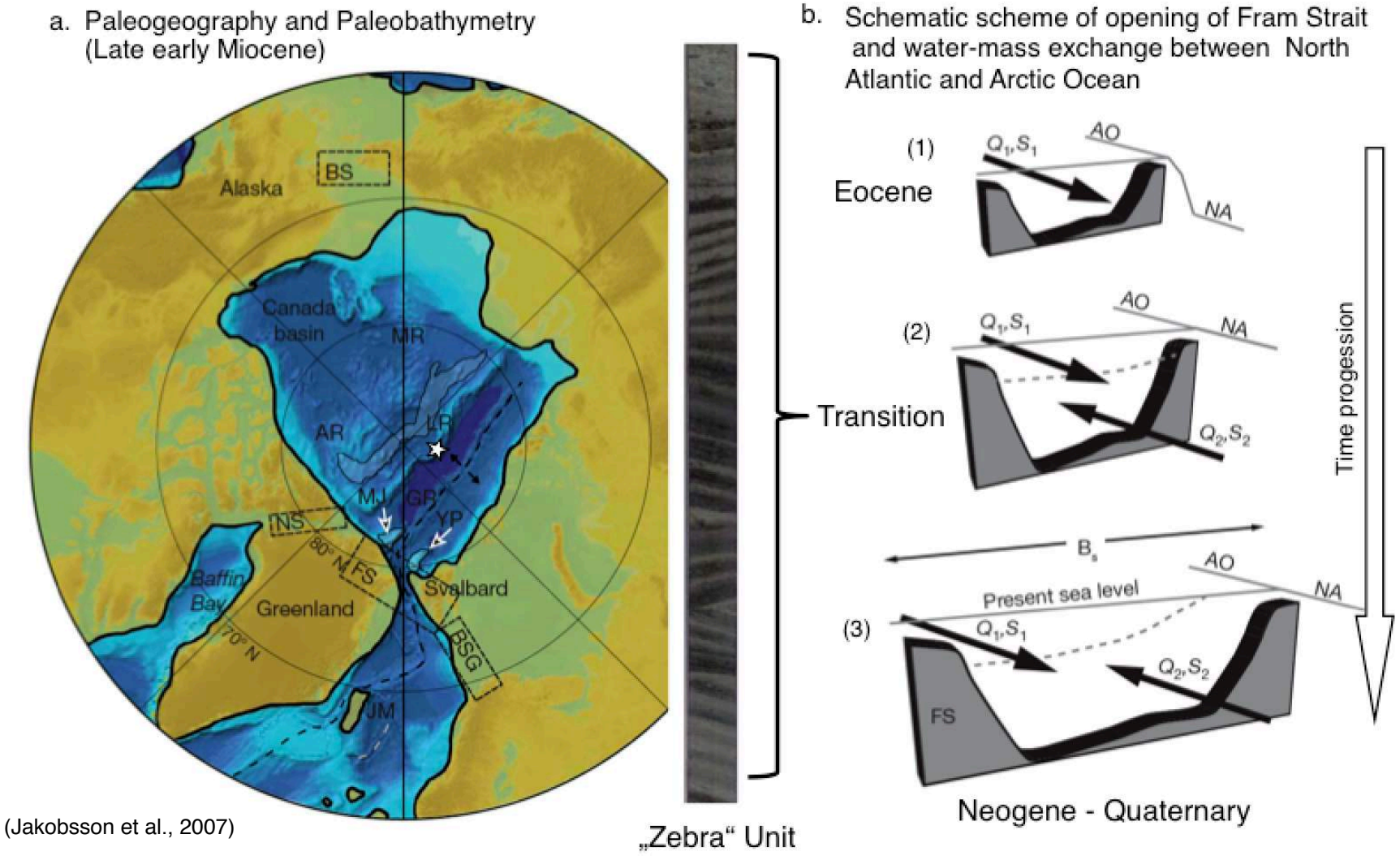
Early Eocene Paleogeography



(Stickley et al., 2009)

Black shales near the North Pole

When did the transition from poorly oxygenated to fully oxygenated conditions occur ???



(Jakobsson et al., 2007)

PETM (55 Ma) and EECO (50 Ma): wet and warm (24°C) Ocean; euxinic conditions

Pagani et al., *Nature* 2006;
Slujs et al., *Nature* 2006, 2008;
Stein et al., *GRL* 2006;
Weller and Stein, *Paleoceanography* 2008

IODP - ACEX

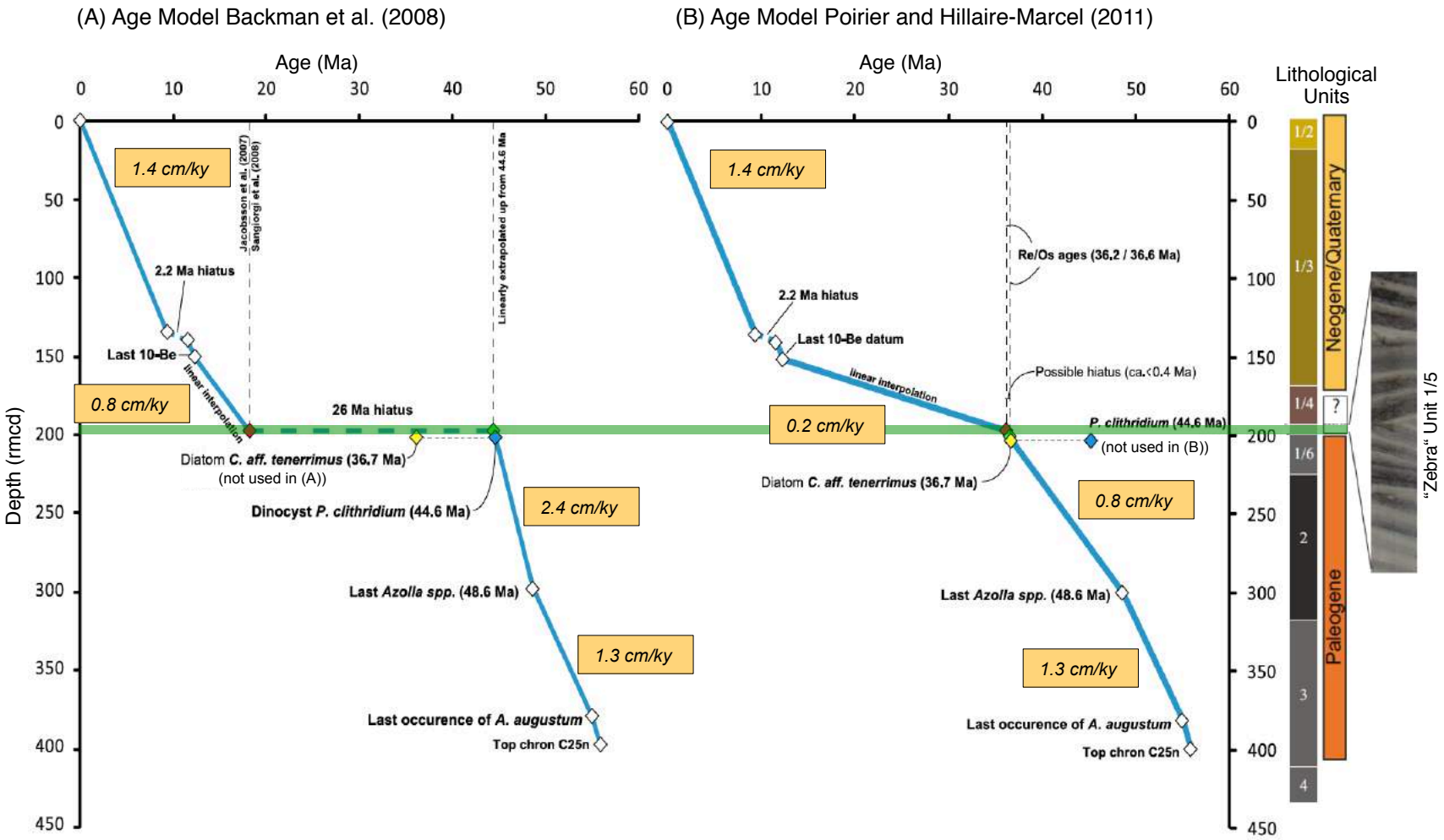
49 Ma: A fresh Arctic Ocean

Brinkhuis et al., *Nature* 2006

47 Ma: Early Arctic Sea Ice

Moran et al., *Nature* 2006
St. Johns, *Paleoceanography* 2008
Stickley et al., *Nature* 2009

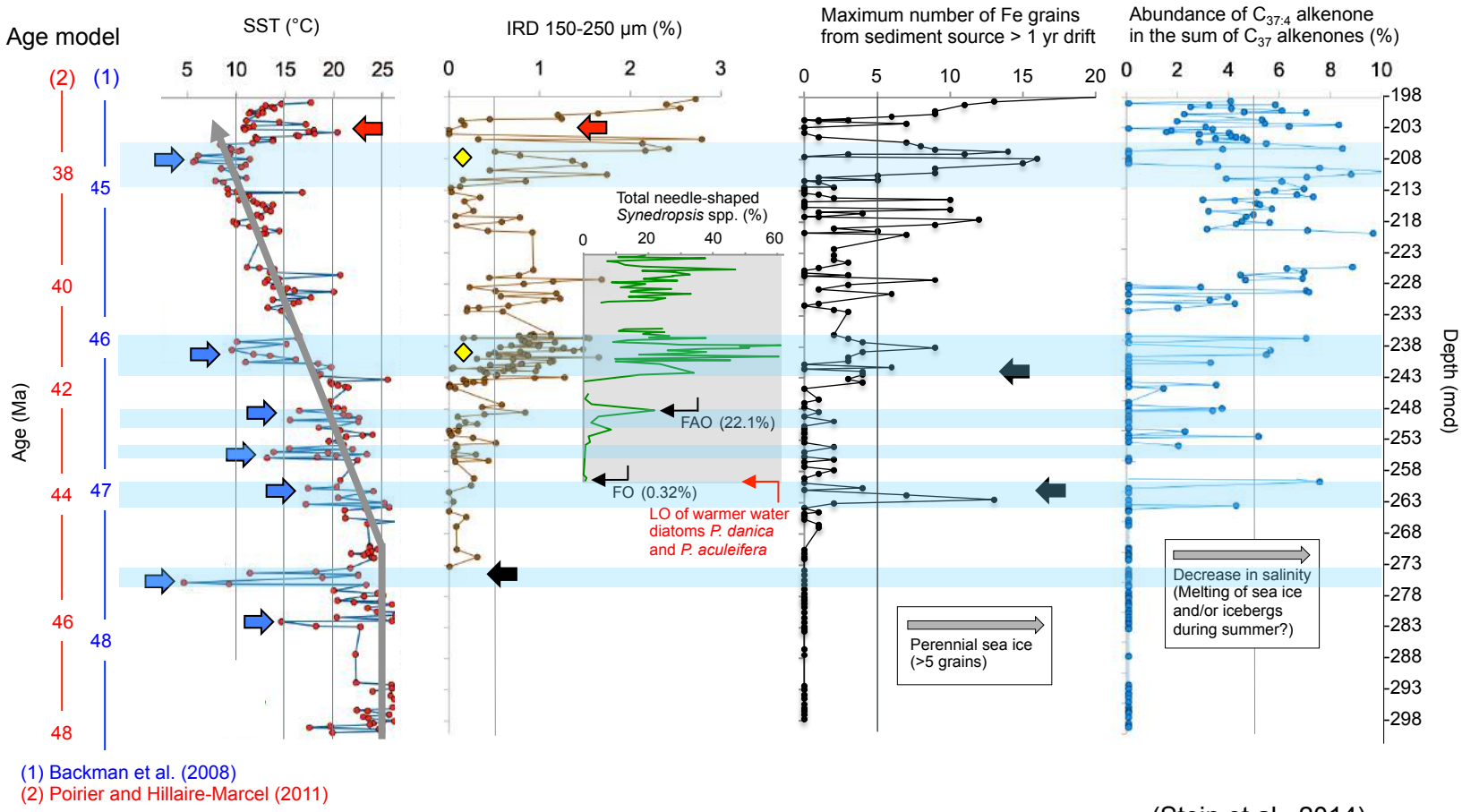
ACEX Chronology: Still under debate !!



(from Stein et al., 2014; based on Poirier and Hillaire-Marcel, 2011, supplemented)

ACEX Chronology: Still under debate !!

