Received 28-March-2002

533-Full3

iSAS/IODP Proposal Cover Sheet

☐ **New** ☑ **Revised** ☐ **Addendum**

Please fill out information in all gray boxes

Above For Official Use Only

Title:	Paleoceanographic and Tectonic Evolution of the Central Arctic Ocean
Proponent(s):	Jan Backman, Nikita Bogdanov, Bernard Coakley, Margo Edwards, Rene Forsberg, Ruth Jackson, Martin Jakobsson, Wilfried Jokat, Yngve Kristoffersen, Larry Mayer, Kathryn Moran
Keywords: *(5 or less)*	Arctic Ocean, Paleoceanography, Tectonics, Lomonosov Ridge — Area: Lomonosov Ridge

Contact Information:

Contact Person:	Professor Jan Backman
Department:	Department of Geology and Geochemistry
Organization:	Stockholm University
Address	S-106 91 Stockholm
Tel.:	46-8-64720 — Fax: 46-8-6747897
E-mail:	backman@geo.su.se

Permission to post abstract on iSAS Web site: ☐ Yes

Abstract: *(400 words or less)*

Five sites are proposed to be drilled on the ridge crest of the Lomonosov Ridge in the central Arctic Ocean. The sites are distributed between 88°N and 81°N in water depths ranging between 800 and 1415 m, and are all located in international waters. The ridge was rifted from the Kara/Barents Sea shelves during early Paleogene time and subsequently subsided to its present water depth. Since that time sediments of biogenic, eolian and ice-rafted origin have accumulated on the ridge crest. In our primary target area between 87°N and 88°N these sediments are about 450 m thick, indicating an average rate of sedimentation of ~10 m/m.y. throughout the course of the Cenozoic. Sampling of these sediments would provide an unprecedented and unique opportunity to acquire a first-order knowledge about the paleoceanographic history of the central Arctic Ocean. Sampling of the underlying bedrock provides a similarly unique opportunity to decipher the tectonic history of the Lomonosov Ridge and the formation of the Eurasian Basin.

The proposed program epitomizes both the spirit and the science of the new Integrated Ocean Drilling Program, calling upon the creative use of mission specific platforms and directly addressing a number of the key scientific questions raised in the IODP Initial Science Plan.

Amongst scientific issues relating to “Environmental Change, Processes and Effects" are:

- the long-term (50 Ma) climate history of the central Arctic Ocean, and its role in Earth's transition from one extreme (Paleogene greenhouse lacking glaciation) to another (Neogene icehouse with bipolar glaciation)
- the shorter-term (Neogene) climate history, connecting the Neogene history of the Arctic Ocean to that of the North Atlantic Ocean at sub-millennial scale resolution
- Scientific issues relating to “Solid Earth Cycles and Geodynamics" are:
- the composition and origin of the pre-Cenozoic bedrock underlying the sediment drape
- the rifting and subsidence history of the Lomonosov Ridge

Five sites distributed over six degrees of latitude are proposed, partly with overlapping goals, which will make the drilling expedition less vulnerable to severe local ice conditions. The major goals of this proposal can be achieved by completing one site to 450 mbsf. Should ice conditions at this site be prohibited, a suite of sites from other areas along the Lomonosov Ridge corridor can be drilled to achieve the proposed science.

Scientific Objectives: (*250 words or less*)

There are two major objectives: understanding the paleoceanographic history and the tectonic evolution of the central Arctic Ocean. The history of Arctic paleoceanography 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. Specific paleoceanographic objectives are to:

- understand the history of ice rafting;
- study local versus regional ice-sheet development
- determine the density structure of Arctic Ocean surface waters, the nature of North Atlantic conveyor and onset of Northern Hemisphere glaciation
- determine the timing and consequences of the opening of the Bering Strait
- study the land-sea links and the response of Arctic to Pliocene warm events
- investigate the development of deep Fram Strait and deep water exchange between Arctic and GIN seas/world ocean
- determine the history of biogenic sedimentation.

The tectonic objectives are focused on Ridge evolution. If proven to be a continental fragment, it represents truly unique global information on the relative strength of continental and oceanic lithosphere. Specific tectonic objectives for drilling on the Lomonosov Ridge are:

- to investigate the nature and origin of the Lomonosov Ridge by sampling the oldest rocks below the regional unconformity in order to establish the pre-Cenozoic environmental setting of the ridge

to study the history of rifting and the timing of tectonic events that affected the ridge.

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
Primary						
LORI-013A	87 39.45N, 144 37.80E	1070	450	30	480	paleoceanography & tectonic
LORI-06A	81 28.54, 140 50.71	802	400	0	400	paleoceanography (Neogene)
LORI-04A	85 23.28, 150 20.62	794	90	110	200	tectonic
LORI-05A	83 58.90, 147 25.02	982	400	0	400	paleoceanographic
LORI-10A	86 24.89, 147 15.56	1132	400	0	400	paleoceanographic
Alternate						
LORI-08A	87 53.99, 138 38.60	1124	450	0	450	paleoceanographic
LORI-14A	87 37.55, 147 14.65	1415	90	110	200	tectonic
LORI-12A	82 04.30, 142 02.58	1392	400	0	400	paleoceanographic (Neogene)

PALEOCEANOGRAPHIC AND TECTONIC EVOLUTION OF THE CENTRAL ARCTIC OCEAN

Jan Backman[1], Nikita Bogdanov[2], Bernard Coakley[3], Margo Edwards[4], Rene Forsberg[5] Ruth Jackson[6], Martin Jakobsson[7], Wilfried Jokat[8], Yngve Kristoffersen[9], Larry Mayer[7], Kathryn Moran[10]

[1] Department of Geology and Geochemistry, Stockholm University, SE-106 91 Stockholm, Sweden

[2] Institute of the Lithophere, Russian Academy of Sciences, RU-109180 Moscow, Russia

[3] Geophysical Institute, University of Alaska, Fairbanks, AK 99775-5780, U.S.A.

[4] Hawai'i Mapping Research Group, University of Hawai'i, 1680 East-West Road, Post 815B, Honolulu, HI 96822, U.S.A.

[5] Geodynamics Dept., KMS, Rentemestervej 8, DK-2400 Copenhagen NV, Denmark

[6] Geological Survey of Canada (Atlantic), Box 1006, Dartmouth, N.S., B2Y 4A2, Canada

[7] Center for Coastal and Ocean Mapping, Chase Ocean Engineering Lab, University of New Hampshire, Durham, N.H. 03824, U.S.A.

[8] Alfred Wegener Institute for Polar and Marine Research, Columbusstrasse, D-27568 Bremerhaven, Germany

[9] Institute of Solid Earth Physics, University of Bergen, N-5007 Bergen, Norway

[10] Graduate School of Oceanography and Department of Engineering, University of Rhode Island, Narragansett, R.I. 02882-1197, U.S.A.

INTRODUCTION

The Arctic Ocean and its marginal seas play a fundamental role in the global ocean/climate system. The dense cold bottom waters of most of the world's oceans, which originate in the Nordic seas, strongly influence global thermohaline circulation, driving world climate. The permanent Arctic sea-ice cover has a tremendous influence on the Earth's albedo and the distribution of fresh water. It varies both seasonally and over longer time periods and thus has a direct influence on global heat distribution and climate. While understanding the history of the Arctic Ocean is critical for climate, ocean-circulation or tectonic model that would be truly global, the logistical difficulties associated with the work in this remote and harsh region have prevented us from gathering the critical data needed to document the role of this key region in the development and maintenance of the global climate system.

Except for the Pleistocene, only fragments of Cenozoic time have been sampled by coring. Thus the Arctic Ocean, despite its critical role in global climate evolution, is the only ocean basin whose history is virtually unknown.

The complex history of this basin, which receives surface water from the North Pacific, the North Atlantic and the various large rivers which drain northern Eurasia and North America, where water exists in all three phases year round, can only be studied by direct sampling of the sediments which record its history. The sediment sections preserved on the basinal highs have captured a record of the development of the Fram and Bering Straits, varying fluxes of fresh water into the basin, the development of the Arctic sea-ice and the history of the high latitude effects of the Cenozoic glaciation. This information is necessary to fully understand the climate of the Northern Hemisphere, providing a data set that complements ice and sediment cores collected at lower latitudes.

In this proposal we outline: the key scientific questions to be addressed by Arctic drilling and their link to the IODP Initial Science Plan; the logistical approach we envision to meet these objectives; the site survey data available and finally; a description of proposed sites.

Five primary sites are proposed (Figure 1) to recover a 450 m thick sediment sequence and the upper 30 m of the underlying acoustic basement (bedrock) from the crest of the Lomonosov Ridge. The sediment sequence represents a unique archive of the past 50 million years of paleoenvironmental evolution in the central Arctic Ocean, whereas the transition into the acoustic basement and its uppermost parts represents a similarly unique archive of the early tectonic evolution of the Eurasian Basin.

GEOLOGIC SETTING

Ever since Bruce Heezen and Maurice Ewing recognized, in their 1961 paper, that the mid-ocean rift system extended from the North Atlantic into the Arctic Ocean, it has been assumed that the Lomonosov Ridge was a continental fragment originally split off from the Eurasian continental margin. Aeromagnetic surveys of the Eurasian Basin have since mapped a remarkably clear pattern of magnetic lineations which can be interpreted in terms of seafloor spreading along the Gakkel Ridge since Chron C24 at ~53 Ma (Wilson, 1963; Vogt et al., 1979; Kristoffersen, 1990a). If we compensate for that motion of the seafloor, the Lomonosov Ridge is indeed brought into juxtaposition with the Barents/Kara Sea margin in the early Cenozoic. Zircon-bearing bedrock samples from the Lomonosov Ridge at 88.9°N yield a latest Permian (~250 Ma) age (Grantz et al., 2001). The only known source for ca 250 Ma old zircons in the circum-Arctic is in the post-tectonic syenites of northern Taymyr Peninsula and nearby islands in the Kara Sea, lending support to the tectonic model in which the ridge is interpreted to be a continental sliver that separated from the Eurasian plate.

As the Lomonosov Ridge moved away from the Eurasian plate and subsided, sedimentation on top of this continental sliver began and continues to the present, providing what may be a continuous stratigraphic sequence (Figures 2-3). The elevation of the ridge above the surrounding abyssal plains (~3 km) indicates that sediments on top of the ridge have been isolated from turbidites and are likely of purely pelagic origin (chiefly biogenic, eolian, ice-rafted).

Deep penetration reflection seismic profiles were acquired from the Lomonosov Ridge on icebreaker-based expeditions in 1991, 1996, and 1998 (Jokat et al., 1992; 1998; 1999; Kristoffersen, 1997a). The first deep penetration seismic cross-lines from the Lomonosov Ridge were collected in 2001 (Kristoffersen and Coakley, in preparation). The first high-resolution chirp profiles were collected in 1996 (Jakobsson, 1999). In 1999, the SCICEX program collected abundant high-resolution seismic chirp data, swath bathymetry and sidescan sonar backscatter data from a USN nuclear submarine (Pyle et al., 1997), contributing many new exciting results (Polyak et al., 2001; Edwards et al., 2001) including a much improved bathymetric chart of the Arctic Ocean (Jakobsson et al., 2000a; see also www.ngdc.noaa.gov/mgg/bathymetry/arctic/arctic.html).

High resolution chirp sub-bottom profiler (Figure 4) and interferometric swath bathymetry and backscatter data collected over the Lomonosov Ridge from the USS Hawkbill in the Spring of 1999 have been provided to the site survey data center at LDEO. The chirp data in Figure 4 shows the continuous drape of mantle-bedded pelagic sediments that are the primary target for this drilling program.

Two of the key seismic profiles (AWI-91090 and AWI-91091) were acquired across the Lomonosov Ridge in about 8/10 ice cover during the 1991 expedition (Jokat et al., 1992). At 88°N in 1 km of water, the ridge is 80 km wide with a 450 m thick section of acoustically stratified sediments that cap the ridge above an unconformity (Figure 3). Below this unconformity, sediments are present in down-faulted asymmetric half-grabens. Seismic velocities from refraction experiments are typical for deep-sea sediments above the unconformity (1.5-2.2 km/s) and are >4 km/s below.

Several dozens of short cores (<10 m) of Pleistocene and Holocene age exist from the central parts of the Lomonosov Ridge, indicating average sedimentation rates of ~7-10 m/m.y. (e.g., Gard, 1993; Jakobsson et al., 2000b; 2001). By assuming that the tectonic model of the onset of Cenozoic marine sedimentation on the ridge is approximately correct in terms of timing (50 Ma: Jokat et al., 1992) and considering the total thickness of the section (450 m) above the unconformity, a rate of 7-10 m/m.y. is consistent with the average sedimentation rate of the entire section: 9 m/m.y.

Little information is available about pre-Pleistocene paleoenvironments in the central Arctic Ocean. Temperate marine conditions existed during the Late Cretaceous (Campanian-Maastrichtian) based on evidence provided by silicoflagellates and diatoms from three short T-3 and CESAR cores, all retrieved from the Alpha Ridge in the Amerasian Basin (Clark et al., 1980; Bukry, 1981; Thiede et al., 1990). One 3.64 m long core (F1-422) containing middle or late Eocene age silicoflagellates also has been retrieved from the Alpha Ridge, providing the sole evidence for early Cenozoic marine conditions in the Arctic (Bukry, 1984). Thus, existing core material, at best, represents a few percent of the Cenozoic paleoceanographic history of the Arctic Ocean.

We conclude that the 450 m thick sediment sequence draping the crest of the Lomonosov Ridge between 87°N and 88°N (Figures 2-3) contains a unique archive of climatic and paleoceanographic information, which is the key to unravelling the long-term (50 Ma) Cenozoic environmental history of the central Arctic Ocean.

FROM GREENHOUSE TO ICEHOUSE: ARCTIC'S ROLE IN THE DEVELOPMENT OF CENOZOIC CLIMATIC EXTREMES AND RAPID CLIMATE CHANGE

Cenozoic climatic extremes - A major element in the evolution of Cenozoic environments has been the transformation from warm Eocene oceans with low latitudinal and bathymetric thermal gradients into the more recent modes of circulation characterized by strong thermal gradients, oceanic fronts, cold deep oceans and cold high latitude surface waters. About 92% of all water in today's oceans are colder than ~10°C. In the Eocene, 50 million years ago, all water in the oceans was warmer than 10°C. Bottom temperatures in the early Eocene, the time of maximum Cenozoic warmth, were on the order of 12°C, and large-scale continental ice sheets did not exist because Earth's warm climate inhibited the growth of continental ice-sheets (Miller et al., 1987; Zachos et al., 2001).

The transition to today's world, Antarctica covered by a continental ice-cap and seasonally variable but persistent sea-ice cover in the Arctic, is linked to both the change in climate that increased latitudinal gradients and to oceanographic changes that connected surface and deep-sea circulation between high and low latitude oceans. Thus, throughout the course of the Cenozoic, the climate on Earth has changed from one extreme (Paleogene greenhouse lacking ice) to another (Neogene icehouse with bipolar glaciation).