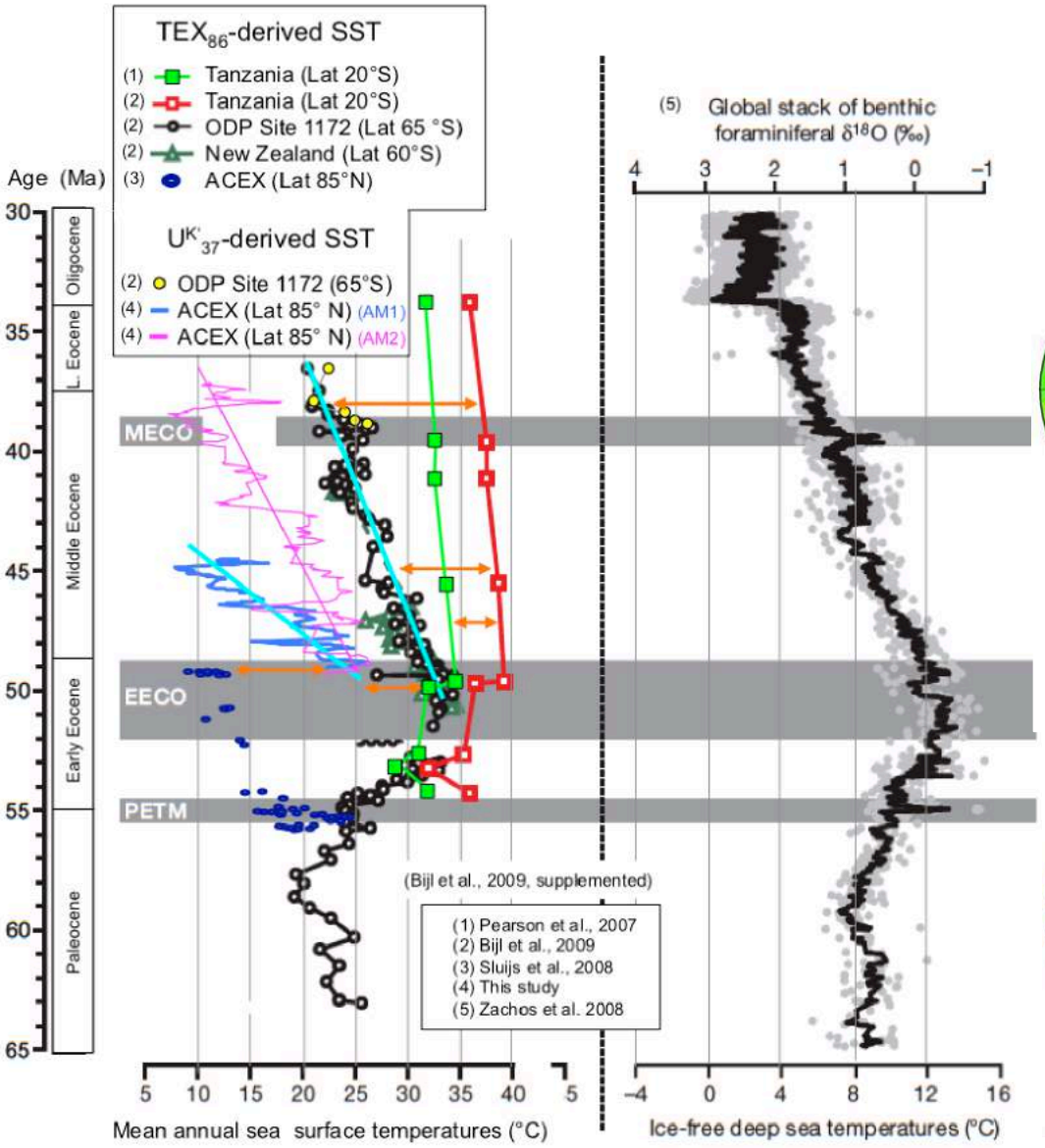
Onset of Arctic sea ice



(1) Backman et al. (2008)
(2) Poirier and Hillaire-Marcel (2011)

(Stein et al., 2014)

A



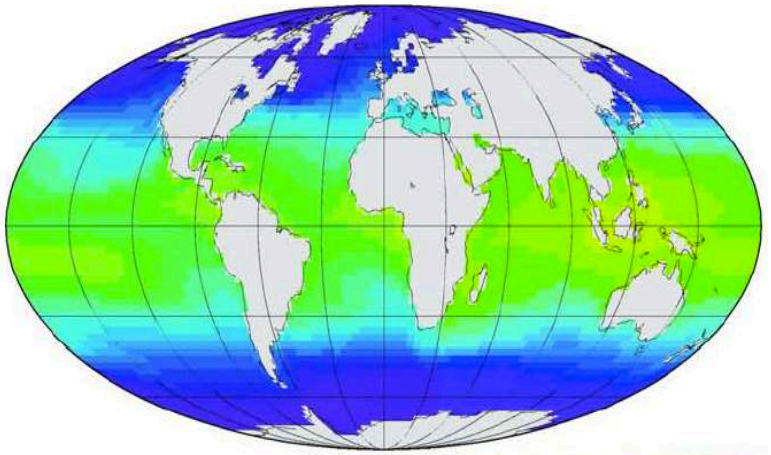
(Stein et al., 2014)

B

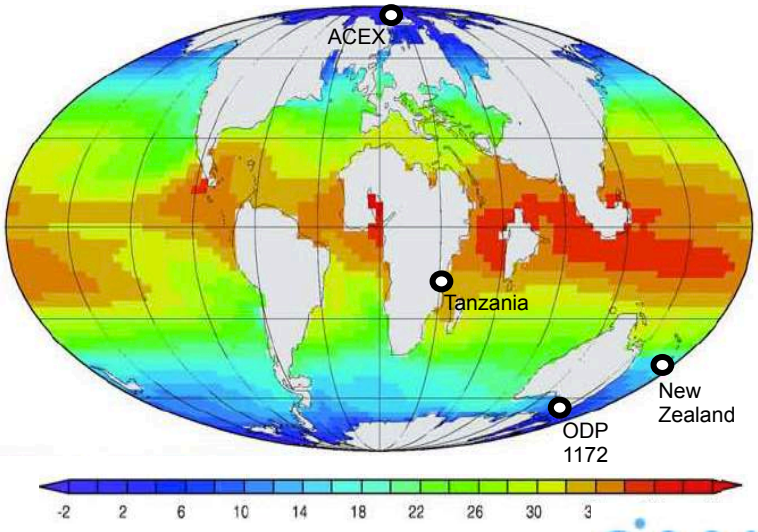
Global distribution of temperature in surface waters derived from isotope-enabled HadCM3 model simulations

(Tindall et al., 2010)

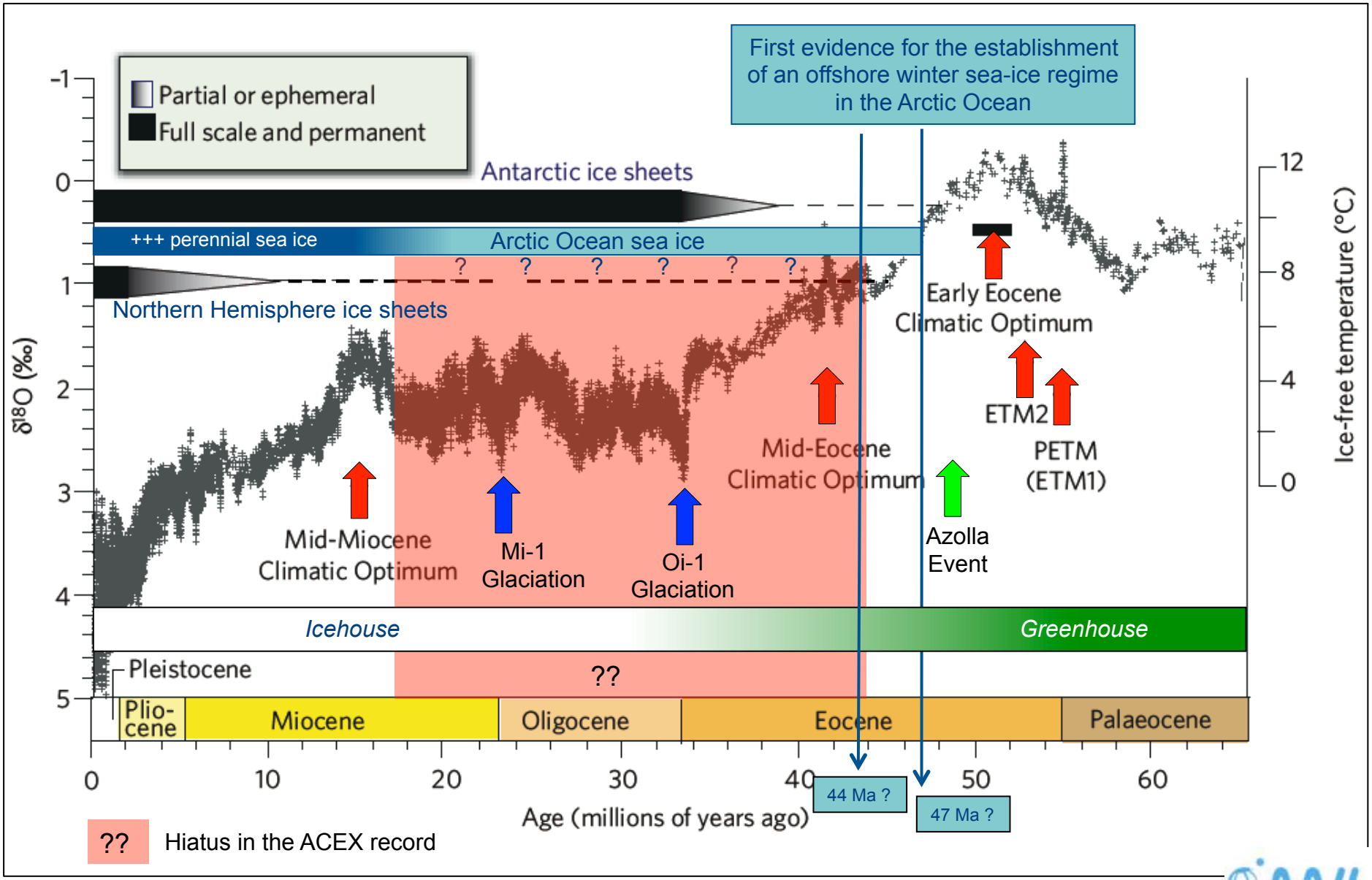
Modern Sea Surface Temperature



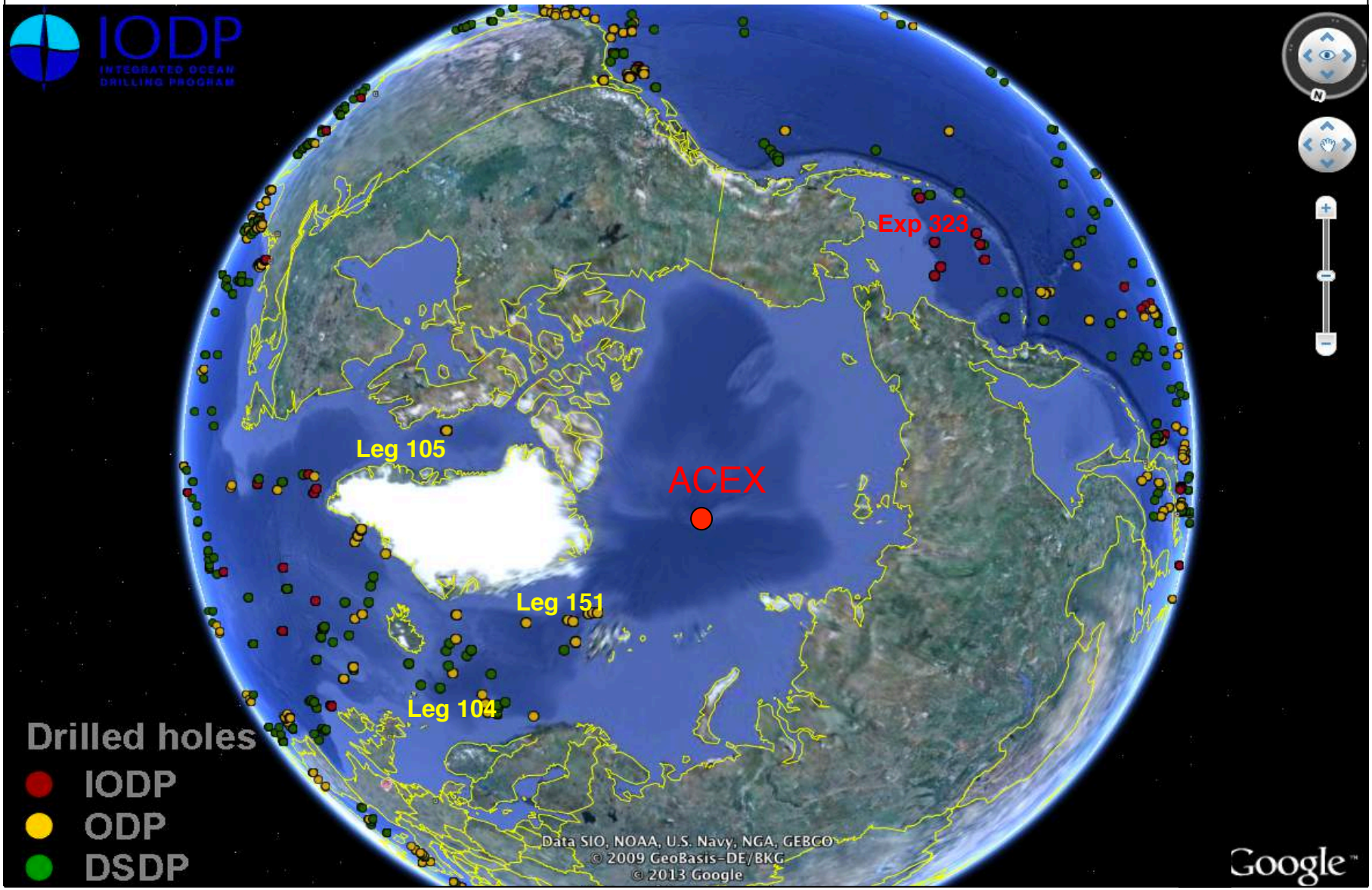
Eocene (55-50 Ma) Sea Surface Temperature