It has long been recognized that our lack of knowledge about the role the Arctic played in the maintenance and development of these climatic extremes is a major gap in our ability to understand and model global environmental change (e.g., COSOD I, 1981; COSOD II, 1987; ODP Long Range Plan, 1996; COMPLEX, 1999; IODP Science Plan, 2001).

The recovery of a 450 m thick, continuous Cenozoic stratigraphic section, encompassing 50 Ma, from the central part of the Lomonosov Ridge between 87°N and 88°N would fill that gap and represent a fundamental step to a quantitative description of global change that incorporates the influence of the Arctic Ocean. Key among our climate objectives is to determine when the Arctic became ice-covered, and study the variability of sea-ice in terms of frequency, extent and magnitude. In this context, the Miocene uplift of the Himalayan-Tibetan region is of particular interest as it may have triggered enhanced flow of Siberian rivers and changed the fresh-water balance of the Arctic's surface waters, considered to be a key factor in the formation of Arctic sea-ice (Driscoll and Haug, 1998).

Rapid climate change - Cenozoic sedimentation rates on the central parts of the Lomonosov Ridge are probably too low to allow ultra-high resolution (sub-annual to decadal) studies of climate change. Late Neogene and Pleistocene sediments on the huge and shallow Siberian shelves were deposited at rates which could permit ultra-high resolution, but problems pertaining to jurisdiction, hydrocarbons and permafrost indicate that higher-resolution sites must be located elsewhere. The sediment section draping the crest on the Lomonosov Ridge becomes progressively thicker when approaching the Siberian (Laptev Sea) margin (Jokat, 1999) and the Lena River. The total sediment thickness above the unconformity is two- to three-fold compared to that occurring on the central parts of the Lomonosov Ridge. The southernmost sites proposed (at ca 81°N to 82°N and 800 m to 1400 m water depth) would avoid the jurisdiction, permafrost and hydrocarbon problems of the shelf environment but still permit sub-millennial scale resolution and studies of Arctic rapid climate change in the Pleistocene and Neogene.

These two topics, Earth’s change from extreme warmth (lack of glaciation) to extreme cold (bipolar glaciation), and rapid climate change, are key elements in the IODP Science Plan. Scientific drilling in the Arctic is the only means available to collect the data necessary to decipher the history of the Arctic Ocean and to connect to the history of the Greenland ice sheet and the North Atlantic. This proposed drilling program would be the first controlled sampling of the Arctic seafloor, with the potential to provide much more detailed, continuous information than has come from short (<10 m), opportunistically sited cores. These data would open a new chapter in the study of Northern Hemisphere climatic behaviour.

PALEOCEANOGRAPHIC OBJECTIVES

The history of Arctic paleoceanography is so poorly known that we can look at the recovery of any material as a true exploration that will increase our knowledge and understanding of this critical region. There are a number of specific paleoceanographic objectives, questions that can be framed on results from lower latitudes, for which we believe there are testable hypotheses and that fully fit the scientific objectives outlined in the IODP Initial Science Plan; we offer some examples of these below:

History of ice rafting: Recent drilling in the Norwegian, Iceland, Irminger, and Greenland Seas has shown that the first coarse ice-rafted material seems to appear earlier off southern Greenland than in the Fram Strait - Yermak Plateau region (Thiede and Myhre, 1996). Does this trend continue into the central Arctic Ocean? Did the cooling and glacial inception occur earlier in the sub-arctic than in the central Arctic or vice versa? These questions can be addressed only through sampling of central Arctic seafloor sediments. The presence or absence of ice-rafted material in a constrained stratigraphic context (see below) should directly address this issue.

Local versus regional ice-sheet development? Drilling results from the Fram Strait and Yermak Plateau regions have shown a series of middle and late Miocene pulses of ice rafting (14 Ma, 10.8-8.6 Ma, 7.2-6.8 Ma, 6.3-5.5 Ma, and continuing in sediments younger than 5 Ma.) (Thiede and Myhre, 1996). Do these represent local Svalbard ice expansion events or can the events also be observed in the central Arctic? The resolution of this issue has important ramifications on the climatic history of the Arctic. Again the presence or absence of ice-rafted material in a constrained stratigraphic context should provide the means to determining the answer to this question.

Density structure of Arctic Ocean surface waters, nature of North Atlantic conveyor and onset of Northern Hemisphere glaciation: Aargard and Carmack (1994) proposed that the convective renewal rate and nature of large scale North Atlantic/Nordic Seas circulation is dependent on the fresh water supply from the Arctic Ocean. Driscoll and Haug (1998) also call upon changes in fresh water input (from Siberian rivers) to facilitate ice formation and contribute to the onset of Northern Hemisphere glaciation. A decrease in fresh water supply would move the present site of deep water North Atlantic convection from the Greenland Sea into the central Arctic Ocean basins; this model implies a virtually ice-free Arctic Ocean. The contrast from ice-covered, well-stratified (oxygen poor) Arctic Ocean waters to ice-free waters with free air-sea exchange (well-oxygenated) will undoubtedly generate a recognizable signal in the sediments accumulating on the seafloor. A major change in river input should yield a strong sedimentological signal and deposit pollen and spores. These signals which can only be measured in the Arctic Basin should also be expressed in a number of other paleceanographic proxies including, major and/or trace element geochemistry (i.e., MnO content), as well as in the isotopic composition of the calcareous benthic forams, if present.

Timing and consequences of the opening of the Bering Strait? Consistent with the model of Aagard and Carmac, Stigebrandt (1981) suggests that a decrease in fresh water supply combined with a shut-off of Bering Strait inflow would result in the virtual loss of sea-ice. Classically, the opening of the Bering Strait has been recognized by a dramatic change in the composition of shallow water marine faunas (e.g., Marincovich, et al., 1990) and in particular the influx of Pacific boreal mollusks to Iceland (Einarsson et al., 1967). Ice-rafted debris should reveal when sea-ice first formed in the Arctic Basin. Is the timing of this first permanent sea-ice cover coincident with the arrival of the Pacific boreal mollusks to Iceland?

Land-sea links: response of Arctic to Pliocene warm events: Svend Funder and colleagues (1985), have demonstrated that northern-most Greenland was forested in the late Pliocene. Was this warm event local or regional? What was the Arctic Ocean doing at this time? Was biogenic carbonate preserved in the Arctic Basin at this time?

Development of deep Fram Strait and deep water exchange between Arctic and GIN seas/world ocean: The Fram Strait represents the only deep-water connection between the Arctic and the world ocean. The timing of the formation of this passage is critical to the development of global circulation models. Several reconstructions exist (based mostly on tectonic arguments, e.g., Lawver, et al., 1990, Eldholm et al., 1990, Kristoffersen, 1990b) that place opening at times ranging from early Oligocene to late Miocene. What would the effect of the outflow of Arctic bottom waters have on the environment within the Arctic Basin?

History of biogenic sedimentation: The four pre-Pleistocene cores from the Alpha Ridge (with ages of ~70 and ~35 Ma, respectively), all consist of black biosiliceous muds that indicate poorly ventilated bottom waters. Was the Arctic continously biosiliceous and poorly stratified between 50 and 35 Ma? (Our drilling strategy will probably only take us back to the early Eocene). Plio-Pleistocene cores from Fram Strait and Yermak Plateau all contain biogenic carbonates. When did the transition from the dominance of biosiliceous sedimentation to carbonate dominated sediments occur? Is this transition related to the strength of North Atlantic advection into the high latitudes?

STRATIGRAPHIC CONTROL

Dating of Arctic Ocean sediments offers a classic problem in stratigraphy. When considering the general lack of information about the composition and microfossil contents of "pre-Pleistocene" sediments in the central Arctic, it appears pointless to speculate about the abundance and preservation of the various microfossil groups (e.g., foraminifers, nannofossils, rads, diatoms, silicoflagellates), although spores, pollen, and dinoflagellates are likely to occur consistently. Magnetostratigraphy and various isotopic methods (e.g., Sr, U-Pb) in combination with biostratigraphy should ensure adequate chronological control. The use of ion microprobe techniques will allow in-situ analysis of element and isotope compositions of geological samples on a micrometer scale. Zircon, monazite and sphene are routinely analyzed for U-Pb ages >20 Ma using ion mass-spectrometry, where ages are determined on individual grains, making the technique well suited for sediment core material.

We must take into account the possibility that foraminiferal calcite may be largely lacking in the Lomonosov Ridge sediments, either due to carbonate dissolution or to paleoecological exclusion, thus preventing us from applying the conventional paleoceanographic proxy methods provided by stable isotope and trace element analysis of foram shells. Still, we consider that the wide array of existing analytical techniques in sedimentology, sediment physical properties, geochemistry, and paleontology, that can be applied on the Lomonosov Ridge sediments will yield adequate answers to our key questions. Available paleoceanographic proxy indicators include, for example, Plio-Pleistocene biogenic carbonate, dinoflagellates, pollen and spores, silicoflagellates, diatoms, O-isotopes in biogenic silica, fish-apatite stable isotopes, etc. Spectral signatures of sediment color banding and provenance studies of IRD are also useful tools for deciphering the Arctic paleoenvironmental puzzle.

TECTONIC SETTING

The Lomonosov Ridge and the Eurasia Basin developed during the Late Cretaceous and Cenozoic, substantially expanding the Arctic Ocean basin and opening a deep-water connection to the North Atlantic. The Lomonosov Ridge has an asymmetric architecture expressed in its central part by strata prograding towards the Amerasian Basin. The topsets have been eroded away. The units are unconformably overlain by a several hundred meter thick drape of velocity <2 km/s (Jokat et al., 1992). In contrast, the Eurasia Basin side of the ridge is a steep terrace of narrow fault blocks which accomodate more than 4 km of vertical relief relative to basement of the Amundsen Basin (Poselov et al., 1998; Sorokin et al., 1998).

The ridge structure changes character from a main block in the central narrow part to a more broadly faulted area towards the Laptev Sea (Jokat, 1998) as well as the Greenland and Canadian margin (Coakley and Cochran, 1998). The central narrow part of the Lomonosov Ridge near the North Pole exhibits a strong uneven reflection below about 600 m of sediments (Kristoffersen, 1998). These reflections resemble the acoustic image of basalt flows which also have been interpreted to cover basement on the margin north of Franz Josef Land and Kvitøya (Baturin, 1987), and may suggest a more or less continuous basalt province between Franz Josef Land and Ellesmere Island during Cretaceous time (Kristoffersen, 1998). Interpretation of the late Paleozoic and Mesozoic paleoenvironment of the northern margin suggests that the area to the north of Svalbard and Franz Josef Land was for the most part elevated to or above sea level from the Permian through Cretaceous, except for the Early

Triassic and Late Jurassic (Dorè, 1991). Present geologic information of pre-Cenozoic rocks from the Lomonosov Ridge is limited to piston core recovery (Eurasian flank near 89°N; Grantz et al., 1998; 2001) of monolithic rubble of indurated siltstone clasts containing reworked Devonian and Carboniferous spores, zircons of latest Permian age, and spores of a Jurassic and Cretaceous fern.

TECTONIC OBJECTIVES

The Lomonosov Ridge is more than 1500 km long and less than 150 km wide. If proven to be a continental fragment, it represents truly unique global information on the relative strength of continental and oceanic lithosphere. The olivine rheology of the oceanic lithosphere is estimated to be three times stronger than typical continental lithosphere which includes a 35 km thick continental crust of predominantly quartz/plagioclase rheology (Vink et al., 1984). Juxtaposed oceanic and continental lithosphere in a tensional stress field would be weakest landward of the continental shelf edge (Lavier and Steckler, 1997; Steckler and ten Brink, 1986) and the Lomonosov Ridge may have formed as a result of this mechanism. The tectonic objectives for drilling on the Lomonosov Ridge are:

- to investigate the nature and origin of the Lomonosov Ridge by sampling the oldest rocks below the regional unconformity in order to establish the pre-Cenozoic environmental setting of the ridge
- to study the history of rifting and the timing of tectonic events that affected the ridge

PRIORITY OF OBJECTIVES

The absolutely overriding **first priority (I)** is the continuous recovery of a ~450 m thick sediment sequence from the crest of the Lomonsov Ridge between 87°N and 88°N. If we can achieve continuous sampling of the 450 m thick section in one of our key sites, the fundamental paleoceanographic objectives that have consistently resulted in our proposal being top-ranked in ODP would be met. These sites are all located between 87°N and 88°N. Our **second priority (II)** is to sample the sites located near the Siberian margin, in order to recover a paleoceanographic Neogene sediments at higher, sub-millennial scale, resolution and to create a latitudinal transect spanning over ~6° of latitude in the Arctic Ocean. Our **third**

priority (III) is to sample the transition across the regional unconformity to establish the pre-Cenozoic environmental setting of the ridge, and to study the rifting and timing of tectonic events that affected the ridge.

DEVELOPMENT OF ODP PROPOSAL 533-FULL IN RESPONSE TO INPUT FROM THE JOIDES ADVISORY STRUCTURE

The preliminary version of Proposal 533 was submitted in March 1998. A full, revised version was subsequently submitted (March 1999), which was followed by a version further revised (September 1999), and later on, an addendum (March 2000) responding to questions raised by the ESSEP. The four external reviews (February 2000) were consistently supportive with respect to scientific content, site selection, and drilling strategies, and therefore did not result in any changes. Input from the JOIDES Site Survey Panel (SSP) added other critical elements to the development of the proposal, not formally included in any previous version of the proposal. This proposal twice received a #1 ranking by JOIDES SCICOM, following the interactive and continuous improvement of the proposal. Another critical phase in the development of the proposal occurred when JOIDES (December 2000) established its Arctic Detailed Planning Group (DPG), having the task to develop a project management plan encompassing the logistical, technical, and budgetary requirements for scientific drilling on the Lomonosov Ridge, which was presented to and accepted by SCICOM in August 2001.

It follows that the present IODP proposal developed through several cycles of internal reviews by the JOIDES Advisory Structure, external reviews, and the recommendations offered by the Arctic DPG. Being shortened to conform to IODP proposal requirements, the present proposal cannot host the details of this development, although the ideas presented here contain the entire progression made since 1998.

OPERATIONAL STRATEGY

Our proposed drilling strategy is based on the work of the JOIDES Arctic Detailed Planning Group (ADPG). The ADPG described strategies for transiting through ice to the drill sites and for maintaining station during drilling. Both of these strategies utilize an

"Armada" of a minimum of three vessels: a nuclear icebreaker (NIB) that will be the front line in ice breaking; a "hunter" icebreaker (HIB) that will manage the broken ice masses to directly protect the drilling operation; and an icebreaker-class drilling vessel.