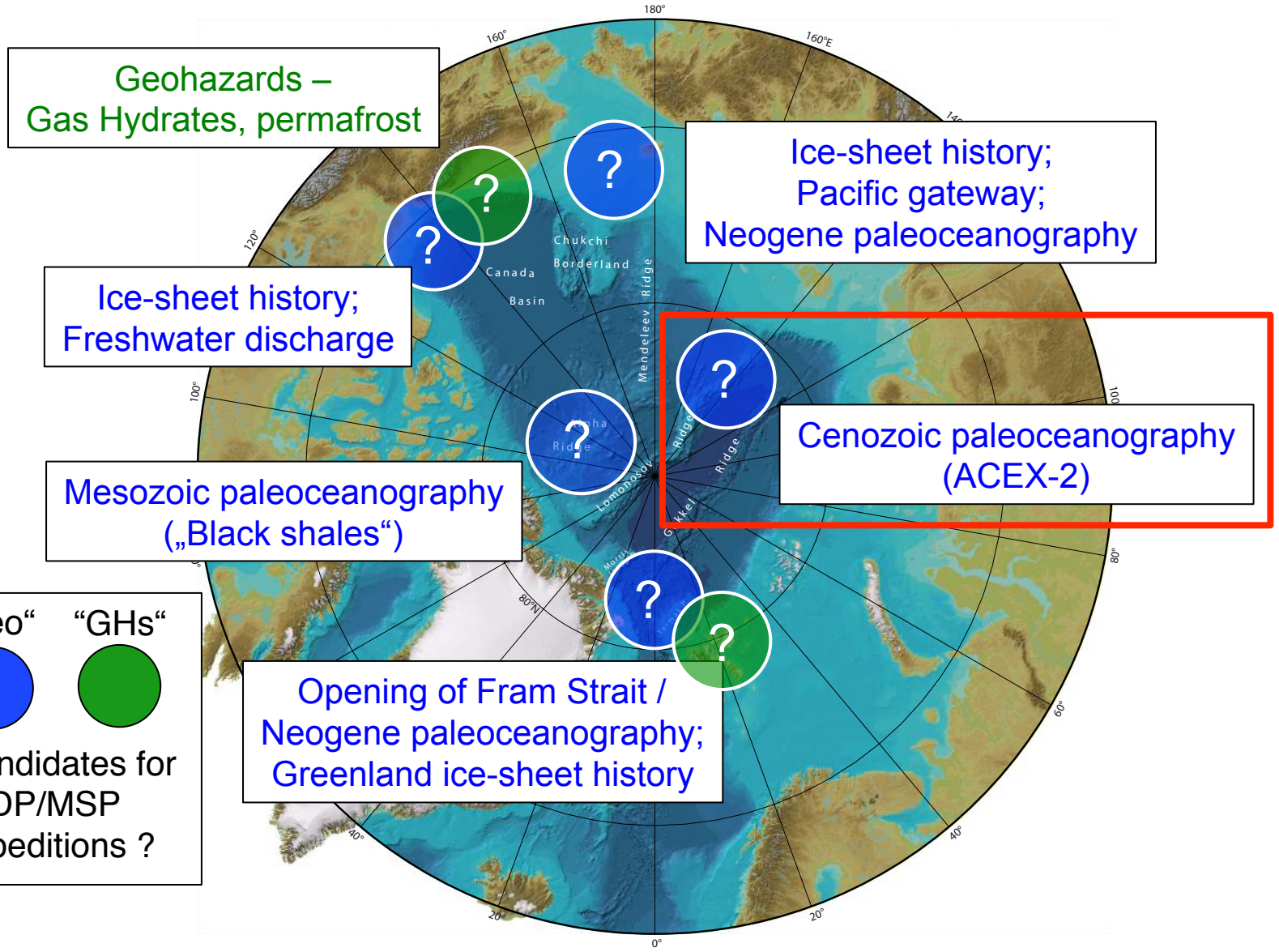
Cenozoic Arctic paleoceanography and glaciation history: From Greenhouse to Icehouse



Arctic Ocean drilling: Emerging fields / new topics / unknown areas



IODP Arctic Ocean: Ideas and Proposals

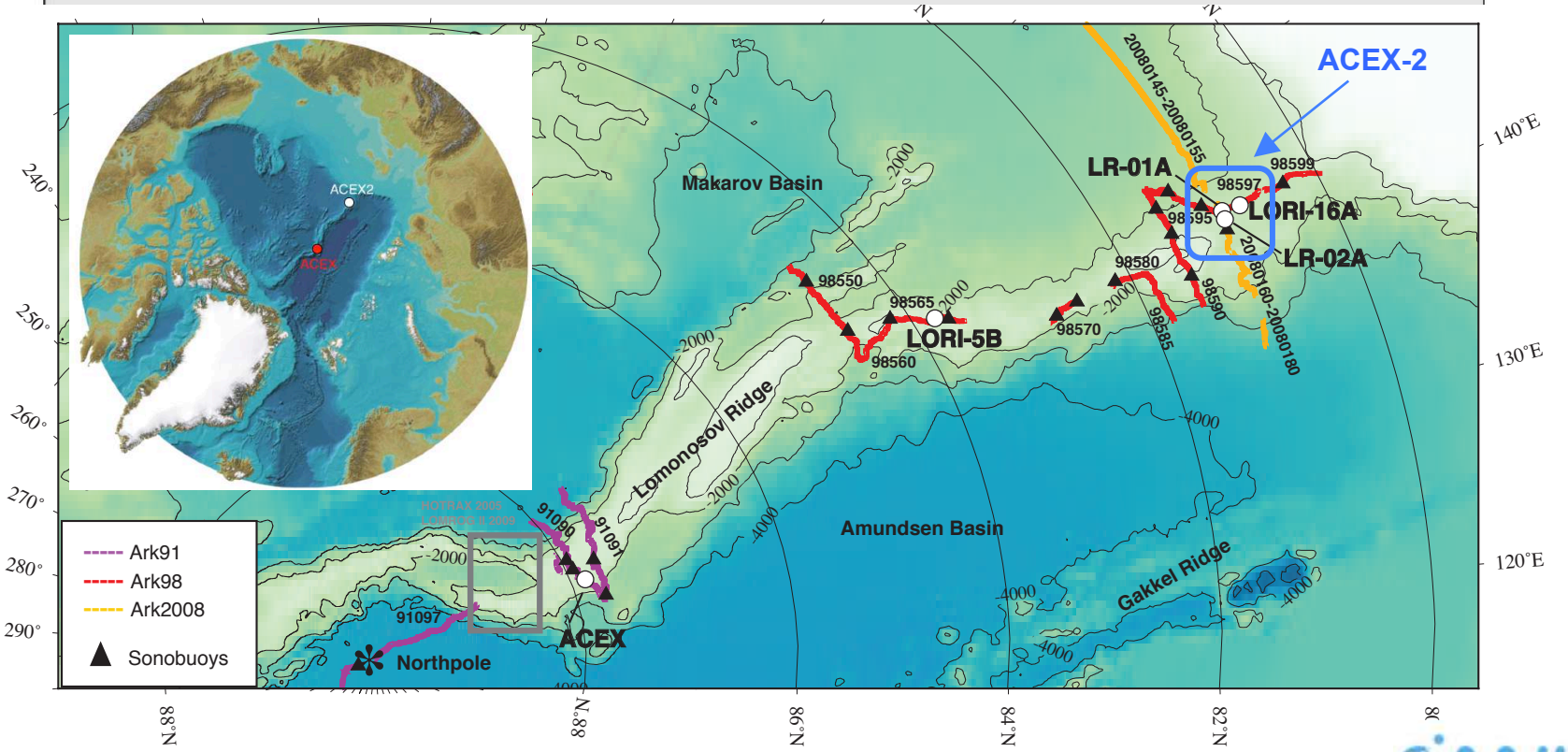


IODP Proposal Cover Sheet

ACEX2

708 - Full

Title	Arctic Ocean Paleoceanography: Towards a Continuous Cenozoic Record from a Greenhouse to an Icehouse World (ACEX2)
Proponents	R. Stein, W. Jokat, H. Brinkhuis, L. Clarke, B. Coakley, M. Jakobsson, J. Matthiessen, M. O'Regan, C. Stickley, K. St. John, E. Weigelt,



IODP Proposal Cover Sheet

ACEX2

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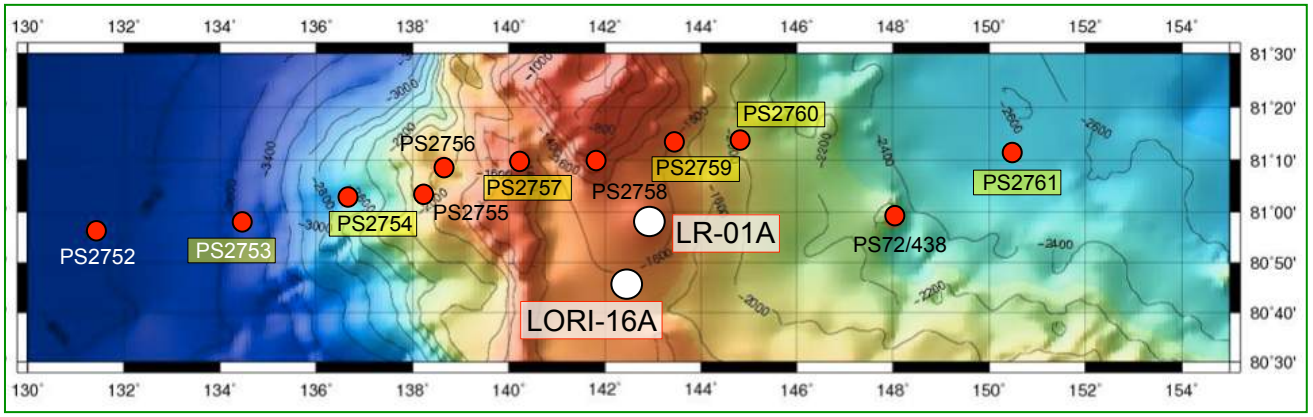
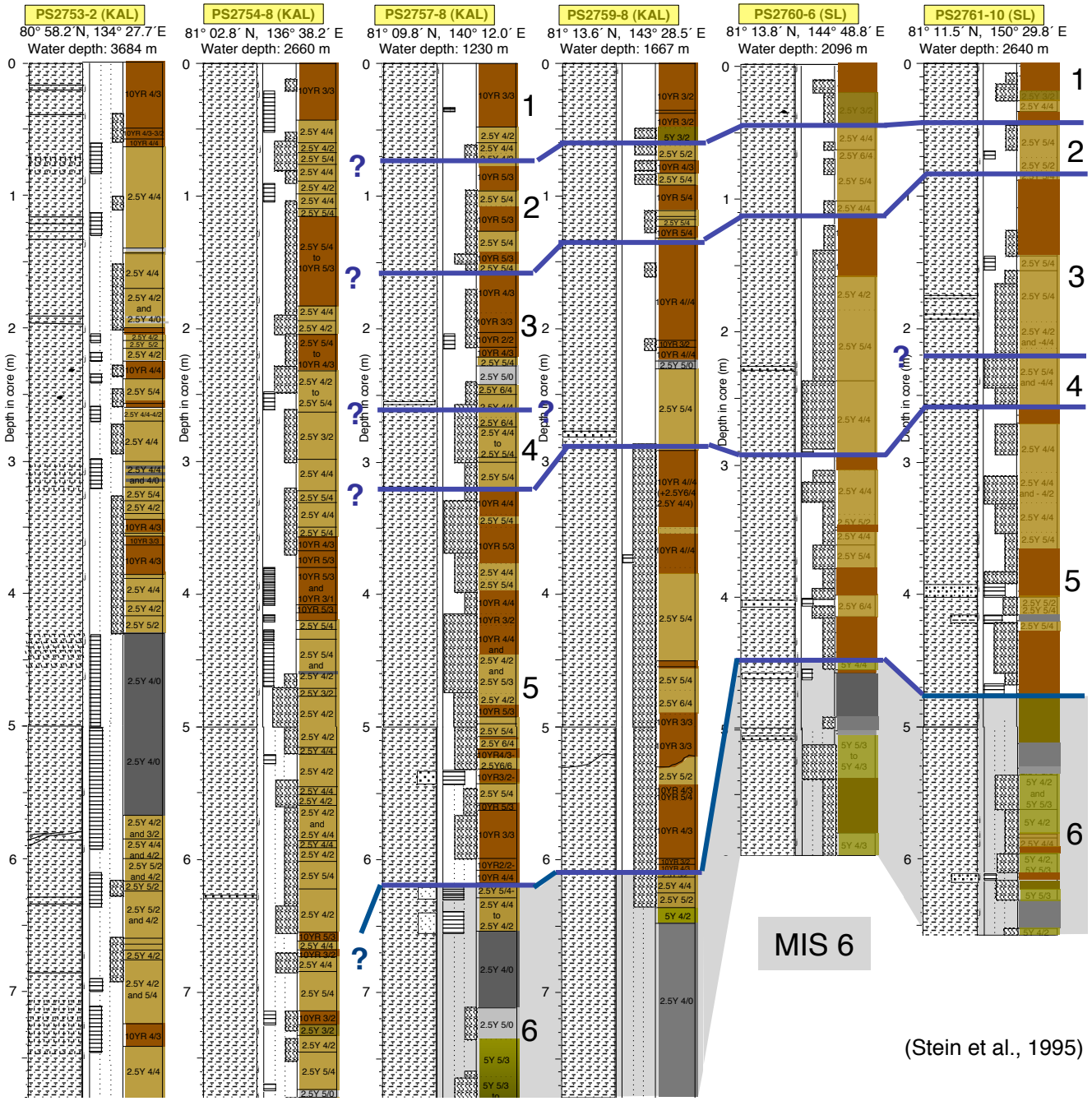
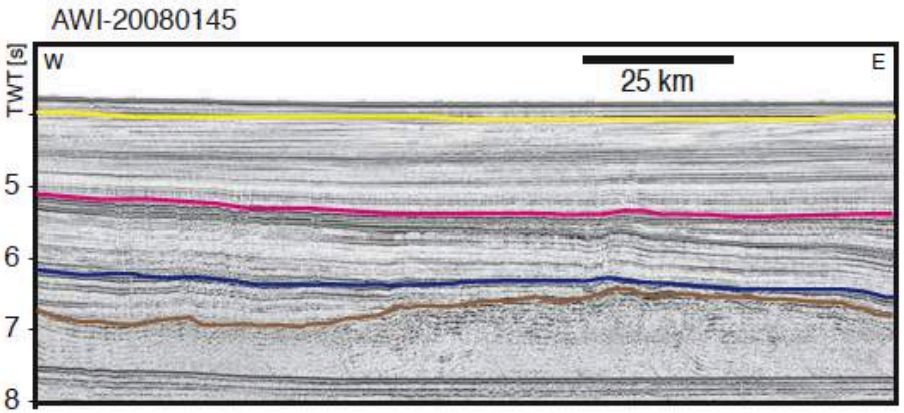