During icebreaking, the prime objective is to transit through a region with a minimum of fuel consumption, vessel damage, and time spent. The strategies, therefore, are ones of avoidance, lead following, and identifying ice environs that would result in minimal resistance. Vessels follow courses that may not be straight in order to minimize the energy and damage. This type of strategy will be followed while the vessels are in transit, but is in stark contrast to ice management strategies. Ice management requires direct engagement of difficult ice in order to ensure that ice does not impact the stationary, drilling platform. The ice management vessels must follow the direction of ice approach to ensure that approaching ice is reduced to a tolerable level for the drilling vessel. The general strategy for ice management, while on station, will have the NIB assigned to break ice first, 3-4 km up drift. This distance would provide 2-3 hours of advance notice of ice conditions. This vessel would also break a wide enough area to allow for room for drift direction shifts. The HIB will work within a close radius of the drilling vessel to manage the ice, reduce it to small floe sizes, and to maintain an ice-free zone.

The ADPG also studied and made recommendations regarding the sampling and logging tools for our original proposal to ODP. They recommended that the ODP advanced piston core (APC) tool be used with a Seacore C200 drill rig. The APC would require only slight modification to be compatible with this rig. They also proposed that Seacore tools comparable to ODP's extended core barrel (XCB) and rotary core barrel (RCB) be used for drilling harder sediments and acoustic basement. Thus, in this proposal, we propose to follow the ADPG's recommendation, but we use the ODP terminology for the proposed sampling and drilling programs.

In earlier submissions of this proposal to ODP, we proposed an offset drilling strategy because we assumed that ice conditions would potentially limit our ability to stay on location for the duration of a multiple deep holes (ca. 300 - 500 mbsf). Subsequently, the ADPG evaluated the operational strategies and recommended a more aggressive strategy, based on successful ice management projects elsewhere (Backman, 2001). This strategy identifies priority contingency areas (PCAs) within which the scientific priorities can be achieved. Because the PCAs are distributed over a 360 nm long and 40 nm wide corridor along the crest of the Lomonosov Ridge, they provide options should any single area have severe ice conditions. Arctic ice experts reported to the DPG that severe conditions can occur within our study corridor, but that during summer months, it is highly unlikely that more than one area would have severe conditions at any single time. Thus, the primary contingency plan is to select the PCA (Table 1; Figure 1) based on a balanced decision that considers the ice conditions and the scientific priority.

Table 1. Summary of the Priority Contingency Areas (PCA) within the proposed study corridor on Lonomosov Ridge

PCA	Latitudinal Ice Window in Corridor	Primary Site	Alternate Site	Science Priority
1	88° - 87°	LORI-13A	LORI-08A	I,III
			LORI-14A	III
2	82.5° – 81.5°	LORI-06A	LORI-12A	II
3	86° - 85°	LORI-04A	SP Range	III
4	83.5° – 84.5°	LORI-05A	SP Range	I, II
5	87° - 86°	LORI-10A	SP Range	I

Because of the added uncertainties that are encountered when trying to position a drill ship in sea-ice, we are requesting permission to position some of our alternate drill sites at selected shotpoint (SP) along given SP segments of our key reflection seismic profiles. In each of these line segments, a specific primary site location is identified. These sites are presented in the overview table (Table 2) and in the enclosed Site Summary Forms. The reason for this strategy is that ice conditions may vary over short geographic distances and influence our ability to achieve the science objectives. For example, on seismic profile AWI-98565 (Figure 7) we suggest that the key paleoceanographic objectives can be achieved by drilling anywhere between SP 500 and SP 1800. In that SP segment, we have identified Site LORI-05A at SP 700 as the most suitable target. Yet, we request permission to drill anywhere within this identified SP range. This will provide the necessary flexibility to adjust our program to existing ice conditions; decisions that must be taken while approaching the target area or while on site.

PROPOSED SITES

We propose five primary drill sites on the Lomonosov Ridge (Figure 1) to recover sequences that address our three priority objectives: (I) recovery of basal Eocene to Recent hemipelagic sediment section to address the proposed paleoenvironmental objectives; (II) recovery of a higher resolution paleoceanographic Neogene section; and (III) recover acoustic basement to address the tectonic history objectives.

Table 2 Primary Proposed Lomonosov Ridge Sites

Site	Latitude (N)	Longitude (E)	Water depth (m)
LORI-13A	87°39.45'	144°37.80'	1070
LORI-06A	81°28.54'	140°50.71'	802
LORI-04A	85°23.28'	150°20.62'	794
LORI-05A	83°58.90'	147°25.02'	989
LORI-10A	86°24.89'	147°15.56'	1132

The first primary site (LORI-13A; Figures 1, 2, 4) is required to ensure recovery of a complete stratigraphic sediment record and to meet our highest priority paleoceanographic objective, a high resolution long-term (50 Ma) climate history of the central Arctic Ocean; and our tectonic objective. We propose to drill and sample to a maximum penetration of 480 m to recover the complete hemipelagic sediment sequence (450 m) and 30 m of acoustic basement (bedrock). Because of the different objectives, we propose to drill three holes at this site, one APC/XCB/RCB hole to full penetration and two APC/XCB holes to recover multiple sections of the sediment sequence to ensure complete recovery for construction of a composite section (Appendix: Site Description Forms). We also propose to log the deepest hole at this site after completion of the RCB coring and release of the RCB bit.

Should drilling or coring result in unexpected problems at LORI-13A, two separate alternate sites are proposed: LORI-08A (Figure 1, 3) for completing the primary paleoceanographic objective (I) and LORI-14A (Figures 1, 2, 4) for completing the tectonic objective (III). We propose to drill and sample three APC/XCB holes to a maximum penetration of 450 m at LORI-08A to recover the hemipelagic sediment sequence. At LORI-14A, we propose to drill and sample a single RCB hole to 200 mbsf to meet the tectonic objectives, where the transition between the oldest part of the hemipelagic sediment sequence and acoustic basement can be reached at a penetration depth of 176 m.

PCA 2 is a large area comprising sites that will address our second science priority: recovery of a shorter-term climate history that will link the Neogene history of the Arctic Ocean to that of the North Atlantic Ocean at a sub-millennial scale resolution. For this objective, Site LORI-06A is proposed (Figures 1, 5). This site has an expanded Neogene sediment section and we propose to drill and sample three APC/XCB holes to a depth of 400 mbsf. An alternate site to this one, Site LORI-12A (Figures 1, 5) is located more than half a degree north so that it could be drilled, should the local ice conditions at LORI-06A be severe or if drilling difficulties are encountered. This site is interpreted to have an expanded Neogene sediment section, similar to the primary site.

Site LORI-13A and its alternate sites are located in PCA 1. Should the ice conditions prevent drilling in this area, the primary paleoceanographic objectives can also be met by drilling in either PCA 4 at Site LORI-10A (Figures 1, 6) or in PCA 5 at Site LORI-05A (Figures 1, 6). At these sites the drilling strategy is identical and we propose to drill and sample three APC/XCB holes to 400 mbsf. One hole at each site would also be targeted for logging. The tectonic objective could be achieved within another priority contingency area at Site LORI-04A (PCA 3; Figures 1, 7) which is situated over a culmination of old sediments and/or basement below the regional unconformity within 200 m of the seafloor. Therefore, we propose to drill and sample a single RCB hole to 200 m. Should drilling difficulties be encountered at any of these three primary sites, alternate sites can be drilled at any point within a limited range along the seismic line (see Site Summary Forms).

REFERENCES

Aagaard, K., and Carmack, 1994. *AGU Geophys. Monogr.,* **85**: 5-20.

Backman, J., 2001. *Joides Journal,***27**: 16-27.

Baturin, D., 1987. *Oceanology,* **27**: 308-312.

Bukry, D., 1981. *Geo-Marine Letters,* **1**: 57-63.

Bukry, D., 1984. *Geology,* **12**:199-201.

Coakley, B., and Cochran, J., 1998. *Internat. Conf. On Arctic Margins*, Celle (Germany), 12-16 Oct. 1998, p. 41.

Clark, D.L. et al., 1980. *GSA Spec. Publ.,* **181**: 1-57.

Dorè, A., 1991. *Palaeogeography, Palaeoclimatology, Palaeoecology,* **87**: 441-492.

Driscoll, N.W., and Haug, G.H., 1998. *Science,* **282**: 436-438.

Edwards, M.H. et al., 2001. *Nature,* **409**: 808-812 .

Einarson, T., et al., 1967. *The Bering Land Bridge*, Stanford Univ. Press, 312-325.

Eldholm, O., et al., 1990. GSA , *The Geology of North America,* v. **L**: 351-364.

Funder, S., et al., 1985. *Geology,* **13**: 542-546.

Gard, G., 1993. *Geology,* **21**: 227-330.

Grantz, A. et al., 1998. *Internat. Conf. On Arctic Margins,* Celle (Germany), 1998, p. 74.

Grantz, A., et al., 2001. *GSA Bull.,* **113**: 1272-1281.

Jokat, W. et al., 1992. *Geology,* **20**: 887-890.

Jokat, W., 1998. *Internat. Conf. On Arctic Margins,* Celle (Germany), 1998, p. 94-95.

Jokat, W. (ed.), 1999. *Ber. Polarforsch.*, **308**: 1-159.

Heezen, B.C., and Ewing, M., 1961. *Geology of the Arctic.* Univ. Toronto Press, 622-642.

Jakobsson, M., 1999. *Marine Geology,* **158**: 111-123.

Jakobsson, M., et al., 2000a. *EOS Trans. AGU,* **81**: 89, 93, 96.

Jakobsson, M., et al., 2000b. *Geology,***28**: 23-26.

Jakobsson, M., et al., 2001. *Global Planetary Change,* **31**: 1-22.

Kristoffersen, Y., 1990a. GSA, *The Geology of North America,* v. **L**: 365-378.

Kristoffersen, Y., 1990b. *NATO ASI Series C,* **308**: 63-76.

Kristoffersen, Y., 1997. *Yearbook 1995/96, Swedish Polar Secretariat,* 72-74.

Kristoffersen, Y., 1998. *Internat. Conf. on Arctic margins,* Celle, (Germany) Oct. 1998.

Lavier, L., and Steckler, M., 1997. *Nature,* **389**: 476-479.

Lawver, L.A., et al., 1990. *NATO ASI Series C,* **308**: 29-62.

Marincovitch Jr., et al., 1990. GSA*, The Geology of North America,* v. **L**: 403-426.

Miller, K.G. et al., 1987. *Paleoceanography,* **2**: 1-19.

Polyak, L., et al., 2001. *Nature,* **410**: 453-457.

Poselov, V.A., et al., 1998. *Internat. Conf. On Arctic Margins,* Celle (Germany), 1998.

Pyle, T., M., et al., 1997. *Sea Technology,* **39**: 10-15.

Sorokin, M., et al., 1998. *Internat. Conf. On Arctic Margins,* Celle (Germany), 1998, p. 175.

Steckler, M. and ten Brink, U., 1986. *Earth Planet. Sci. Lett.,* **79**: 120-132.

Stigebrandt, A., 1981. *J. Phys. Oceanogr.,* **11**: 1407-1422.

Thiede, J. et al., 1990. GSA, *The Geology of North America,* v. **L**: 427-458.

Thiede, J., and Myhre, A.M.., 1996. *Proc. ODP, Sci. Res.,* **151**: 645-658.

Vink, G. et al., 1984. *J. Geophys. Res.,* **89**: 10.072-10.076.

Vogt, P.R. et al., 1979. *J. Geophys. Res.,* **84**: 1071-1089.

Wilson, J.T., 1963. *Nature,* **198**: 925-929.

Zachos, J.C., et al., 2001. *Science,* **292**: 686-693.

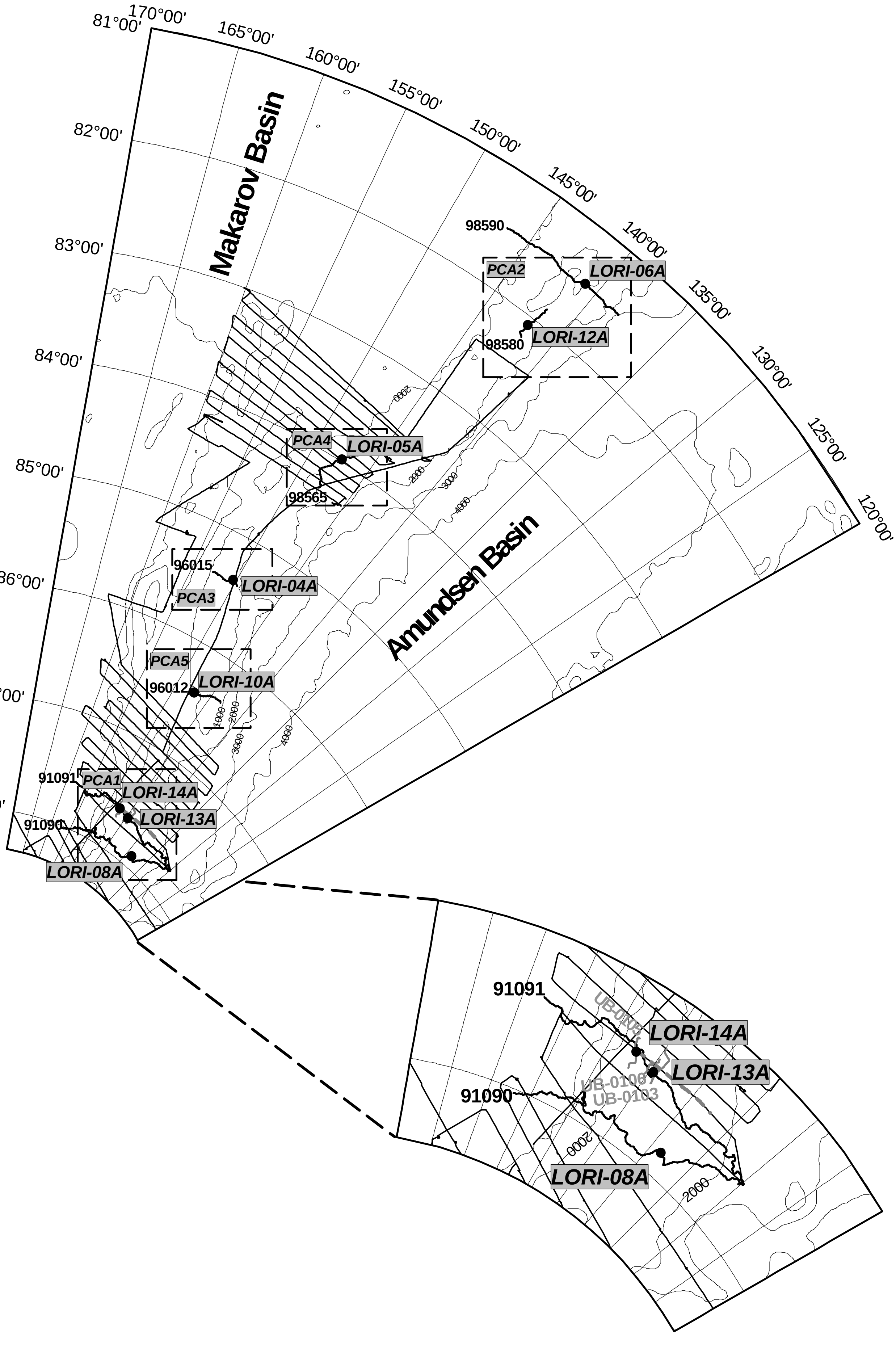


Figure 1. Primary (13, 6, 4, 5, 10) and alternate (8, 14, 12) LORI sites, reflection seismic profiles (icebreaker data: wiggly lines), and SCICEX chirp profiles (regular grid). PCA: Priority Contingency Areas. Thick gray stippled line in PCA1: Chirp profile shown in Figure 4.