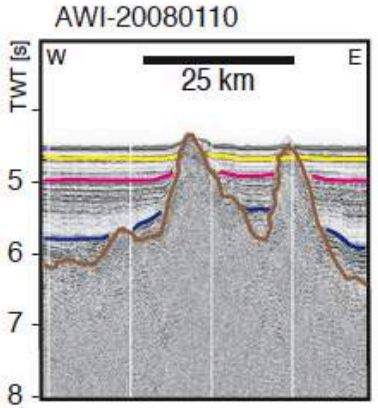


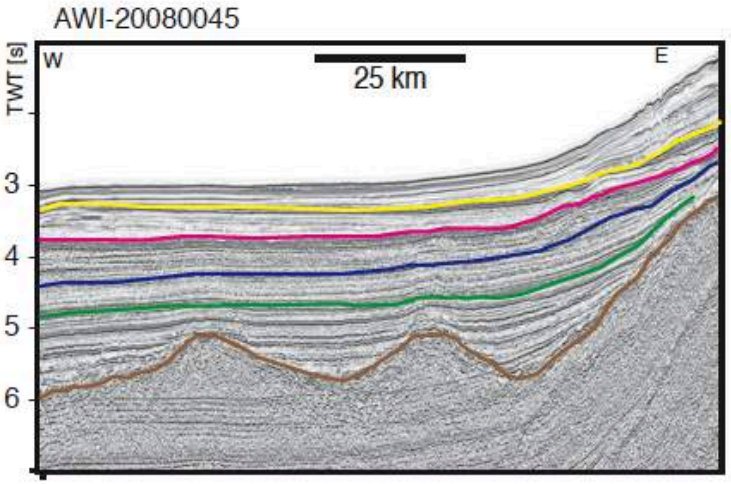
(Stein et al., 1995)

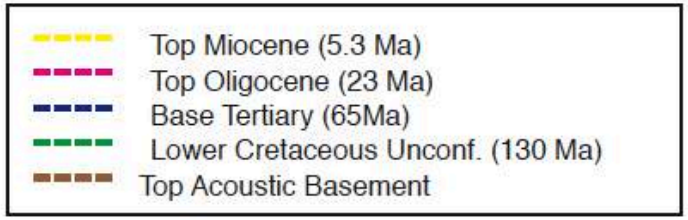
ACEX2 - 708-Full (Stein et al., 2014)

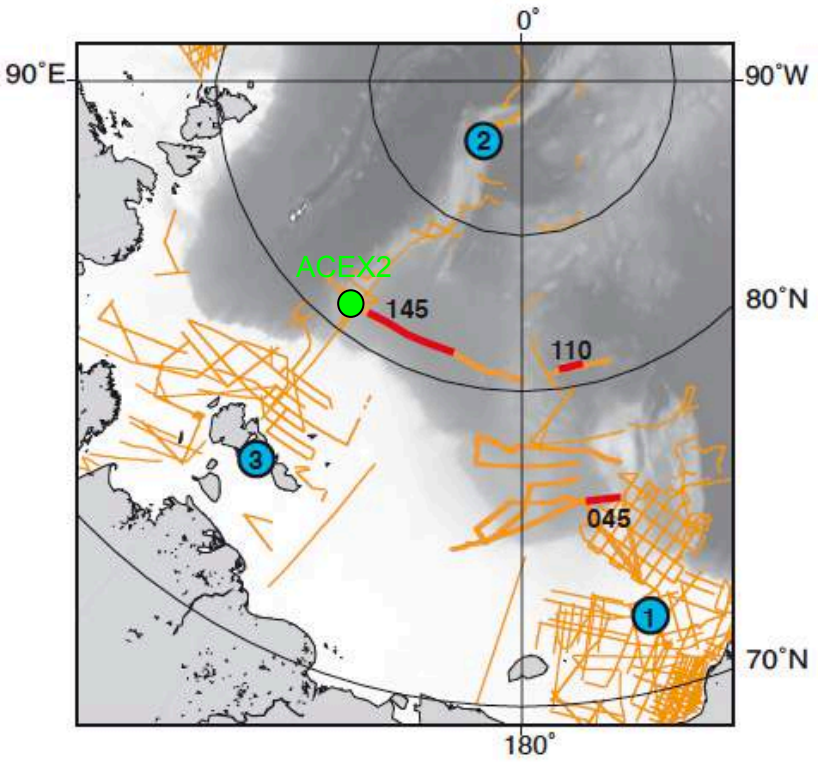
(Hegewald and Jokat, 2013)



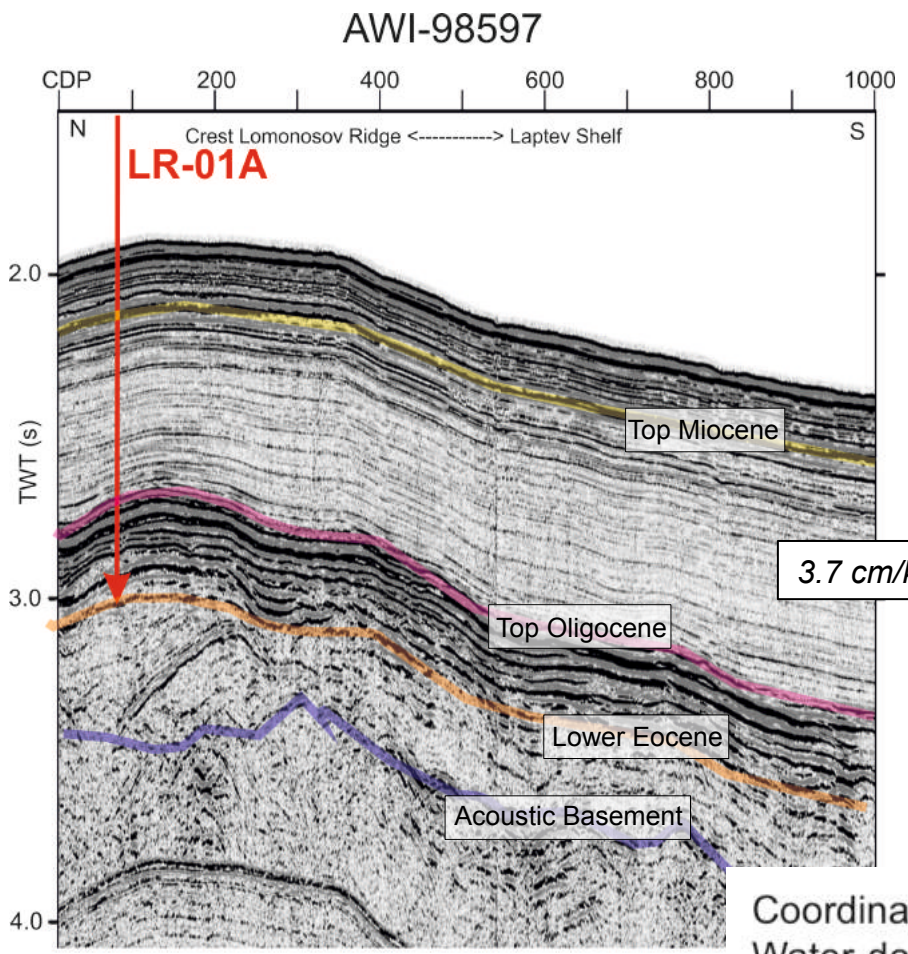


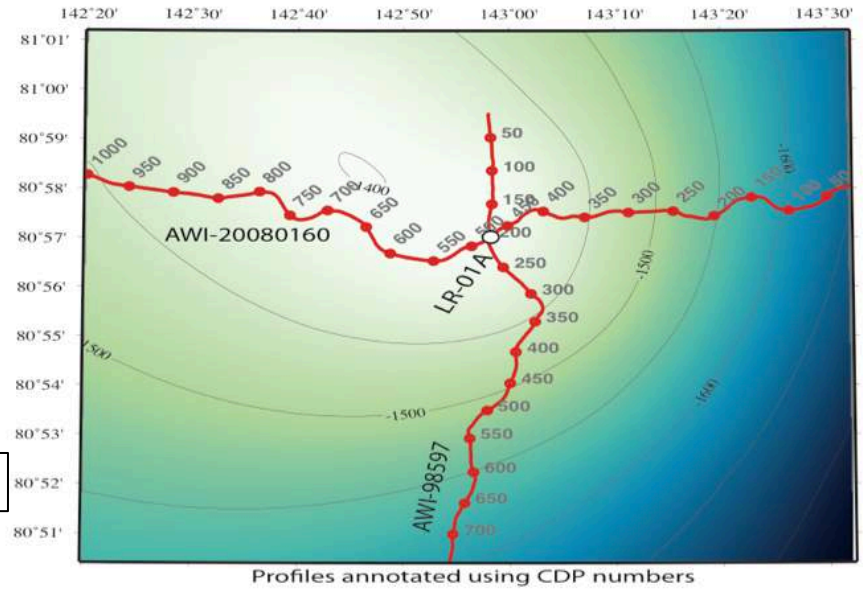






ACEX2 - 708-Full (Stein et al., 2014)





Coordinates:	80° 57.01'N, 142° 58.3'E
Water-depth:	1405 m
Top Miocene (yellow):	175 mbsf
Top Oligocene (pink):	835 mbsf
Lower Eocene (orange):	1141 mbsf
Basement (purple):	1225 mbsf
Penetration total:	1225 m

ACEX2 - 708-Full (Stein et al., 2014)

Scientific Objectives

A complete Cenozoic sedimentary sequence from the central Arctic Ocean will be studied to answer the following key questions:

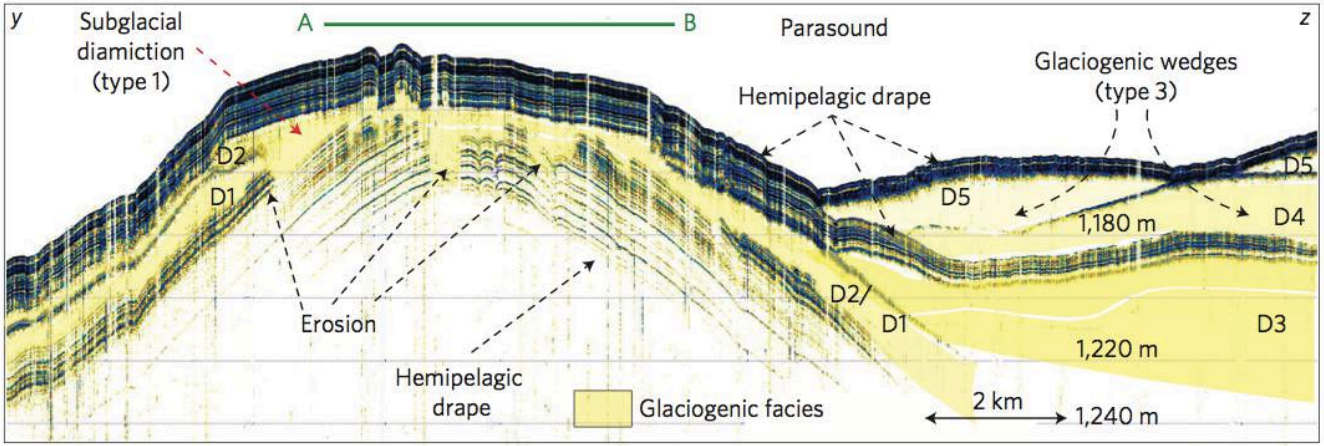
- Did the Arctic Ocean climate follow the global climate evolution during its course from early Cenozoic Greenhouse to late Cenozoic Icehouse conditions?
- Are the Early Eocene Climate Optimum (poor recovery in the ACEX record) and the Oligocene and Mid-Miocene warmings also reflected in Arctic Ocean records?
- Did extensive glaciations (e.g., the OI-1 and Mi-1 glaciations) develop synchronously in both the Northern and Southern Hemispheres?
- What is the timing of repeated major (Plio-)Pleistocene Arctic glaciations as postulated from sediment echosounding and multi-channel seimic reflection profiling?
- What was the variability of sea-ice in terms of frequency, extent and magnitude?
- When and how did the change from a warm, fresh-water-influenced, biosilica-rich and poorly ventilated Eocene ocean to a cold, fossil-poor, and oxygenated Neogene ocean occur?
- How critical is the exchange of water masses between the Arctic Ocean and the Atlantic and Pacific for the long-term climate evolution as well as rapid climate change?
- What is the history of Siberian river discharge and how critical is it for sea-ice formation, water mass circulation and climate change?
- How did the Arctic Ocean evolve during the Pliocene warm period and succeeding cooling? How do the ACEX2 record correlate with the terrestrial record from the Siberian Lake Elgygytgyn?
- What is the cause of the major hiatus recovered in the ACEX record? Does this hiatus in fact exist?