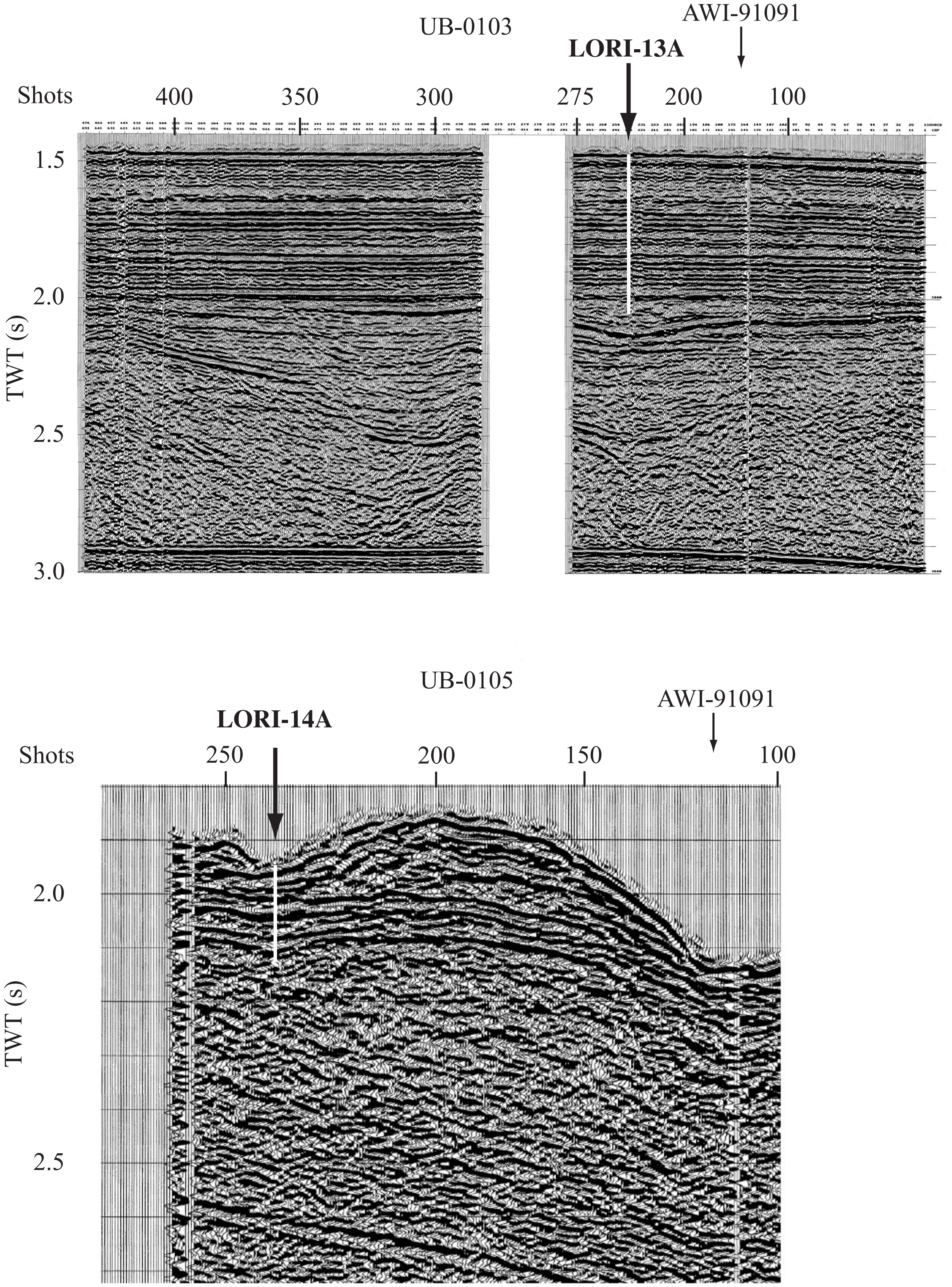


Figure 2. Primary paleoceanographic Site LORI-13A on seismic line UB-0103 (upper panel). Alternate tectonic Site LORI-14A on seismic line UB-0105 (lower panel). Crossline AWI-91091 marked. Geographic locations are shown in Figure 1.

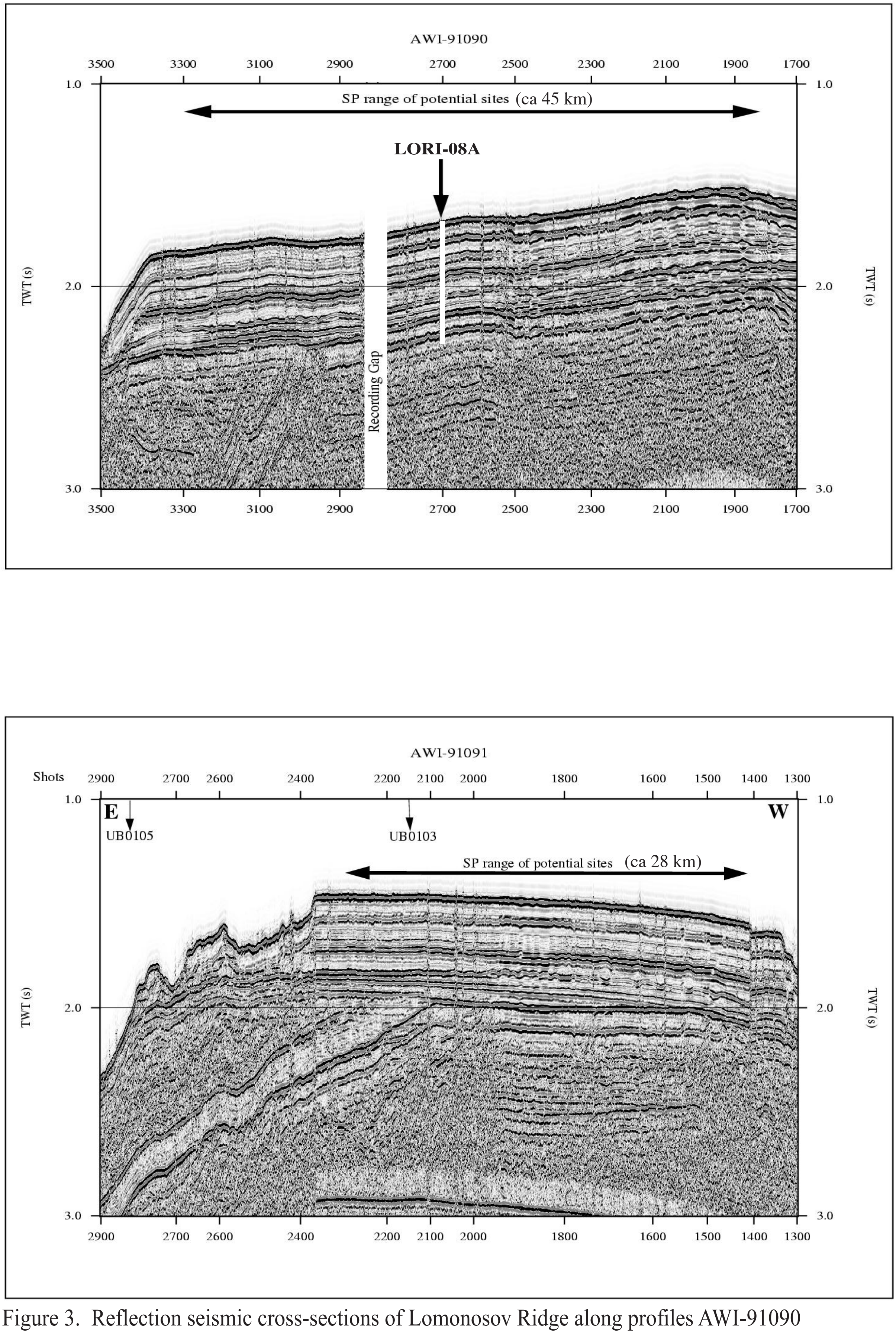


Figure 3. Reflection seismic cross-sections of Lomonosov Ridge along profiles AWI-91090 (upper panel) and AW-91091 (lower panel). Shotpoint ranges of potential paleoceanographic sites are shown, e.g., Site LORI-08A. Geographic locations are shown in Figure 1. Vertical arrows show positions of seismic crosslines UB-0103 and UB-0105 (see Figure 2).

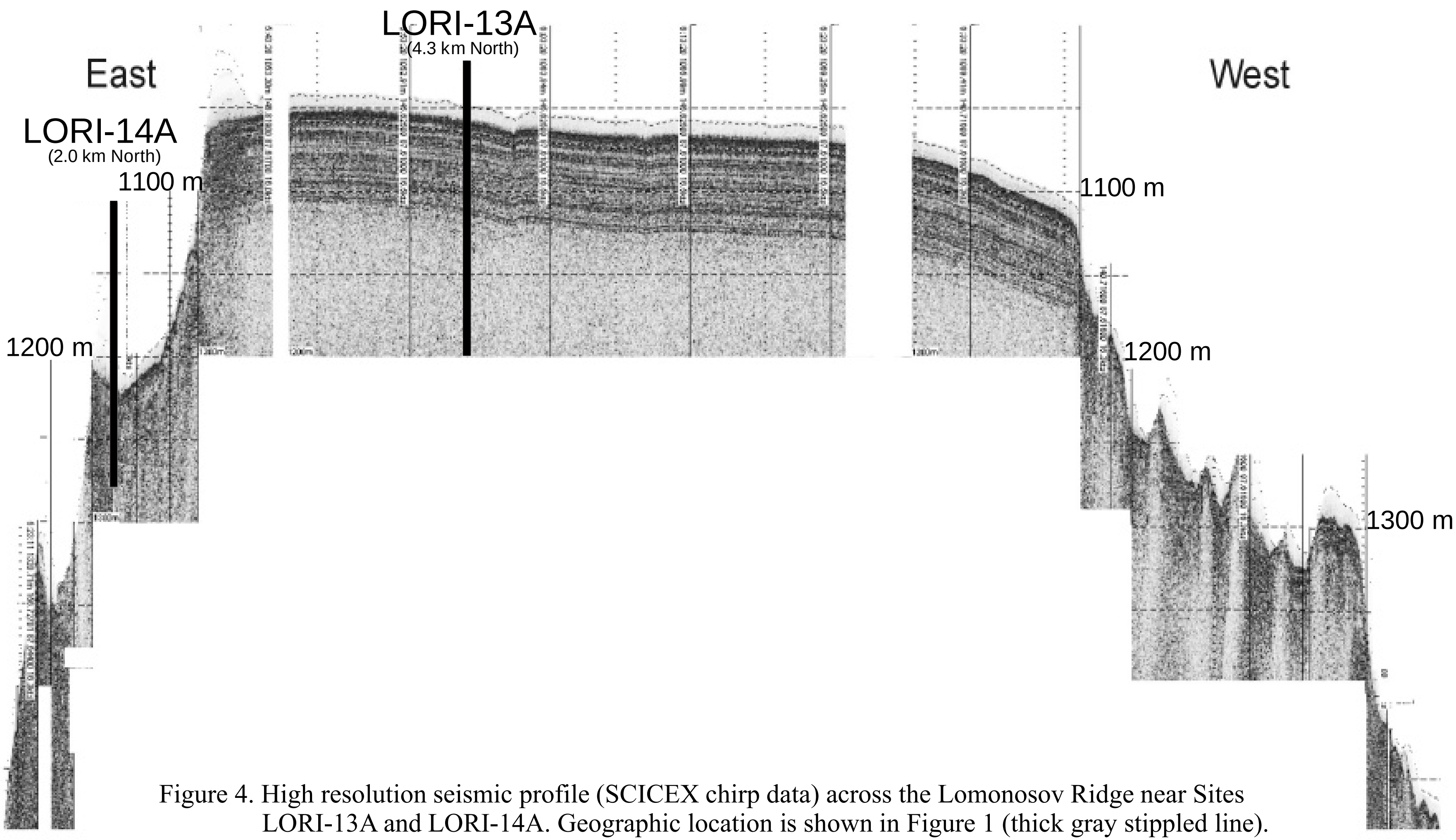
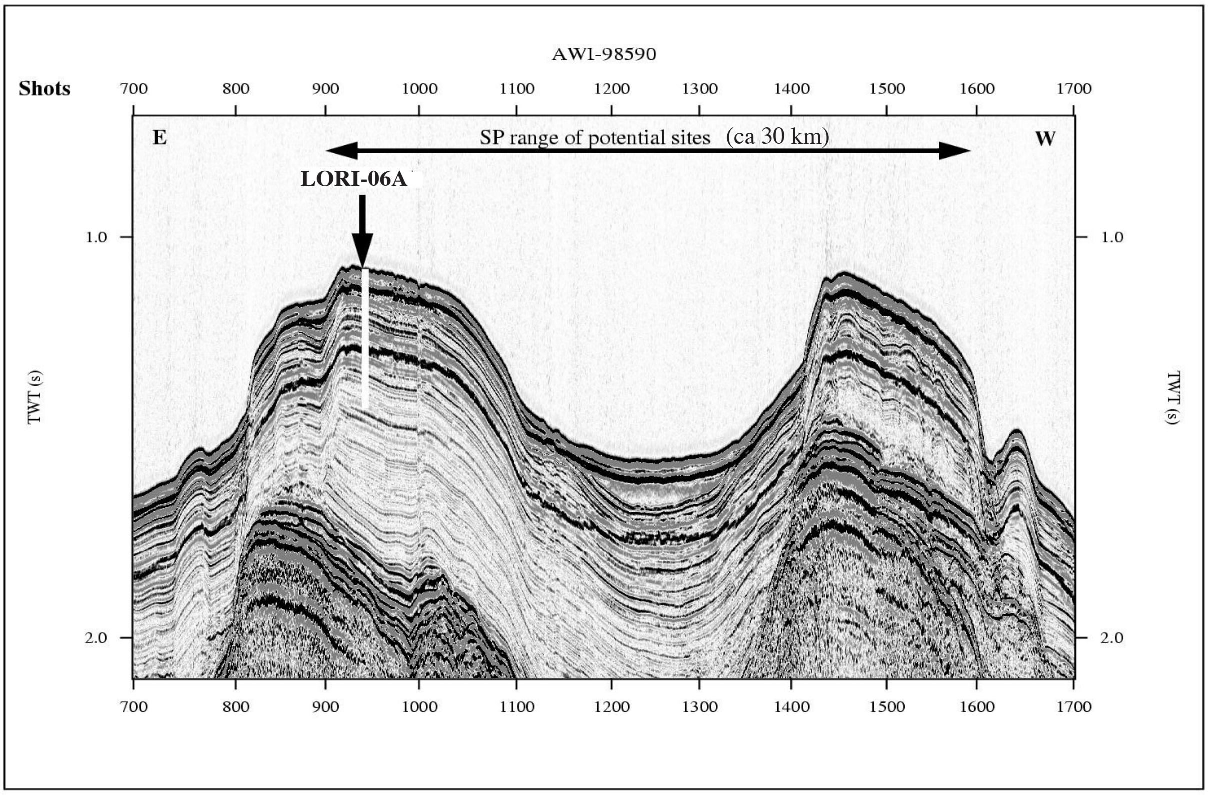


Figure 4. High resolution seismic profile (SCICEX chirp data) across the Lomonosov Ridge near Sites LORI-13A and LORI-14A. Geographic location is shown in Figure 1 (thick gray stippled line).



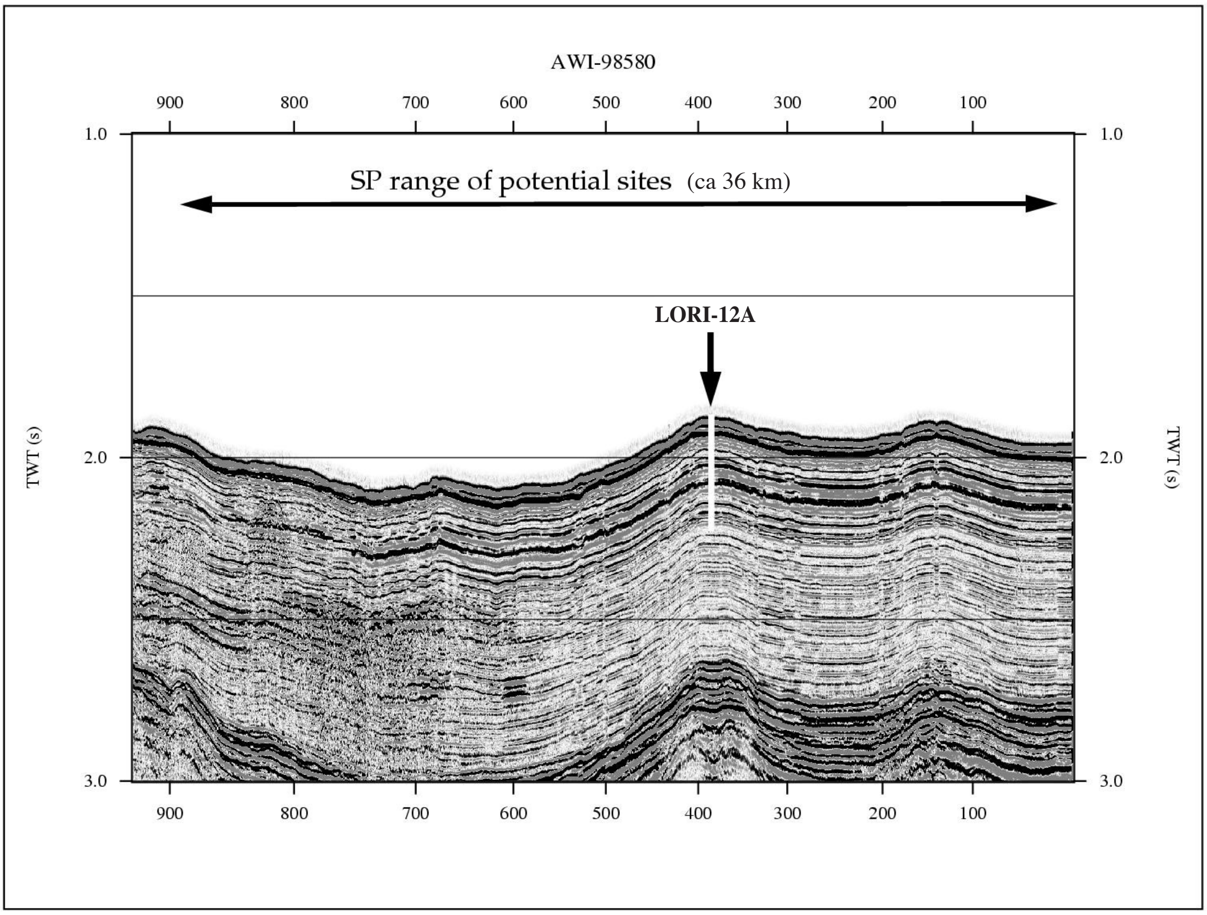


Figure 5. Primary (LORI-06A) and alternate (LORI-12A) high resolution Neogene sites from Priority Contingency Area (PCA) 2. Geographic locations are shown in Figure 1.

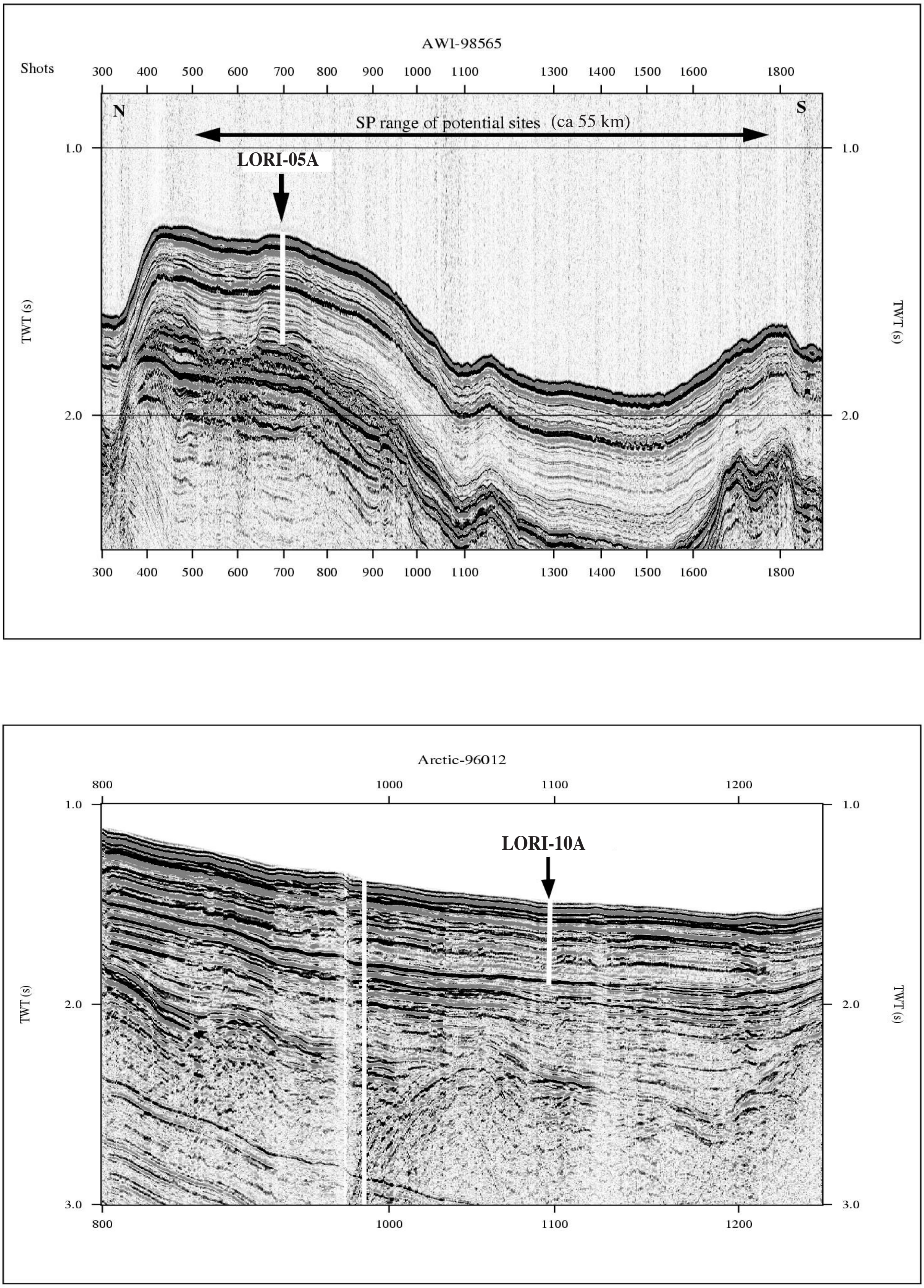


Figure 6. Primary paleoceanographic objectives can also be met by drilling in either Priority Contingency Area (PCA) 4 at Site LORI-10A (lower panel) or in PCA5 at Site LORI-05A (upper panel). Geographic locations are shown in Figure 1.

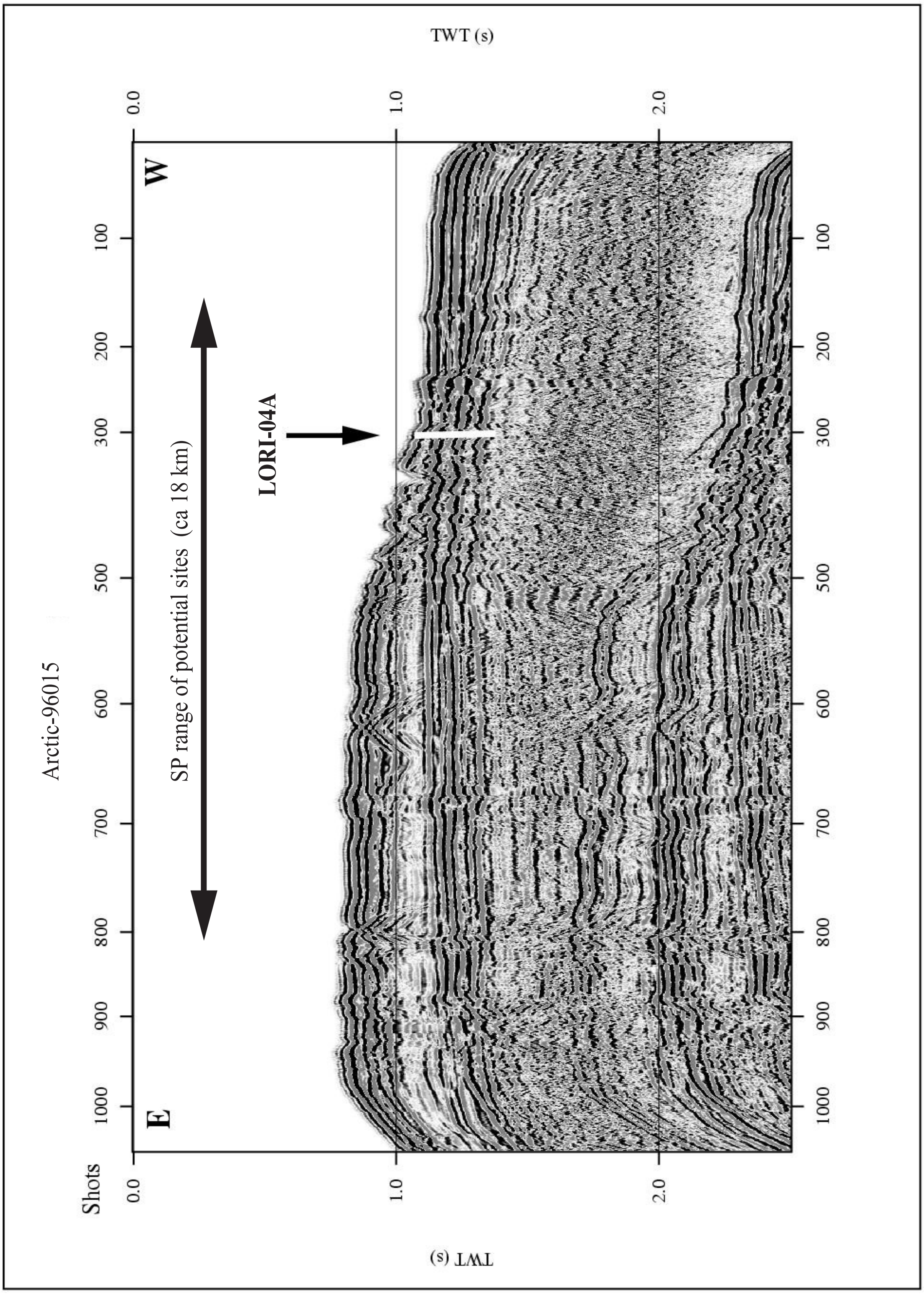


Figure 7. Reflection seismic cross-section of Lomonosov Ridge along profile Arctic-96015 from Priority Contingency Area (PCA) 4, showing relatively thin sediment cover (ca 70-90 m) above the regional unconformity at Site LORI-04A, designed to achieve tectonic objectives. Geographic location is shown in Figure 1.

iSAS/IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New ___ **Revised** _X_

Section A: Proposal Information

Title of Proposal:	Paleoceanographic and Tectonic Evolution of the Central Arctic Ocean
Date Form Submitted:	March 27, 2002
Site Specific Objectives with Priority (Must include general objectives in proposal)	1. Drill and sample the most complete stratigraphic pelagic sediment section to meet the paleoceanographic objectives for understanding the paleo Arctic Ocean circulation, its relationship with global climate, and changes in sediment flux to the basin. 2. Penetrate and sample acoustic basement to meet the tectonic objectives.
List Previous Drilling in Area:	N/A

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	LORI-13A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Lomonosov Ridge
Latitude:	Deg: 87	Min: 39.45	Jurisdiction:	International waters
Longitude:	Deg: 144	Min: 37.80	Distance to Land:	450 km
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: √	Alt:	Water Depth:	1070 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	450 What is the total sed. thickness? 450 m	30 m
		Total Penetration: 480 m
General Lithologies:	Silty clays, clays, siltstone, claystone	Continental crust rock: lithology is not known, but could range from volcanics to carboniferous rocks.
Coring Plan: *(Specify or check)*	Drill and sample 2 APC/XCB holes to 450 mbsf and 1 APC/XCB/RCB hole to 480 mbsf. 1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐ ** Systems Currently Under Development*	

Wireline Logging Plan:

Standard Tools		Special Tools				LWD	
Neutron-Porosity	√	Borehole Televiewer	☐	Formation Fluid Sampling	☐	Density-Neutron	☐
Litho-Density	√	Nuclear Magnetic Resonance	☐	Borehole Temperature & Pressure	☐	Resistivity-Gamma Ray	☐
Gamma Ray	√	Geochemical	☐	Borehole Seismic	☐	Acoustic	☐
Resistivity	√	Side-Wall Core Sampling	☐				
Acoustic	√						
Formation Image				Others ( )		Others ( )	

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ____________°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:

Drilling/Coring: 8	Logging: 2	Total On-Site: 10

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐
Shallow Water Flow	☐	Currents	☐	Methane Hydrate	☐
Abnormal Pressure	☐	Fractured Zone	☐	Diapir and Mud Volcano	☐
Man-made Objects	☐	Fault	☐	High Temperature	☐
H_2S	☐	High Dip Angle	☐	Ice Conditions	√
CO_2	☐				

What is your Weather window? (Preferable period with the reasons)

August - September

Form 2 - Site Survey Detail

iSAS/IODP Site Summary Forms:

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-13A	Date Form Submitted: 27 March 2002

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): AWI Parasound Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): UB 0103 airgun Location of Site on line SP 246 Crossing Lines(s): AWI 91091
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			SCICEX data
8a	Side-looking sonar (surface)			SCICEX data
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			SCICEX data
12	Sediment cores			Piston cores from Arctic '91 and '96
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			8/10 to 10/10
15	OBS microseismicity			
16	Navigation			GPS
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites;

Form 3 - Detailed Logging Plan

iSAS/IODP Site Summary Forms:

New *Revised X*

Proposal #: 533-Full3	Site #: LORI-13A	Date Form Submitted: 27 March 2002
Water Depth (m): 1070	Sed. Penetration (m): 450	Basement Penetration (m): 30

Do you need to use the conical side-entry sub (CSES) at this site? No
Are high temperatures expected at this site? No
Are there any other special requirements for logging at this site? No
If "Yes" Please describe requirements:____________________

____

What do you estimate the total logging time for this site to be: 48 hours

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Correlation of holes to seismic for paleoceanographic objectives	3
Litho-Density	Correlation of holes to seismic for paleoceanographic objectives	3
Natural Gamma Ray	Correlation of holes to seismic for paleoceanographic objectives	3
Resistivity-Induction	Correlation of holes to seismic for paleoceanographic objectives	3
Acoustic	Correlation of holes to seismic for paleoceanographic objectives	3
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New *Revised X*

Proposal #: 533-Full3	Site #: LORI-13A	Date Form Submitted: 27 March 2002

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple APC to refusal, XCB 30 m into basement and log.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	N/A
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	N/A
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Ice management is planned.
7	What abandonment procedures do you plan to follow:	Procedures are under development by JOI and JEODI. With four vessels located near one another, the overall risk is lower than with a single vessel operation.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Ice – refer to the JOIDES Arctic Detailed Planning Group Report
9	Summary: What do you consider the major risks in drilling at this site?	Ice could delay operations. If poor ice conditions exist in one Priority Contingency Area (PCA), we would move to a more ice favorable PCA area.

Form 5 – Lithologic Summary

iSAS/IODP Site Summary Forms:

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-13A	Date Form Submitted: 27 March 2002

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0-450			2.2	Mudstone	pelagic	10	
450	Unconformity	Paleo-gene	6	Continental crustal rock – lithology unknown			

iSAS/IODP Site Summary Forms:
Form 1 - General Site Information
Please fill out information in all gray boxes
Revised 7 March 2002

New _ Revised X

Section A: Proposal Information

Title of Proposal:	Paleoceanographic and Tectonic Evolution of the Central Artic Ocean
Date Form Submitted:	March 27, 2002
Site Specific Objectives with Priority (Must include general objectives in proposal)	Drill and sample a complete stratigraphic pelagic sediment section to meet paleoceanographic objectives for understanding the paleo Arctic Ocean circulation, it relationship with global climate, and changes in sediment flux to the basin.
List Previous Drilling in Area:	N/A

Section B: General Site Information

Site Name:	LORI-08A		Area or Location:	Lomonosov Ridge
Latitude:	Deg: 87	Min: 53.9	Jurisdiction:	International Waters
Longitude:	Deg: 138	Min: 38.6	Distance to Land:	430 km
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary:	Alt: √	Water Depth:	1124 m

Section C: Operational Information

	Sediments			Basement
Proposed Penetration: (m)	450 m			0 m
	What is the total sed. thickness?	450	m	
			Total Penetration:	450 m
General Lithologies:	Silty clays, clays, siltstone, claystone			
Coring Plan: *(Specify or check)*	Drill and sample 3 APC/XCB holes to 450 mbsf.			
	1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐			
	* *Systems Currently Under Development*			

Wireline Logging Plan:

Standard Tools		Special Tools		LWD
Neutron-Porosity	√	Borehole Televiewer ☐ ☐	Formation Fluid Sampling ☐ ☐	Density-Neutron ☐ ☐
Litho-Density	√	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
Gamma Ray	√	Geochemical ☐	Borehole Seismic	Acoustic
Resistivity	√	Side-Wall Core Sampling		
Acoustic	√			
Formation Image			Others ( )	Others ( )

Max.Borehole Temp. :	*Expected value (For Riser Drilling)* ________°C
Mud Logging: *(Riser Holes Only)*	Cuttings Sampling Intervals from m to m, m intervals from m to m, m intervals *Basic Sampling Intervals: 5m*
Estimated days:	Drilling/Coring: 7 — Logging: 2 — Total On-Site: 9
Future Plan:	*Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards			*What is your Weather window? (Preferable period with the reasons)*
Shallow Gas ☐ ☐	Complicated Seabed Condition ☐ ☐	Hydrothermal Activity ☐ ☐	Aug. – Sept.
Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐	
Shallow Water Flow ☐	Currents ☐	Methane Hydrate ☐	
Abnormal Pressure ☐	Fractured Zone ☐	Diapir and Mud Volcano ☐	
Man-made Objects ☐	Fault ☐	High Temperature ☐	
H_2S ☐	High Dip Angle	Ice Conditions √	
CO_2			

iSAS/IODP Site Summary Forms:

Form 2 - Site Survey Detail

Please fill out information in all gray boxes

New _ *Revised* *X*

Proposal #: 533-Full3	Site #: LORI-08A	Date Form Submitted: March 27, 2002

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): AWI Parasound Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): AWI 91090 Airgun Location of Site on line (SP or Time only): SP 2700 Crossing Lines(s):
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			SCICEX data
8a	Side-looking sonar (surface)			SCICEX data
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			SCICEX data
12	Sediment cores			Piston cores from Arctic '91 and '96
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			8/10 to 10/10
15	OBS microseismicity			
16	Navigation			GPS
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific

iSAS/IODP Site Summary Forms:

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-08A	Date Form Submitted: March 27, 2002
Water Depth (m): 1124	Sed. Penetration (m): 450	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? No
Are high temperatures expected at this site? No
Are there any other special requirements for logging at this site? No
If "Yes" Please describe requirements:______________________________

What do you estimate the total logging time for this site to be: 40 hours

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Correlation of holes to seismic for paleoceanographic objectives	3
Litho-Density	Correlation of holes to seismic for paleoceanographic objectives	3
Natural Gamma Ray	Correlation of holes to seismic for paleoceanographic objectives	3
Resistivity-Induction	Correlation of holes to seismic for paleoceanographic objectives	3
Acoustic	Correlation of holes to seismic for paleoceanographic objectives	3
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-08A	Date Form Submitted: March 27, 2002

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple APC/XCB to 450 mbsf and log.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	N/A
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	N/A
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What “special” precautions will be taken during drilling?	Ice management is planned.
7	What abandonment procedures do you plan to follow:	Procedures are under development by JOI and JEODI. With four vessels located near one another, the overall risk is lower than with w single vessel operation.
8	Please list other natural or manmade hazards which may effect ship’s operations: (e.g. ice, currents, cables)	Ice – refer to the JOIDES Arctic Detailed Planning Group Report.
9	Summary: What do you consider the major risks in drilling at this site?	Ice could delay operations. If poor ice conditions exist in one Priority Contingency Area (PCA), we would move to a more ice favorable PCA area.

Form 5 – Lithologic Summary

iSAS/IODP Site Summary Forms:

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-08A	Date Form Submitted: March 27, 2002

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
0-450			1.5	Mudstone	Pelagic	10	

iSAS/IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New _ **Revised X**

Section A: Proposal Information

Title of Proposal:	Paleoceanographic and Tectonic Evolution of the Central Artic Ocean
Date Form Submitted:	March 27, 2002
Site Specific Objectives with Priority (Must include general objectives in proposal)	Penetrate and sample acoustic basement to meet the tectonic objectives.
List Previous Drilling in Area:	N/A

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	LORI-14A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Lomonosov Ridge
Latitude:	Deg: 87	Min: 37.55	Jurisdiction:	International Waters
Longitude:	Deg: 147	Min: 14.65	Distance to Land:	450 km
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary:	Alt: √	Water Depth:	1415 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	90 What is the total sed. thickness? 90 m	110 m
		Total Penetration: 200 m
General Lithologies:	Silty clays, clays, siltstone, claystone	Continental crust rock: lithology is not known, but could range from volcanics to carboniferous rocks.

Coring Plan: *(Specify or check)*	Drill and sample a single RCB hole to 200 mbsf. 1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐ ** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity	Borehole Televiewer ☐	Formation Fluid Sampling ☐	Density-Neutron ☐
Litho-Density	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
Gamma Ray	Geochemical ☐	Borehole Seismic ☐	Acoustic ☐
Resistivity	Side-Wall Core Sampling ☐		
Acoustic			
Formation Image		Others ( )	Others ( )

Max.Borehole Temp. :	*Expected value (For Riser Drilling)* ____________°C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring: 3	Logging: 0	Total On-Site: 3

Future Plan:	*Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas ☐	Complicated Seabed Condition ☐	Hydrothermal Activity ☐
Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐
Shallow Water Flow ☐	Currents ☐	Methane Hydrate ☐
Abnormal Pressure ☐	Fractured Zone ☐	Diapir and Mud Volcano ☐
Man-made Objects ☐	Fault ☐	High Temperature ☐
H_2S ☐	High Dip Angle ☐	Ice Conditions √
CO_2 ☐		

What is your Weather window? (Preferable period with the reasons)

August - September

Form 2 - Site Survey Detail

iSAS/IODP Site Summary Forms:

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-14A	Date Form Submitted: March 27, 2002

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): AWI 9Parasound Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): UB0105 Airgun Location of Site on line (SP or Time only): SP 240 Crossing Lines(s): AWI 91091
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			SCICEX data
8a	Side-looking sonar (surface)			SCICEX data
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			SCICEX data
12	Sediment cores			Piston cores from Arctic '91 and '96
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			8/10 to 10/10
15	OBS microseismicity			
16	Navigation			GPS
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for

Form 3 - Detailed Logging Plan

iSAS/IODP Site Summary Forms:

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-14A	Date Form Submitted: March 27, 2002
Water Depth (m): 1415	Sed. Penetration (m): 90	Basement Penetration (m): 110

Do you need to use the conical side-entry sub (CSES) at this site? No
Are high temperatures expected at this site? No
Are there any other special requirements for logging at this site? No
If "Yes" Please describe requirements:____________________

What do you estimate the total logging time for this site to be: 0 hours

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity		
Litho-Density		
Natural Gamma Ray		
Resistivity-Induction		
Acoustic		
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-14A	Date Form Submitted: March 27, 2002

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Drill and sample a single RCB hole to 200 mbsf into basement.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	N/A
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	N/A
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Ice management is planned.
7	What abandonment procedures do you plan to follow:	Procedures are under development by JOI and JEODI. With four vessels located near one another, the overall risk is lower than with w single vessel operation.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Ice – refer to the JOIDES Arctic Detailed Planning Group Report.
9	Summary: What do you consider the major risks in drilling at this site?	Ice could delay operations. If poor ice conditions exist in one Priority Contingency Area (PCA), we would move to a more ice favorable PCA area.

Form 5 – Lithologic Summary

iSAS/IODP Site Summary Forms:

New _ *Revised* *X*

Proposal #: 533-Full3	Site #: LORI-14A	Date Form Submitted: March 27, 2002

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
90	Unconformity	Paleo-gene	6	Continental crustal rock – lithology unknown			

iSAS/IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New _ **Revised X**

Section A: Proposal Information

Title of Proposal:	Paleoceanographic and Tectonic Evolution of the Central Artic Ocean
Date Form Submitted:	March 27, 2002
Site Specific Objectives with Priority (Must include general objectives in proposal)	Drill and sample the most complete stratigraphic pelagic sediment section to meet paleoceanographic objectives for Neogene climate history.
List Previous Drilling in Area:	N/A

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	LORI-06A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Lomonosov Ridge
Latitude:	Deg: 81	Min: 28.54	Jurisdiction:	International Waters
Longitude:	Deg: 140	Min: 50.71	Distance to Land:	320 km
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: √	Alt:	Water Depth:	802 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	400 What is the total sed. thickness? 400 m	0 m
		Total Penetration: 400 m
General Lithologies:	Silty clays, clays, siltstone, claystone	
Coring Plan: *(Specify or check)*	Drill and sample 3 APC/XCB holes to 400 mbsf. 1-2-3-APC ☐ VPC ☐ * XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐ ** Systems Currently Under Development*	

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity √	Borehole Televiewer ☐	Formation Fluid Sampling ☐	Density-Neutron ☐
Litho-Density √	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
Gamma Ray √	Geochemical ☐	Borehole Seismic ☐	Acoustic ☐
Resistivity √	Side-Wall Core Sampling ☐		
Acoustic √			
Formation Image √		Others ( )	Others ( )

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ______ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:

Drilling/Coring: 6	Logging: 2	Total On-Site: 8

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas ☐	Complicated Seabed Condition ☐	Hydrothermal Activity ☐
Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐
Shallow Water Flow ☐	Currents ☐	Methane Hydrate ☐
Abnormal Pressure ☐	Fractured Zone ☐	Diapir and Mud Volcano ☐
Man-made Objects ☐	Fault ☐	High Temperature ☐
H_2S ☐	High Dip Angle ☐	Ice Conditions √
CO_2 ☐		

What is your Weather window? (Preferable period with the reasons)

August - September

Form 2 - Site Survey Detail

iSAS/IODP Site Summary Forms:

Please fill out information in all gray boxes

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-06A	Date Form Submitted: March 27, 2002

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Parasound Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): AWI 98590 Airgun Location of Site on line (SP or Time only): SP 950 Crossing Lines(s):
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			SCICEX data
8a	Side-looking sonar (surface)			SCICEX data
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			SCICEX data
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			8/10 to 10/10
15	OBS microseismicity			
16	Navigation			GPS
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

iSAS/IODP Site Summary Forms:

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-06A	Date Form Submitted: March 27, 2002
Water Depth (m): 802	Sed. Penetration (m): 400	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? No
Are high temperatures expected at this site? No
Are there any other special requirements for logging at this site? No
If "Yes" Please describe requirements:____________________

What do you estimate the total logging time for this site to be: 40 hours

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Correlation of holes to seismic for paleoceanographic objectives	3
Litho-Density	Correlation of holes to seismic for paleoceanographic objectives	3
Natural Gamma Ray	Correlation of holes to seismic for paleoceanographic objectives	3
Resistivity-Induction	Correlation of holes to seismic for paleoceanographic objectives	3
Acoustic	Correlation of holes to seismic for paleoceanographic objectives	3
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-06A	Date Form Submitted: March 27, 2002

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple APC/XCB to 400 mbsf and log.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	N/A
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	N/A
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Ice management is planned.
7	What abandonment procedures do you plan to follow:	Procedures are under development by JOI and JEODI. With four vessels located near one another, the overall risk is lower than with w single vessel operation.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Ice – refer to the JOIDES Arctic Detailed Planning Group Report.
9	Summary: What do you consider the major risks in drilling at this site?	Ice could delay operations. If poor ice conditions exist in one Priority Contingency Area (PCA), we would move to a more ice favorable PCA area.