ACEX2 - 708-Full (Stein et al., 2014)

nature geoscience (2013) LETTERS
PUBLISHED ONLINE: 11 AUGUST 2013 | DOI: 10.1038/NGEO1904

Repeated Pleistocene glaciation of the East Siberian continental margin

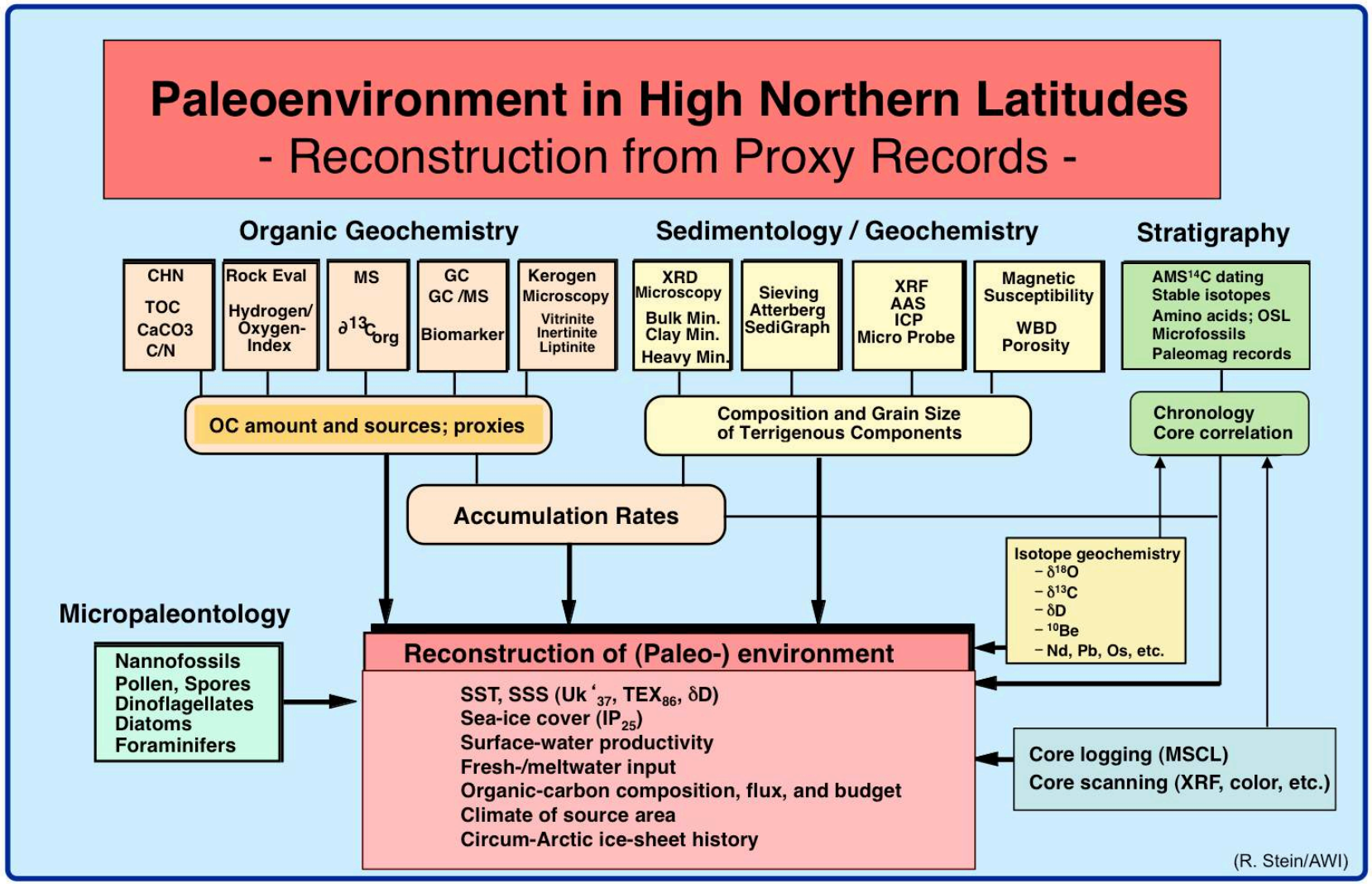
Frank Niessen[1]*, Jong Kuk Hong[2]*, Anne Hegewald[1], Jens Matthiessen[1], Rüdiger Stein[1], Hyoungjun Kim[2], Sookwan Kim[2,3], Laura Jensen[1], Wilfried Jokat[1], Seung-Il Nam[2] and Sung-Ho Kang[2]



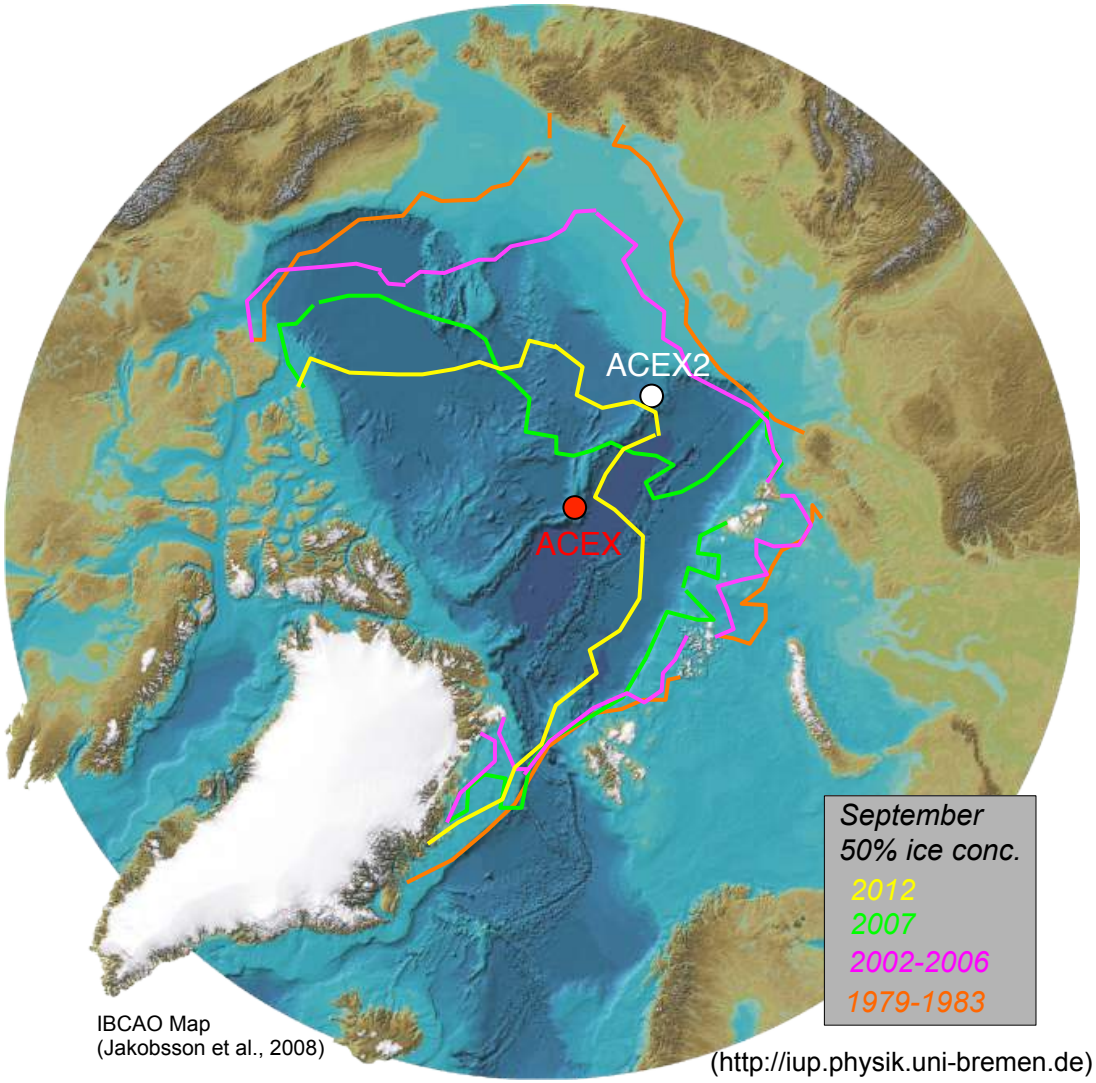
ACEX2 - 708-Full (Stein et al., 2014)

We propose one primary drill site on southern Lomonosov Ridge, Site LR-01A, located on crossing point of line AWI-98597 and line AWI-20080160 (Fig. 9a). At this site, we propose drilling three APC/XCB/RCB holes down to basement (the "purple" reflector in ~1225 mbsf; Fig. 9b). This is required to ensure recovery of a complete composite stratigraphic sediment record and to meet our highest priority paleoceanographic objective, the **continuous long-term Cenozoic climate history of the central Arctic Ocean**. Based on its protected location and the existing seismic profiles, a continuous record without a major hiatus is very probable. Logging should be carried out at one of the holes. For the entire drilling, coring, and logging activities, a total 29 days is estimated. As alternate drilling locations Site LR-02A, LORI-16A and LORI-05B (located on line AWI-20080160, AWI-98597 and AWI-98565, respectively; Fig. 9a) are proposed.

ACEX2 - 708-Full (Stein et al., 2014)



ACEX2 - 708-Full (Stein et al., 2014)



ACEX2 - 708-Full (Stein et al., 2014)

SEP Review (February 28, 2014)

Proposal number	708-Full
Proposal title	Arctic Ocean Paleoceanography: Towards a Continuous Cenozoic Record from a Greenhouse to an Icehouse World (ACEX2)
Contact proponent	R. Stein
SEP science watchdogs	Webster, Romans
SEP site survey data watchdogs	Kim, Flood
Date of E-review	February 28, 2014
Overall rating (science + data)	Excellent
Recommendation	Forward to E-FB
Suggested drilling platforms	MSP
Links to IODP Science Plan	Challenges 1 and 2
Links to other global research programs	ICDP

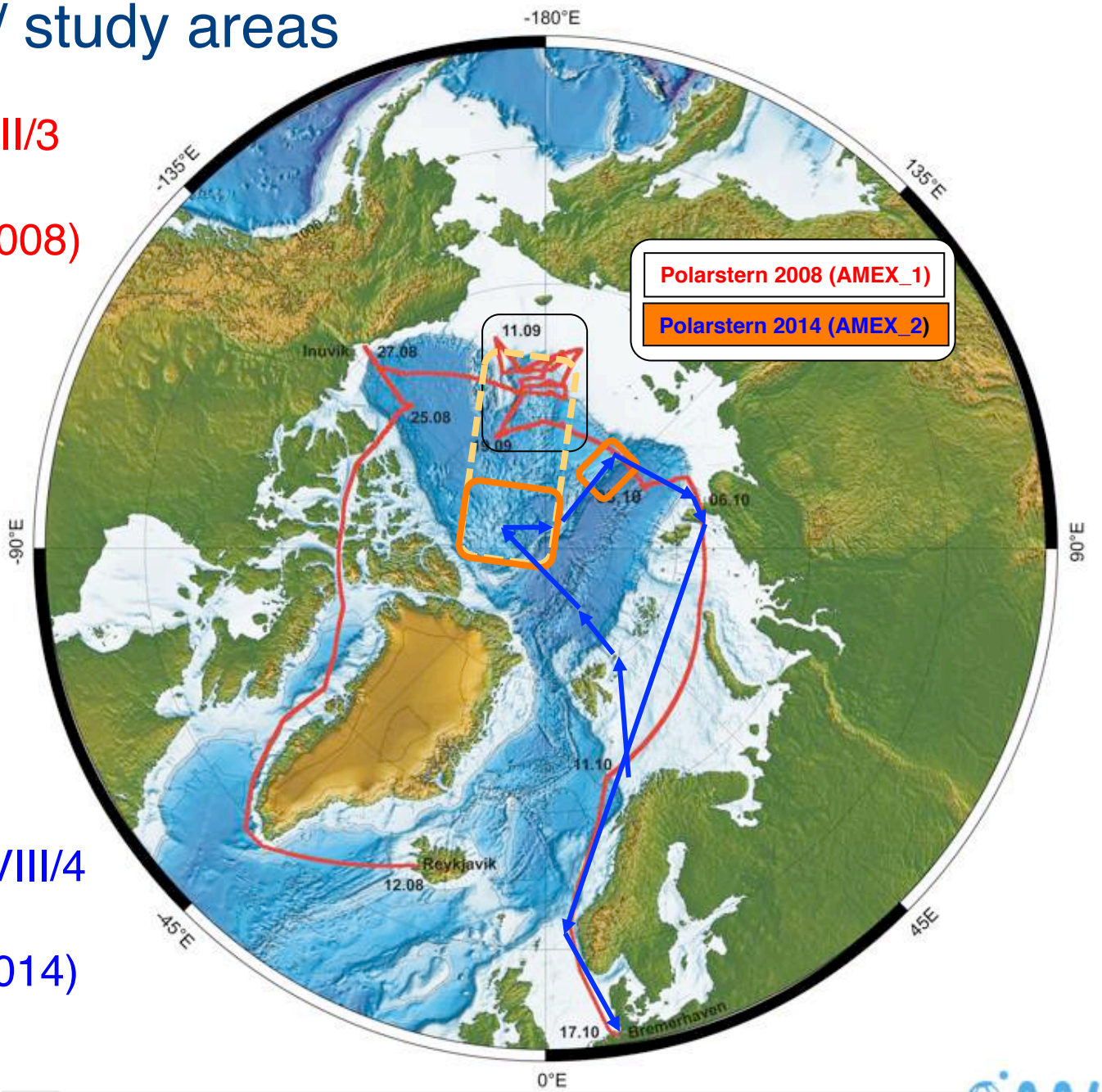
ACEX2 - 708-Full (Stein et al., 2014)