Form 5 – Lithologic Summary

iSAS/IODP Site Summary Forms:

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-06A	Date Form Submitted: March 27, 2002

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
400		Neo-gene	2.2	Mudstone	Pelagic	~15	

iSAS/IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New _ **Revised** X

Section A: Proposal Information

Title of Proposal:	Paleoceanographic and Tectonic Evolution of the Central Artic Ocean
Date Form Submitted:	March 27, 2002
Site Specific Objectives with Priority (Must include general objectives in proposal)	Drill and sample the most complete stratigraphic pelagic sediment section to meet paleoceanographic objectives for Neogene climate history.
List Previous Drilling in Area:	N/A

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	LORI-12A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Lomonosov Ridge
Latitude:	Deg: 82	Min: 04.3	Jurisdiction:	International Waters
Longitude:	Deg: 142	Min: 02.6	Distance to Land:	340 km
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary:	Alt: √	Water Depth:	1392 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	400	0 m
	What is the total sed. thickness? 400 m	
		Total Penetration: 400 m
General Lithologies:	Silty clays, clays, siltstone, claystone	

Coring Plan: *(Specify or check)*

Drill and sample 3 APC/XCB holes to 400 mbsf.

1-2-3-APC ☐ VPC ☐ * XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐

** Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity √	Borehole Televiewer ☐	Formation Fluid Sampling ☐	Density-Neutron ☐
Litho-Density √	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
Gamma Ray √	Geochemical ☐	Borehole Seismic ☐	Acoustic ☐
Resistivity √	Side-Wall Core Sampling ☐		
Acoustic √			
Formation Image √		Others ( )	Others ( )

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ________ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:

Drilling/Coring: 6	Logging: 2	Total On-Site: 8

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas ☐	Complicated Seabed Condition ☐	Hydrothermal Activity ☐
Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐
Shallow Water Flow ☐	Currents ☐	Methane Hydrate ☐
Abnormal Pressure ☐	Fractured Zone ☐	Diapir and Mud Volcano ☐
Man-made Objects ☐	Fault ☐	High Temperature ☐
H_2S ☐	High Dip Angle ☐	Ice Conditions √
CO_2 ☐		

What is your Weather window? (Preferable period with the reasons)

August - September

Form 2 - Site Survey Detail

iSAS/IODP Site Summary Forms:

Please fill out information in all gray boxes

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-12A	Date Form Submitted: March 27, 2002

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Parasound Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): AWI 98580 Airgun Location of Site on line (SP or Time only): SP 400 Crossing Lines(s):
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			SCICEX data
8a	Side-looking sonar (surface)			SCICEX data
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			SCICEX data
12	Sediment cores			
13	Rock sampling			PS51/067-1 sl
14a	Water current data			
14b	Ice Conditions			8/10 to 10/10
15	OBS microseismicity			
16	Navigation			GPS
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m

Form 3 - Detailed Logging Plan

iSAS/IODP Site Summary Forms:

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-12A	Date Form Submitted: March 27, 2002
Water Depth (m): 1392	Sed. Penetration (m): 400	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? No
Are high temperatures expected at this site? No
Are there any other special requirements for logging at this site? No
If "Yes" Please describe requirements:______________________________

____

What do you estimate the total logging time for this site to be: 40 hours

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Correlation of holes to seismic for paleoceanographic objectives	3
Litho-Density	Correlation of holes to seismic for paleoceanographic objectives	3
Natural Gamma Ray	Correlation of holes to seismic for paleoceanographic objectives	3
Resistivity-Induction	Correlation of holes to seismic for paleoceanographic objectives	3
Acoustic	Correlation of holes to seismic for paleoceanographic objectives	3
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-12A	Date Form Submitted: March 27, 2002

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple APC/XCB to 400 mbsf and log.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	N/A
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	N/A
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Ice management is planned.
7	What abandonment procedures do you plan to follow:	Procedures are under development by JOI and JEODI. With four vessels located near one another, the overall risk is lower than with w single vessel operation.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Ice – refer to the JOIDES Arctic Detailed Planning Group Report.
9	Summary: What do you consider the major risks in drilling at this site?	Ice could delay operations. If poor ice conditions exist in one Priority Contingency Area (PCA), we would move to a more ice favorable PCA area.

Form 5 – Lithologic Summary

iSAS/IODP Site Summary Forms:

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-12A	Date Form Submitted: March 27, 2002

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
400		Neo-gene	2.2	Mudstone	Pelagic	~15	

iSAS/IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New _ **Revised** X

Section A: Proposal Information

Title of Proposal:	Paleoceanographic and Tectonic Evolution of the Central Artic Ocean
Date Form Submitted:	March 27, 2002
Site Specific Objectives with Priority (Must include general objectives in proposal)	Penetrate and sample acoustic basement to meet the tectonic objectives.
List Previous Drilling in Area:	N/A

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	LORI-04A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Lomonosov Ridge
Latitude:	Deg: 85	Min: 23.28	Jurisdiction:	International Waters
Longitude:	Deg: 150	Min: 20.62	Distance to Land:	450 km
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: √	Alt:	Water Depth:	794 m

Section C: Operational Information

	Sediments		Basement
Proposed Penetration: (m)	170		30 m
	What is the total sed. thickness?	170 m	
		Total Penetration:	200 m
General Lithologies:	Silty clays, clays, siltstone, claystone		Continental crust rock: lithology is not known, but could range from volcanics to carboniferous rocks.
Coring Plan: *(Specify or check)*	Drill and sample a single RCB hole to 200 mbsf.		

1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐

Systems Currently Under Development ☐

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity ☐	Borehole Televiewer ☐	Formation Fluid Sampling ☐	Density-Neutron ☐
Litho-Density ☐	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
Gamma Ray ☐	Geochemical ☐	Borehole Seismic ☐	Acoustic ☐
Resistivity ☐	Side-Wall Core Sampling ☐		
Acoustic ☐			
Formation Image ☐		Others ( )	Others ( )

Max.Borehole Temp. : *Expected value (For Riser Drilling)*

________ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring: 3	Logging: 0	Total On-Site: 3

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas ☐	Complicated Seabed Condition ☐	Hydrothermal Activity ☐
Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐
Shallow Water Flow ☐	Currents ☐	Methane Hydrate ☐
Abnormal Pressure ☐	Fractured Zone ☐	Diapir and Mud Volcano ☐
Man-made Objects ☐	Fault ☐	High Temperature ☐
H_2S ☐	High Dip Angle ☐	Ice Conditions √
CO_2 ☐		

What is your Weather window? (Preferable period with the reasons)

August - September

Form 2 - Site Survey Detail

iSAS/IODP Site Summary Forms:

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-04A	Date Form Submitted: March 27, 2002

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): AWI 9Parasound Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): AWI 96015 Location of Site on line (SP or Time only): SP 300 Crossing Lines(s):
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			SCICEX data
8a	Side-looking sonar (surface)			SCICEX data
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			SCICEX data
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			8/10 to 10/10
15	OBS microseismicity			
16	Navigation			GPS
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for

Form 3 - Detailed Logging Plan

iSAS/IODP Site Summary Forms:

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-04A	Date Form Submitted: March 27, 2002
Water Depth (m): 794	Sed. Penetration (m): 170	Basement Penetration (m): 30

Do you need to use the conical side-entry sub (CSES) at this site? No
Are high temperatures expected at this site? No
Are there any other special requirements for logging at this site? No
If "Yes" Please describe requirements:________________________________

____

What do you estimate the total logging time for this site to be: 0 hours

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity		
Litho-Density		
Natural Gamma Ray		
Resistivity-Induction		
Acoustic		
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-04A	Date Form Submitted: March 27, 2002

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Drill and sample a single RCB hole to 200 mbsf into basement.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	N/A
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	N/A
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Ice management is planned.
7	What abandonment procedures do you plan to follow:	Procedures are under development by JOI and JEODI. With four vessels located near one another, the overall risk is lower than with w single vessel operation.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Ice – refer to the JOIDES Arctic Detailed Planning Group Report.
9	Summary: What do you consider the major risks in drilling at this site?	Ice could delay operations. If poor ice conditions exist in one Priority Contingency Area (PCA), we would move to a more ice favorable PCA area.

Form 5 – Lithologic Summary

iSAS/IODP Site Summary Forms:

New _ *Revised* *X*

Proposal #: 533-Full3	Site #: LORI-04A	Date Form Submitted: March 27, 2002

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
170	Unconformity	Paleo-gene	6	Continental crustal rock – lithology unknown			

iSAS/IODP Site Summary Forms:
Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New _ **Revised** **X**

Section A: Proposal Information

Title of Proposal:	Paleoceanographic and Tectonic Evolution of the Central Artic Ocean
Date Form Submitted:	March 27, 2002
Site Specific Objectives with Priority (Must include general objectives in proposal)	Drill and sample the most complete stratigraphic pelagic sediment section to meet paleoceanographic objectives.
List Previous Drilling in Area:	N/A

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	LORI-05A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Lomonosov Ridge
Latitude:	Deg: 83	Min: 58.90	Jurisdiction:	International Waters
Longitude:	Deg: 147	Min: 25.02	Distance to Land:	400 km
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: √	Alt:	Water Depth:	989 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	400 What is the total sed. thickness? 400 m	0 m
		Total Penetration: 400 m
General Lithologies:	Silty clays, clays, siltstone, claystone	
Coring Plan: *(Specify or check)*	Drill and sample 3 APC/XCB holes to 400 mbsf.	
	1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐	*Systems Currently Under Development*

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity √	Borehole Televiewer ☐	Formation Fluid Sampling ☐	Density-Neutron ☐
Litho-Density √	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
Gamma Ray √	Geochemical ☐	Borehole Seismic ☐	Acoustic ☐
Resistivity √	Side-Wall Core Sampling ☐		
Acoustic √			
Formation Image √		Others ( )	Others ( )

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ____________ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from	m	to	m,		m intervals
from	m	to	m,		m intervals

Basic Sampling Intervals: 5m

Estimated days:

Drilling/Coring: 6	Logging: 2	Total On-Site: 8

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas ☐	Complicated Seabed Condition ☐	Hydrothermal Activity ☐
Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐
Shallow Water Flow ☐	Currents ☐	Methane Hydrate ☐
Abnormal Pressure ☐	Fractured Zone ☐	Diapir and Mud Volcano ☐
Man-made Objects ☐	Fault ☐	High Temperature ☐
H_2S ☐	High Dip Angle ☐	Ice Conditions √
CO_2 ☐		

What is your Weather window? (Preferable period with the reasons)

August - September

Form 2 - Site Survey Detail

iSAS/IODP Site Summary Forms:

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-05A	Date Form Submitted: March 27, 2002

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Parasound Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): AWI 98565 Airgun Location of Site on line (SP or Time only): SP 700 Crossing Lines(s):
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			SCICEX data
8a	Side-looking sonar (surface)			SCICEX data
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			SCICEX data
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			8/10 to 10/10
15	OBS microseismicity			
16	Navigation			GPS
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m.

Form 3 - Detailed Logging Plan

iSAS/IODP Site Summary Forms:

New _   *Revised X*

Proposal #: 533-Full3	Site #: LORI-05A	Date Form Submitted: March 27, 2002
Water Depth (m): 989	Sed. Penetration (m): 400	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? No
Are high temperatures expected at this site? No
Are there any other special requirements for logging at this site? No
If "Yes" Please describe requirements:______________________________

____

What do you estimate the total logging time for this site to be: 40 hours

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Correlation of holes to seismic for paleoceanographic objectives	3
Litho-Density	Correlation of holes to seismic for paleoceanographic objectives	3
Natural Gamma Ray	Correlation of holes to seismic for paleoceanographic objectives	3
Resistivity-Induction	Correlation of holes to seismic for paleoceanographic objectives	3
Acoustic	Correlation of holes to seismic for paleoceanographic objectives	3
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New _ *Revised* *X*

Proposal #: 533-Full3	Site #: LORI-05A	Date Form Submitted: March 27, 2002

#		
1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple APC/XCB to 400 mbsf and log.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	N/A
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	N/A
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Ice management is planned.
7	What abandonment procedures do you plan to follow:	Procedures are under development by JOI and JEODI. With four vessels located near one another, the overall risk is lower than with w single vessel operation.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Ice – refer to the JOIDES Arctic Detailed Planning Group Report.
9	Summary: What do you consider the major risks in drilling at this site?	Ice could delay operations. If poor ice conditions exist in one Priority Contingency Area (PCA), we would move to a more ice favorable PCA area.