ECORD Facility Board Meeting (Bremen, March 05-06, 2014)

The EFB is of the opinion that it is desirable to consider multiple Arctic proposals within the system to ensure that the best science objectives can be addressed with the best placed and designed expedition. Although your proposal is the first and highly ranked Arctic proposal to reach the EFB, there are concerns regarding site survey data and the location of drill sites. We appreciate that the issue of site survey data will be addressed during an upcoming expedition this summer. Other concerns include the length of drill pipe required, the interpretation of the seismic lines, and possible diagenesis. More specifically, the *Vidar Viking* or similar size vessel cannot hold sufficient pipe for proposed drilling targets; it is not obvious that the "hiatus" is missing from indicated seismic lines; primary biogenic carbonate and silica do not exist at depth in the ACEX cores because of alteration; the fidelity of organic proxies at great depth is uncertain. We assume that SEP will discuss these issues further in several months and send additional commentary. In summary, the EFB decided not to schedule your proposal at this stage, but seriously consider it and other Arctic proposals at next year's EFB meeting.

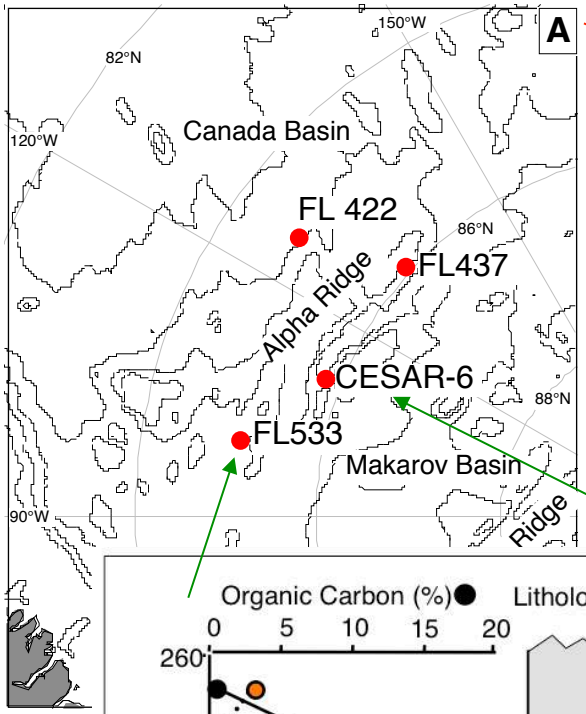
Cruise tracks / study areas

Polarstern ARK-XXIII/3
AMEX1
(Aug 12 – Oct 19, 2008)
Chief scientist: W. Jokat

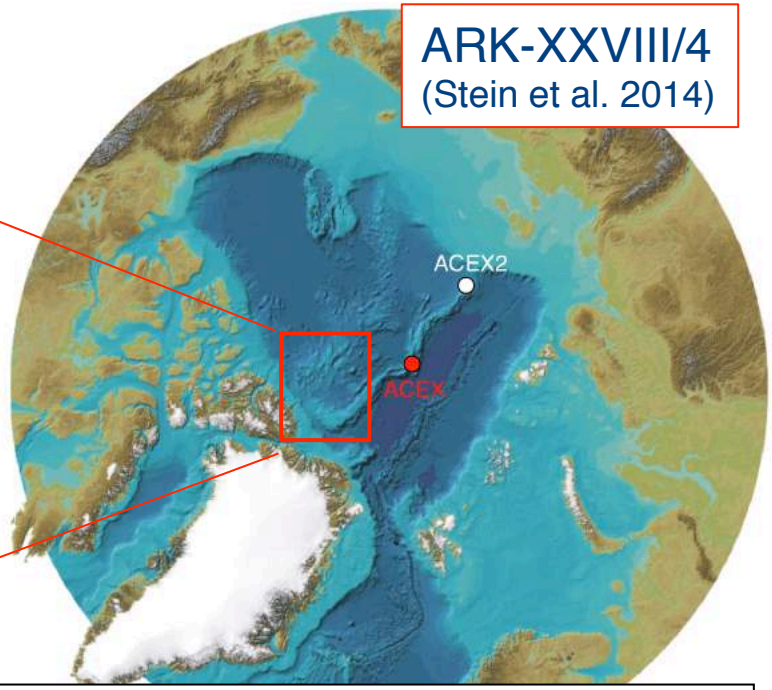


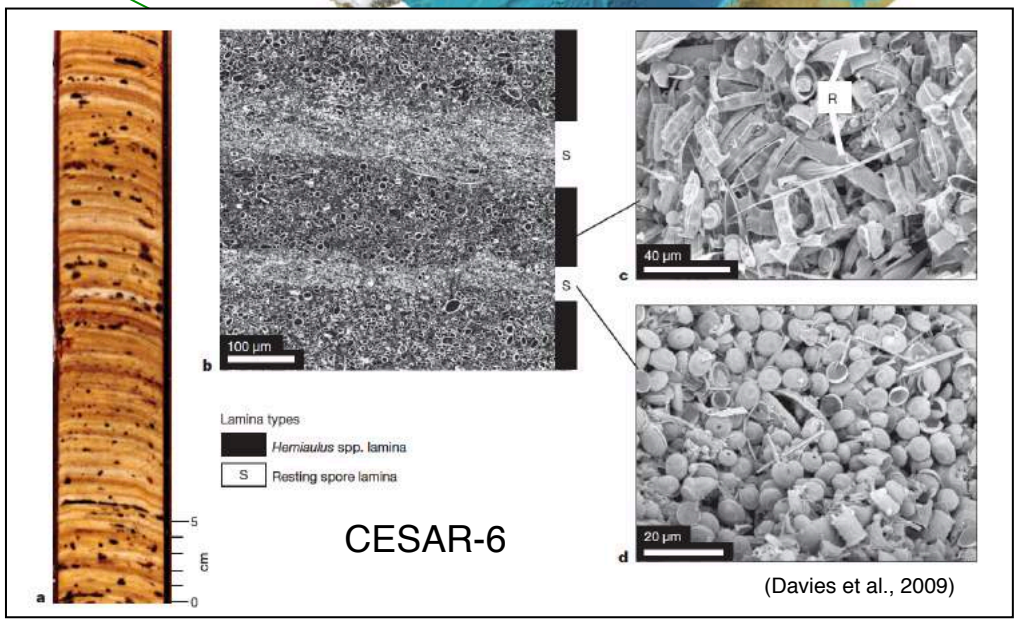
Polarstern ARK-XXVIII/4
AMEX2 (scheduled)
(Aug 05 – Oct 09, 2014)
Chief scientist: R. Stein

ARK-XXVIII/4
(Stein et al. 2014)

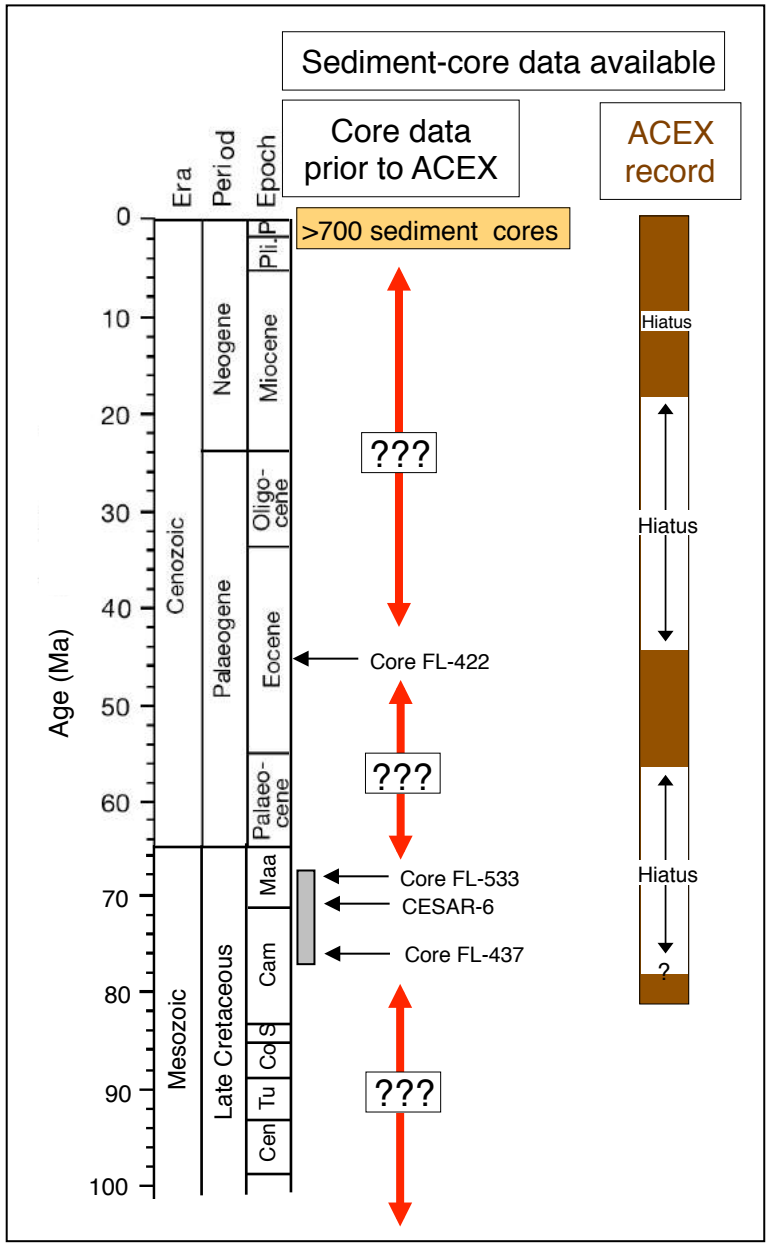


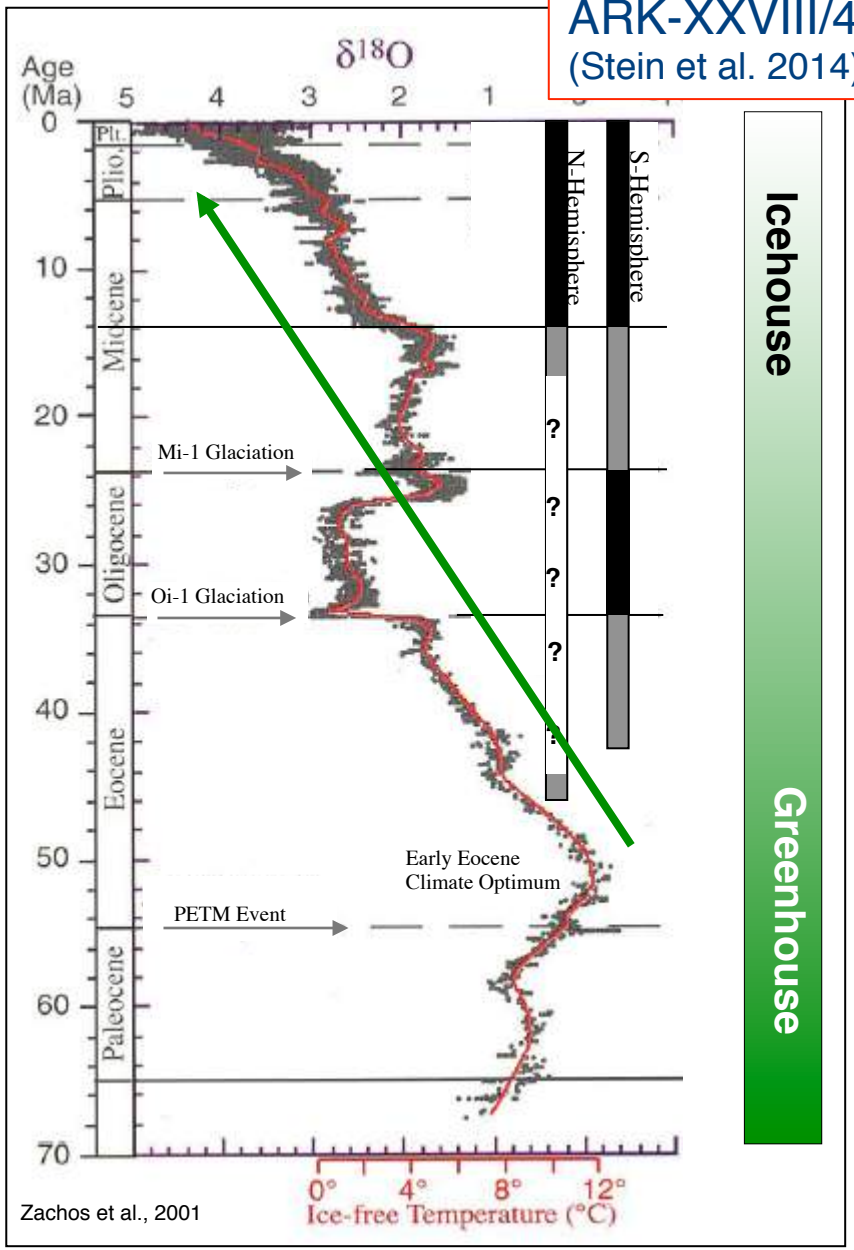
Stein, 2008; data from Clark et al., 1986, Firth and Clark, 1998)





(Davies et al., 2009)





(Stein, 2008; based on Miller et al., 1987, 1991; Thiede et al., 1990; Lear et al., 2000; Zachos et al., 2001; Backman, et al., 2006; Backman et al., 2008).

Geosciences – Overall goals

ARK-XXVIII/4
(Stein et al. 2014)

Marine Geology

(1) High-resolution reconstruction of changes in paleoclimate, paleoceanic circulation, paleoproductivity, and sea-ice distribution during Late Quaternary

(2) Reconstruction of long-term history of the Mesozoic and Cenozoic Arctic Ocean and its environmental evolution from a warm (Greenhouse) to an ice-covered polar (Icehouse) ocean

Marine Geophysics

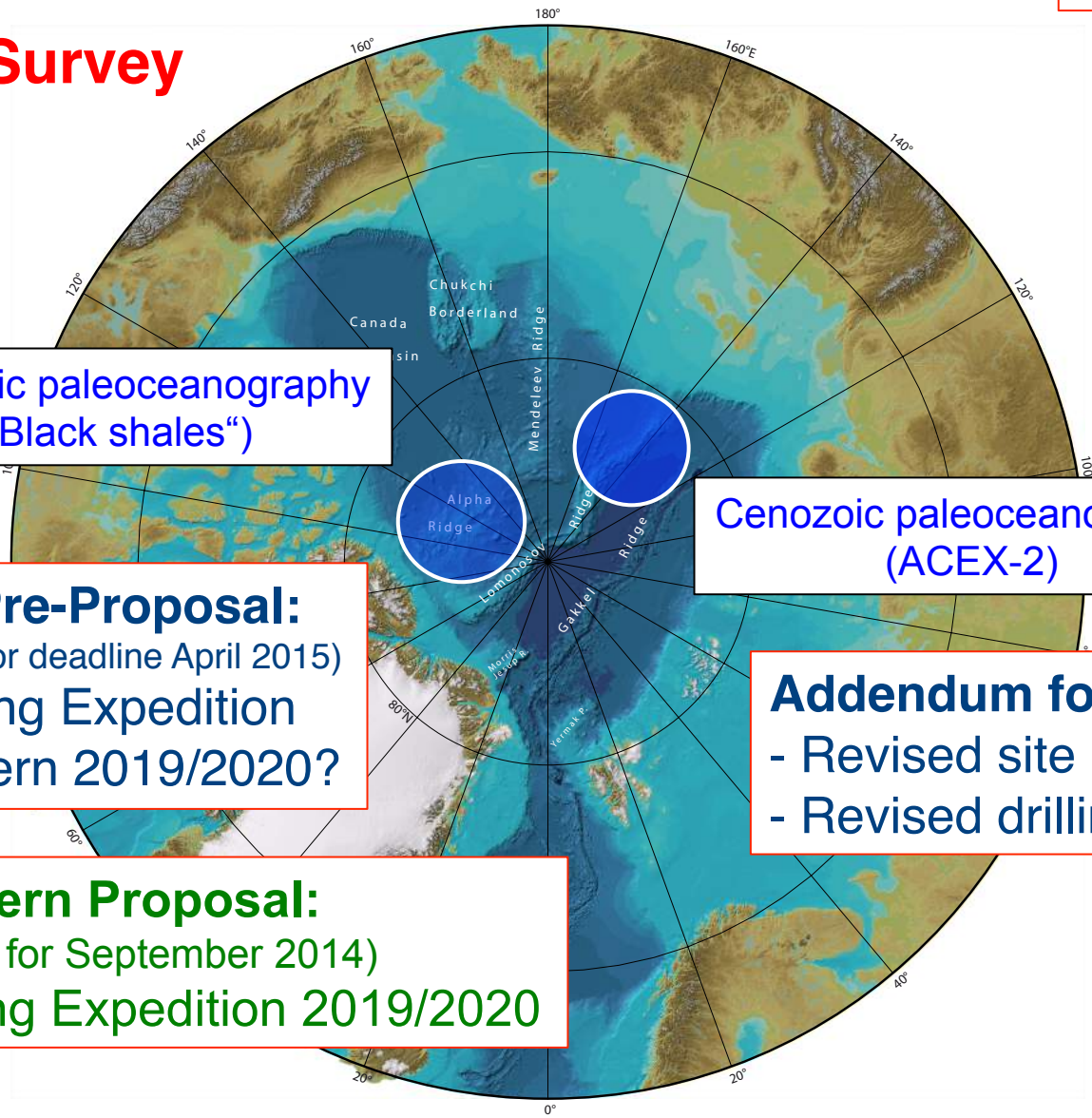
(1) Reconstruction of the tectonic and sedimentary evolution of the Arctic Ocean and the adjacent continental shelves

(2) Gathering tie lines to existing profiles for correlating their age model into the new lines

Geosciences – Overall goals

ARK-XXVIII/4
(Stein et al. 2014)

IODP Site Survey



Mesozoic paleoceanography
(„Black shales“)

Cenozoic paleoceanography
(ACEX-2)

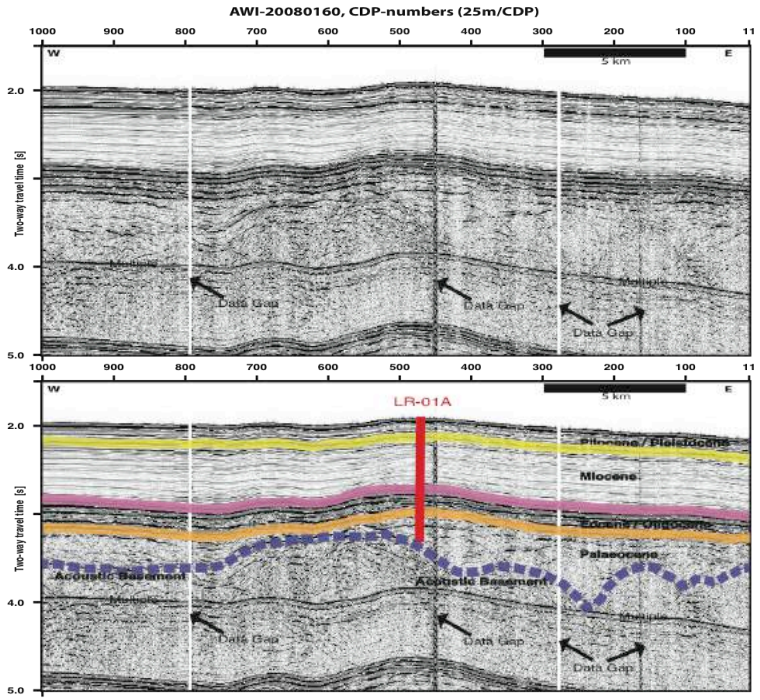
New IODP Pre-Proposal:
(to be submitted for deadline April 2015)
- MeBo Drilling Expedition
- RV Polarstern 2019/2020?

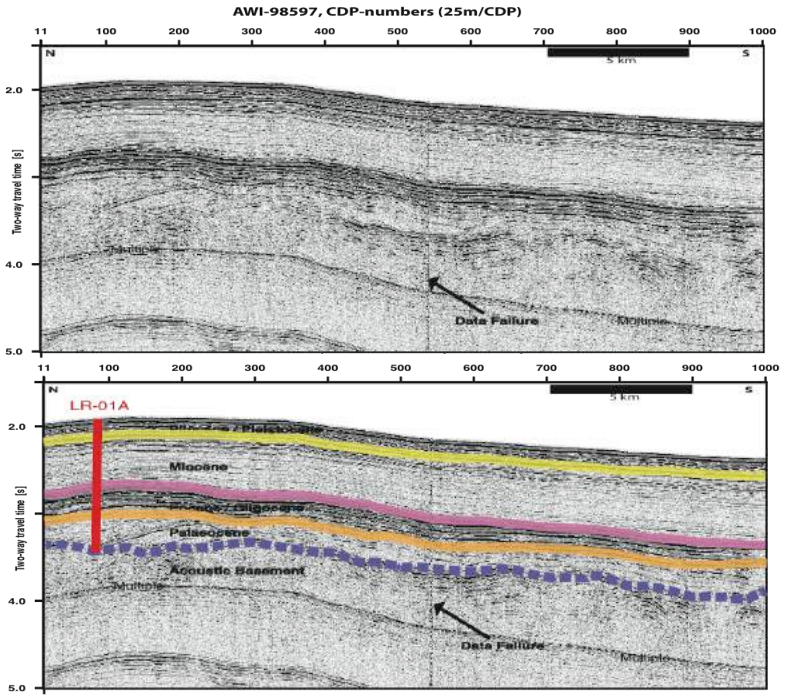
Addendum for 708-Full
- Revised site location
- Revised drilling depth

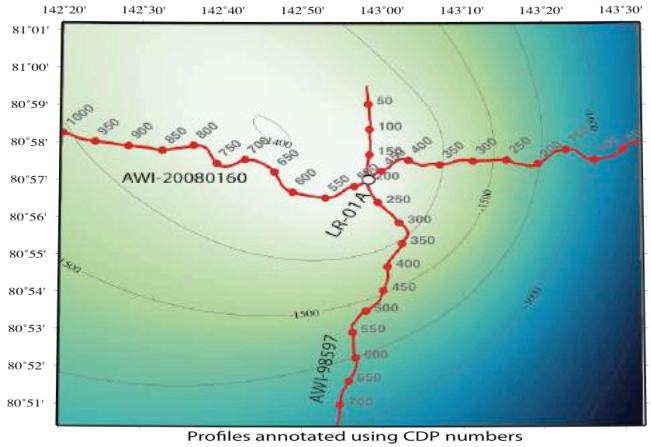
New Polarstern Proposal:
(to be submitted for September 2014)
- MeBo Drilling Expedition 2019/2020


Thank you very much.
Questions ????

Site Summary Form 6 IODP Proposal 708 Site LR-01A







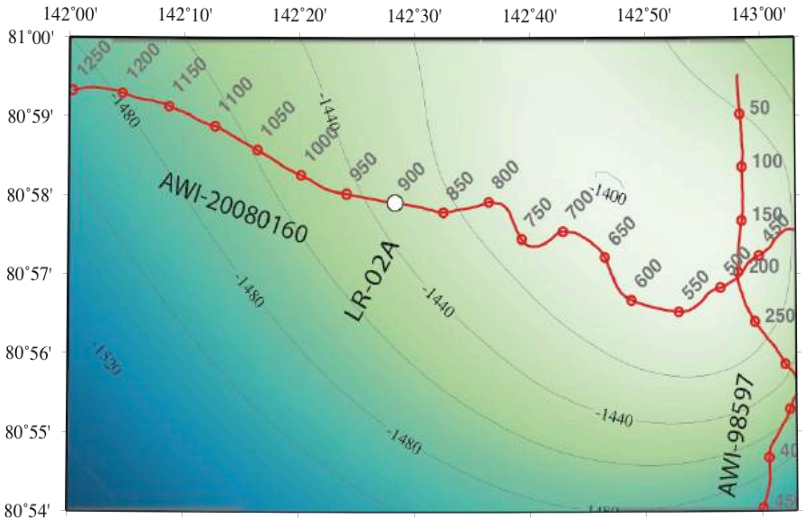
Profiles annotated using CDP numbers

Coordinates:	80° 57.01'N, 142° 58.3'E
Water-depth:	1405 m
Top Miocene (yellow):	175 mbsf
Top Oligocene (pink):	835 mbsf
Lower Eocene (orange):	1141 mbsf
Basement (purple):	1225 mbsf
Penetration total:	1225 m

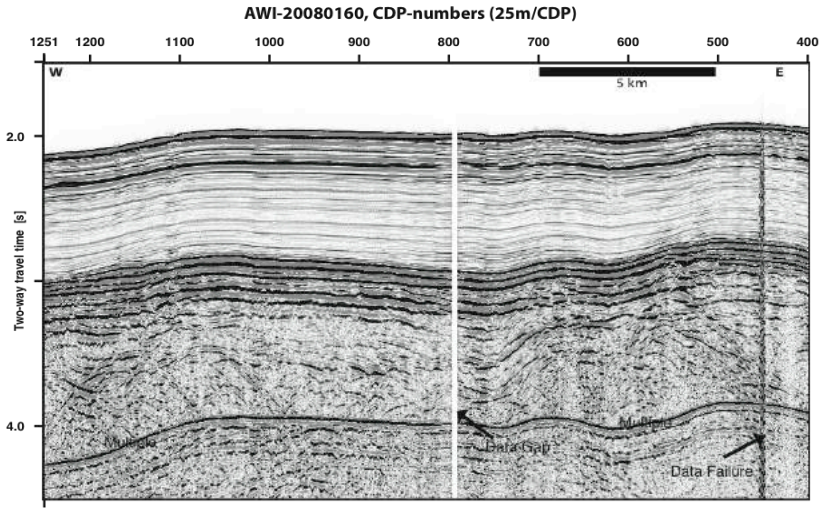
SSDB locations of these graphics and supporting data:

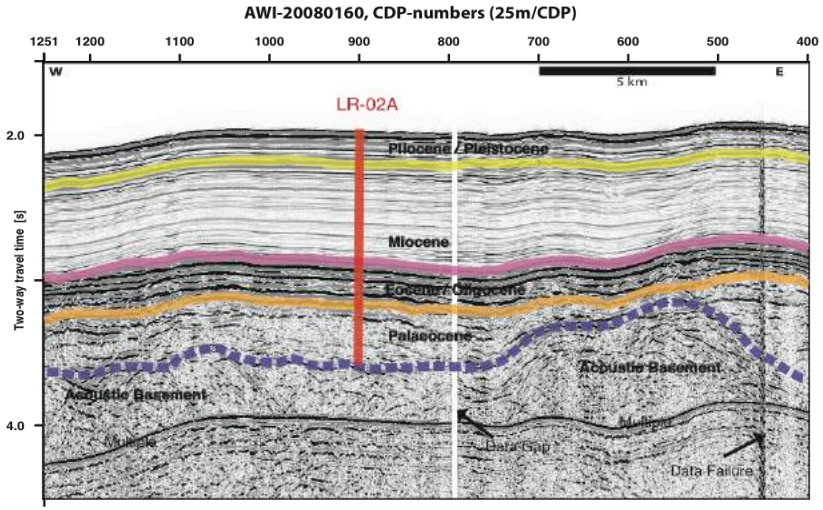
-Location map:	LR-01A_map.pdf
-Seismic figures:	LR-01A_AWI-20080160.pdf
	LR-01A_AWI-98597.pdf
-SEGY data:	AWI-20080160stack.sgy
	AWI-98597stack.sgy
-Navigation data:	20080160_cdplocs.asc
	98597_cdplocs.asc

Site Summary Form 6 IODP Proposal 708 Site LR-02A



Profiles annotated using CDP numbers



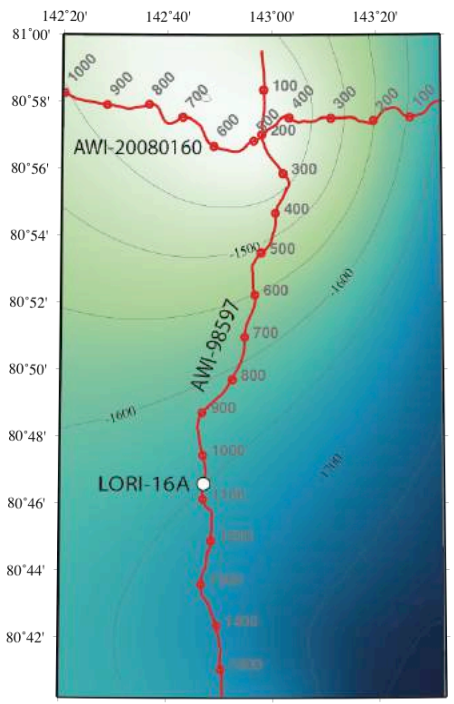


Coordinates:	80° 57.9'N, 142° 28.3'E
Water-depth:	1450 m
Top Miocene (yellow):	220 mbsf
Top Oligocene (pink):	965 mbsf
Lower Eocene (orange):	1270 mbsf
Basement (purple):	2150 mbsf
Penetration total:	2150 m

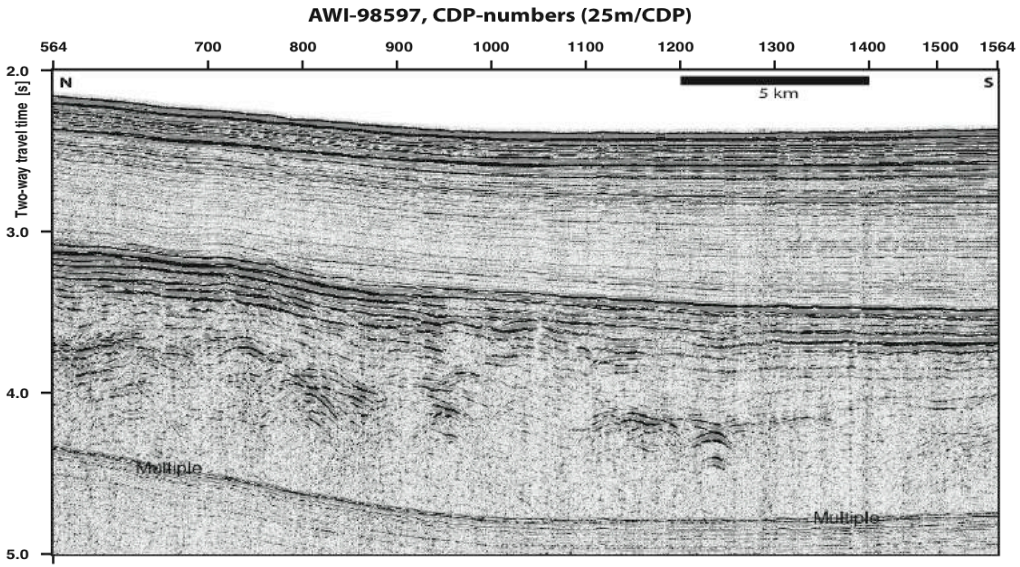
SSDB locations of these graphics and supporting data:

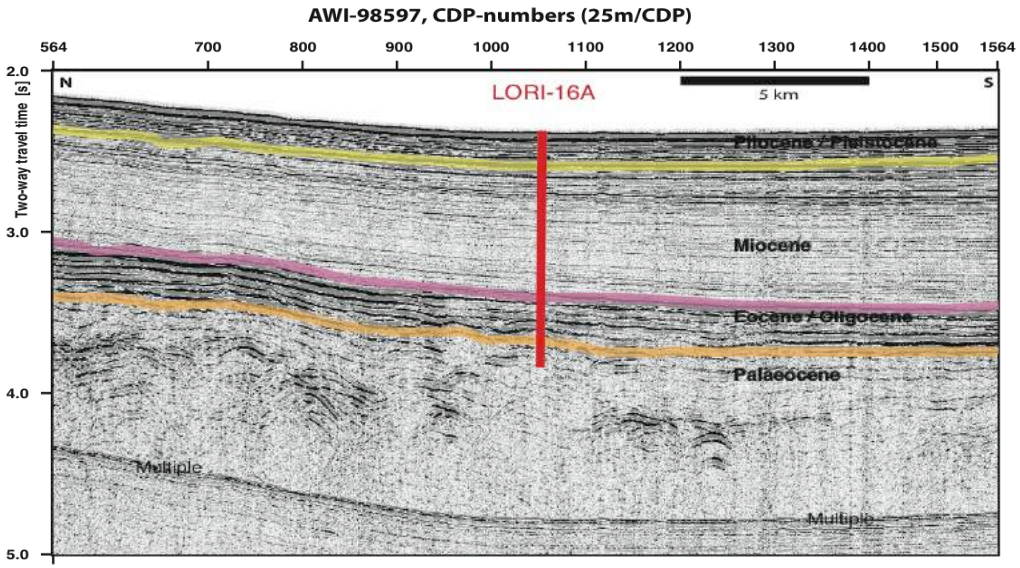
-Location map:	LR-02A_map.pdf
-Seismic figures:	LR-02A_AWI-20080160.pdf
-SEGY data:	AWI-20080160stack.sgy
-Navigation data:	20080160_cdplocs.asc

Site Summary Form 6 IODP Proposal 708 Site LORI-16A



Profiles annotated using CDP numbers

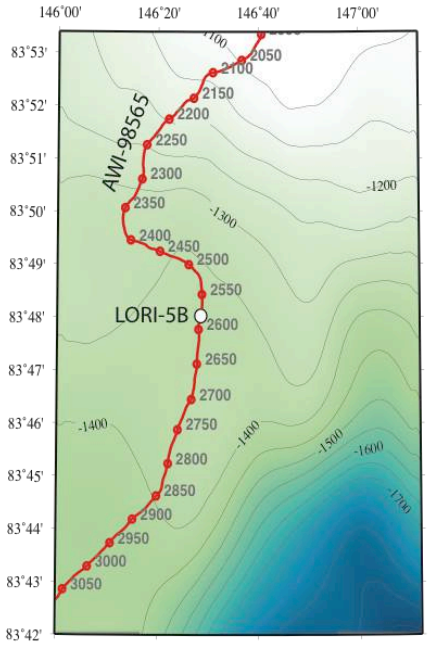




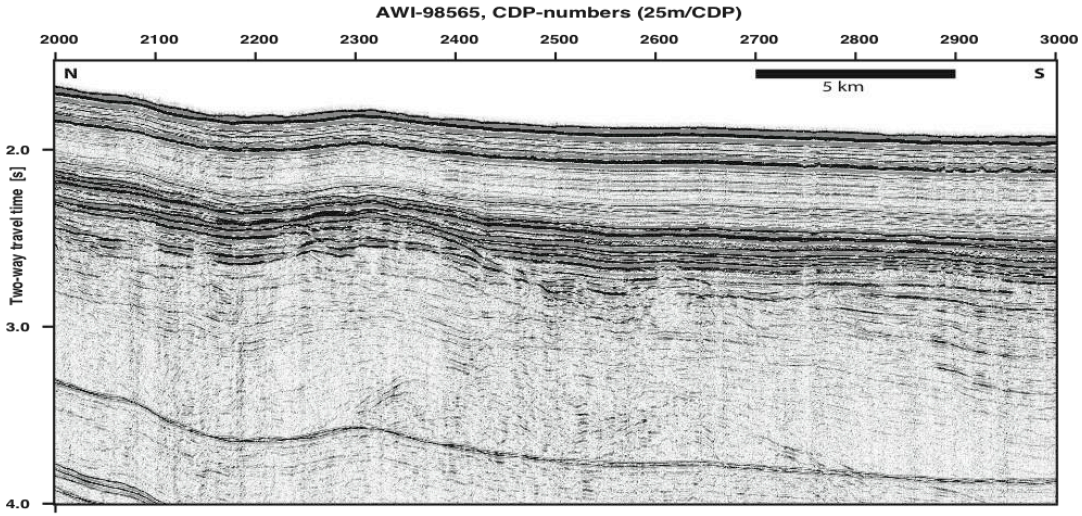
Coordinates: 80° 46.6'N, 142° 46.9'E
Water-depth: 1752 m
Top Miocene (yellow): 195 mbsf
Top Oligocene (pink): 1395 mbsf
Lower Eocene (orange): 1840 mbsf
Penetration: 2160 m

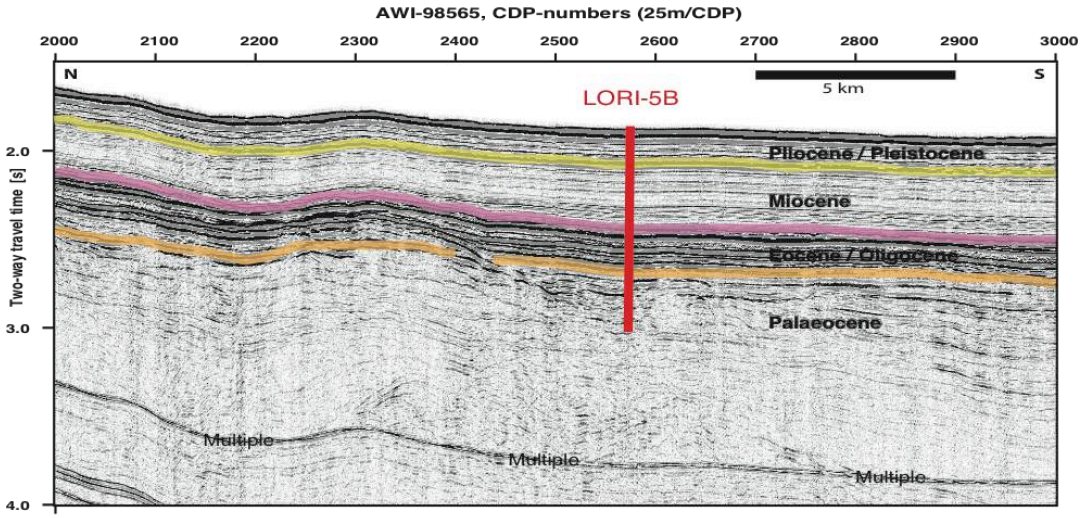
SSDB locations of these graphics and supporting data:
-Location map: LORI-16_map.pdf
-Seismic figures: LORI-16A_AWI-98597.pdf
-SEGY data: AWI-98597stack.sgy
-Navigation data: 98597_cdplocs.asc

Site Summary Form 6 IODP Proposal 708 Site LORI-5B



Profiles annotated using CDP numbers





Coordinates: 83° 48.03'N, 146° 28.5'E
Water-depth: 1334 m
Top Miocene (yellow): 180 mbsf
Top Oligocene (pink): 660 mbsf
Lower Eocene (orange): 1000 mbsf
Penetration: 1750 m

SSDB locations of these graphics and supporting data:
-Location map: LORI-5B_map.pdf
-Seismic figures: LORI-5B_AWI-98565.pdf
-SEGY data: AWI-98565stack.sgy
-Navigation data: 98565_cdplocs.asc