Form 5 – Lithologic Summary

iSAS/IODP Site Summary Forms:

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-05A	Date Form Submitted: March 27, 2002

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
400		Neo-gene?	2.2	Mudstone	Pelagic	10-15?	

iSAS/IODP Site Summary Forms:

Form 1 - General Site Information

Please fill out information in all gray boxes
Revised 7 March 2002

New _ **Revised X**

Section A: Proposal Information

Title of Proposal:	Paleoceanographic and Tectonic Evolution of the Central Artic Ocean
Date Form Submitted:	March 27, 2002
Site Specific Objectives with Priority (Must include general objectives in proposal)	Drill and sample the most complete stratigraphic pelagic sediment section to meet paleoceanographic objectives.
List Previous Drilling in Area:	N/A

Section B: General Site Information

Site Name: (e.g. SWPAC-01A)	LORI-10A	If site is a reoccupation of an old DSDP/ODP Site, Please include former Site #	Area or Location:	Lomonosov Ridge
Latitude:	Deg: 86	Min: 24.89	Jurisdiction:	International Waters
Longitude:	Deg: 147	Min: 15.56	Distance to Land:	500 km
Coordinates System:	WGS 84, Other ( )			
Priority of Site:	Primary: √	Alt:	Water Depth:	1132 m

Section C: Operational Information

	Sediments	Basement
Proposed Penetration: (m)	400 What is the total sed. thickness? 400 m	0 m
		Total Penetration: 400 m
General Lithologies:	Silty clays, clays, siltstone, claystone	

Coring Plan: *(Specify or check)*	Drill and sample 3 APC/XCB holes to 400 mbsf.
	1-2-3-APC ☐ VPC* ☐ XCB ☐ MDCB* ☐ PCS ☐ RCB ☐ Re-entry ☐ HRGB ☐
	Systems Currently Under Development

Wireline Logging Plan:

Standard Tools	Special Tools		LWD
Neutron-Porosity √	Borehole Televiewer ☐	Formation Fluid Sampling ☐	Density-Neutron ☐
Litho-Density √	Nuclear Magnetic Resonance ☐	Borehole Temperature & Pressure ☐	Resistivity-Gamma Ray ☐
Gamma Ray √	Geochemical ☐	Borehole Seismic ☐	Acoustic ☐
Resistivity √	Side-Wall Core Sampling ☐		
Acoustic √			
Formation Image √		Others ( )	Others ( )

Max.Borehole Temp. : *Expected value (For Riser Drilling)* ____________ °C

Mud Logging: *(Riser Holes Only)*

Cuttings Sampling Intervals

from m to m, m intervals

from m to m, m intervals

Basic Sampling Intervals: 5m

Estimated days:	Drilling/Coring: 6	Logging: 2	Total On-Site: 8

Future Plan: *Longterm Borehole Observation Plan/Re-entry Plan*

Hazards/ Weather:

Please check following List of Potential Hazards

Shallow Gas ☐	Complicated Seabed Condition ☐	Hydrothermal Activity ☐
Hydrocarbon ☐	Soft Seabed ☐	Landslide and Turbidity Current ☐
Shallow Water Flow ☐	Currents ☐	Methane Hydrate ☐
Abnormal Pressure ☐	Fractured Zone ☐	Diapir and Mud Volcano ☐
Man-made Objects ☐	Fault ☐	High Temperature ☐
H_2S ☐	High Dip Angle ☐	Ice Conditions √
CO_2 ☐		

What is your Weather window? (Preferable period with the reasons)

August - September

Form 2 - Site Survey Detail

iSAS/IODP Site Summary Forms:

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-10A	Date Form Submitted: March 27, 2002

	Data Type	SSP Requir-ements	Exists In DB	Details of available data and data that are still to be collected
1	High resolution seismic reflection			Primary Line(s): Parasound Location of Site on line (SP or Time only) Crossing Lines(s):
2	Deep Penetration seismic reflection			Primary Line(s): AWI 96012 Airgun Location of Site on line (SP or Time only): SP1100 Crossing Lines(s):
3	Seismic Velocity†			
4	Seismic Grid			
5a	Refraction (surface)			
5b	Refraction (near bottom)			
6	3.5 kHz			Location of Site on line (Time)
7	Swath bathymetry			SCICEX data
8a	Side-looking sonar (surface)			SCICEX data
8b	Side-looking sonar (bottom)			
9	Photography or Video			
10	Heat Flow			
11a	Magnetics			
11b	Gravity			SCICEX data
12	Sediment cores			
13	Rock sampling			
14a	Water current data			
14b	Ice Conditions			8/10 to 10/10
15	OBS microseismicity			
16	Navigation			GPS
17	Other			

SSP Classification of Site:	SSP Watchdog:	Date of Last Review:
SSP Comments:		

X=required; X*=may be required for specific sites; Y=recommended; Y*=may be recommended for specific sites; R=required for re-entry sites; T=required for high temperature environments; † Accurate velocity information is required for holes deeper than 400m

Form 3 - Detailed Logging Plan

iSAS/IODP Site Summary Forms:

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-10A	Date Form Submitted: March 27, 2002
Water Depth (m): 989	Sed. Penetration (m): 400	Basement Penetration (m): 0

Do you need to use the conical side-entry sub (CSES) at this site? No
Are high temperatures expected at this site? No
Are there any other special requirements for logging at this site? No
If "Yes" Please describe requirements:____________________

____

What do you estimate the total logging time for this site to be: 40 hours

Measurement Type	Scientific Objective	Relevance (1=high, 3=Low)
Neutron-Porosity	Correlation of holes to seismic for paleoceanographic objectives	3
Litho-Density	Correlation of holes to seismic for paleoceanographic objectives	3
Natural Gamma Ray	Correlation of holes to seismic for paleoceanographic objectives	3
Resistivity-Induction	Correlation of holes to seismic for paleoceanographic objectives	3
Acoustic	Correlation of holes to seismic for paleoceanographic objectives	3
FMS		
BHTV		
Resistivity-Laterolog		
Magnetic/Susceptibility		
Density-Neutron (LWD)		
Resitivity-Gamma Ray (LWD)		
Other: Special tools (CORK, PACKER, VSP, PCS, FWS, WSP		

For help in determining logging times, please contact the ODP-LDEO Wireline Logging Services group at: borehole@ldeo.columbia.edu http://www.ldeo.columbia.edu/BRG/brg_home.html Phone/Fax: (914) 365-8674 / (914) 365-3182	Note: Sites with greater than 400 m of penetration or significant basement penetration require deployment of standard toolstrings.

iSAS/IODP Site Summary Forms:

Form 4 – Pollution & Safety Hazard Summary

Please fill out information in all gray boxes

New _ *Revised X*

Proposal #: 533-Full3	Site #: LORI-10A	Date Form Submitted: March 27, 2002

1	Summary of Operations at site: (Example: Triple-APC to refusal, XCB 10 m into basement, log as shown on page 3.)	Triple APC/XCB to 400 mbsf and log.
2	Based on Previous DSDP/ODP drilling, list all hydrocarbon occurrences of greater than background levels. Give nature of show, age and depth of rock:	N/A
3	From Available information, list all commercial drilling in this area that produced or yielded significant hydrocarbon shows. Give depths and ages of hydrocarbon-bearing deposits.	N/A
4	Are there any indications of gas hydrates at this location?	No
5	Are there reasons to expect hydrocarbon accumulations at this site? Please give details.	No
6	What "special" precautions will be taken during drilling?	Ice management is planned.
7	What abandonment procedures do you plan to follow:	Procedures are under development by JOI and JEODI. With four vessels located near one another, the overall risk is lower than with w single vessel operation.
8	Please list other natural or manmade hazards which may effect ship's operations: (e.g. ice, currents, cables)	Ice – refer to the JOIDES Arctic Detailed Planning Group Report.
9	Summary: What do you consider the major risks in drilling at this site?	Ice could delay operations. If poor ice conditions exist in one Priority Contingency Area (PCA), we would move to a more ice favorable PCA area.

Form 5 – Lithologic Summary

iSAS/IODP Site Summary Forms:

New _ *Revised* X

Proposal #: 533-Full3	Site #: LORI-10A	Date Form Submitted: March 27, 2002

Sub-bottom depth (m)	*Key reflectors, Unconformities, faults, etc*	*Age*	*Assumed velocity (km/sec)*	*Lithology*	*Paleo-environment*	*Avg. rate of sed. accum. (m/My)*	*Comments*
400		Neo-gene?	2.2	Mudstone	Pelagic	10	

CURRICULUM VITAE
JAN BACKMAN

Business Address
Department of Geology and Geochemistry
Stockholm University
SE-106 91 Stockholm, Sweden
Phone: (46) (8) 164720 Fax: (46) (8) 674 7861 Email: backman@geo.su.se

Education

1985	Docent, Stockholm university (SU)
1980	Filosofie doktor (Ph.D. - SU)
1974	Filosofie kandidat (B.Sc. - SU)

Professional experience

1997-	Professor of General and Historical Geology (SU)
1988-97	University Lecturer (SU)
1986-87	University Lecturer, University of Cambridge (UK)
1982-88	Senior Research Scientist (Swedish Research Council - NFR/SU)
1982	Research Scientist (NFR/SU)
1981	Post-doc fellowship (NFR), hosted by N.J. Shackleton (UK)
1976-80	Graduate Student Stipend (SU)
1975	Summer Research Fellow, WHOI (USA)

Award

1994	Björkénska Priset, University of Uppsala

Sea-going experience

2001	Shipboard Scientist, ODP Leg 199, D/V *JOIDES Resolution*
1999	Shipboard Scientist, IMAGES Leg 3, R/V *Marion Dufresne*
1996	Shipboard Scientist, SWEDARCTIC 96 (Arctic), I/B *Oden*
1994	Shipboard Scientist, ODP Leg 154, D/V *JOIDES Resolution*
1992	Shipboard Scientist, Cruise Ew9209, R/V *Maurice Ewing*
1991	Shipboard Scientist, Arctic Ocean Expedition, FS *Polarstern*
1990	Shipboard Scientist, ODP Leg 130, D/V *JOIDES Resolution*
1987	Co-Chief Scientist, ODP Leg 115, D/V *JOIDES Resolution*
1986	Shipboard Scientist, ODP Leg 108, D/V *JOIDES Resolution*
1981	Shipboard Scientist, DSDP Leg 81, D/V *Glomar Challenger*

University Service

2000-02	Associate Dean, Faculty of Science (SU)
2000-02	Dean of Earth Sciences (SU)
1997-99	Associate Dean of Earth Sciences (SU)
1996-03	Head of Department (Department of Geology and Geochemistry, SU)
1996-02	Member of Board, Faculty of Science (SU)

Other Service

2002-03	Member, Technical Review Panel, IHP-ARI Action (EU)
2001-03	Co-Chair, JEODI WP5: Scientific challenges of the Arctic (EU)
2000-01	Chair, Arctic Detailed Planning Group (JOI/ODP)
1999-01	Member, Arctic Program Planning Group (JOI/ODP)
1999-01	Vice President, European Union of Geosciences (EUG)
2001	Member, Human Potential Programme Panel (EU)
1999	Convenor, Marine geology and geophysics, EUG X
1999	Convenor, Man-made versus natural climate change The Royal Swedish Academy of Sciences
1997-99	Secretary, European Union of Geosciences Board

1997-99 Member, Swedish Scientific Committee for EUG 10
1997-03 Member, European Union of Geosciences Council
1996-98 Member, Organizing Committee, 7th International Nannoplankton Association Conference, Puerto Rico
1996-97 Convenor, Conference Commemorating Swedish Deep-Sea Expedition 1947-48, The Royal Swedish Academy of Sciences
1995-96 Co-ordinator, Marine Geology and Geophysics SWEDARCTIC's 1996 expedition, central Arctic Ocean
1995- Voting Member, Subcommission on Neogene Stratigraphy International Union of Geological Sciences
1995 Member, ODP International Review Committee Ocean Drilling Program Council

Selected Publications

Jakobsson, M., Backman, J., Løvlie, R., & Murray, A., in preparation. Central Arctic Ocean sedimentation: Further support for cm-scale rates.

Jakobsson, M., Løvlie, R., Arnold, E.M., Backman, J., Polyak, L., Knutsen, J.-O., & Musatov, E., 2001. Pleistocene stratigraphy and paleoenvironmental variation from Lomonosov Ridge sediments, central Arctic Ocean. *Global Planet. Change,* **31:**1-22.

Jakobsson, M., Løvlie, R., Al-Hanbali, H., Arnold, E., Backman, J. & Mörth, M., 2000. Manganese and color cycles in Arctic Ocean sediments constrain Pleistocene chronology. *Geology,* **28**:23-26.

Aldahan, A., Possnert, G., Scherer, R., Shi, N., Backman, J., & Boström. K., 2000. Trace-element and major-element stratigraphy in Quaternary sediments from the Arctic Ocean and implications for glacial termination. *Journ. Sed. Res.,* **70:**1095-1106.

Aldahan, A.A., Shi Ning, Possnert, G., Backman, J. & Boström, K., 1997. 10Be records from sediments of the Arctic Ocean covering the past 350 ka. *Marine Geology,* **144:**144-162.

Bodén, P. & Backman, J., 1996. A laminated sediment sequence from the northern North Atlantic and its climatic record. *Geology,* **24:**507-510.

Schneider, D.A., Backman, J., Curry, W. & Possnert, G., 1996. Paleomagnetic constraints on sedimentation rates in the eastern Arctic Ocean. *Quaternary Research,* **46:**62-71.

Gard, G. & Backman, J., 1990. Synthesis of Arctic and Subarctic coccolith biochronology and history of North Atlantic drift water influx during the last 500.000 years. *In* Bleil, U. & Thiede, J. (eds.), Geological History of the Polar Oceans: Arctic versus Antarctic. *NATO ASI Ser. C* (Kluwer, Dortrecht), 417-436.

Ocean Drilling Program Proposals

Jansen, E., Backman, J., Baldauf, J.G. & Kristoffersen, Y., 1989. A proposal for ODP drilling in the Nordic Seas (the Arctic Ocean-the Norwegian/Greenland sea-the NW Atlantic Ocean system), addressing high northern latitude paleoceanography and paleo-climatology. ***(Scheduled as Leg 151, Aug-Sept 1993 and Leg 162, July-Aug 1995)***

Curry, W.B., Backman, J., Shackleton, N.J. & Mountain, G.S., 1992. 388-REV: A proposal to core the Ceara Rise, west equatorial Atlantic: Cenozoic history of deep water circulation and chemistry. ***(Scheduled as Leg 154, Febr-March 1994)***

Backman, J., Coakley, B., Edwards, M., Forsberg, R., Jackson, R., Jakobsson, M., Jokat, W., Kristoffersen, Y., Mayer, L., Moran, K., & Musatov, E., 1999. Paleoceanographic and tectonic evolution of the central Arctic Ocean. ***(Proposal 533-Full2 was ranked #1 by SCICOM, August 2000; re-ranked #1 by SCICOM, August 2001)***

deMenocal, P., Tamaki, K., Brown, F.H., Hochon, P., Suwa, G., Katoh, S., White, T., Prell, W., & Backman, J., 1999. 575-Full3. Gulf of Aden drilling: Testing African climate-human evolution hypothesis. *(Proposal 575-Full3 was ranked #11 by SCICOM, August 2001).*

Potential reviewers of IODP Proposal 533
Paleoceanographic and tectonic evolution of the central Arctic Ocean

We suggest four individuals that are well qualified to provide comments on the paleoceanographic aspects of the proposed drilling program.

Professor Margaret L. Delaney
Institute of Marine Sciences
University of California
Santa Cruz, CA 95064
U.S.A.
phone: +1 831 459 4736
email: delaney@cats.ucsc.edu

Professor Eystein Jansen
Bjerknes Centre
University of Bergen
Allégaten 55
N-5007 Bergen
NORWAY
phone: +47-55-583491
email: eystein.jansen@geol.uib.no

Professor Nick Shackleton
University of Cambridge
Godwin Institute for Quaternary Research
New Museums Site
Pembroke Street
Cambridge CB2 3SA
ENGLAND
phone: (44) 1223 334876
email: njs5@cam.ac.uk

Professor Dennis A. Darby
Department of Ocean, Earth &
Atmospheric Sciences
Old Dominion University
Norfolk, VA 23529
U.S.A.
phone: +1 757 683 3000
email: ddarby@odu.edu

We also suggest four marine geophysiscists/structural geologists, who may provide comments on the tectonic objectives of the proposal:

Professor Olav Eldholm
Department of Geology
University of Oslo
Postboks 1047 - Blindern
N-0316 Oslo
NORWAY
phone: +47 2285 6676
email: olav.eldholm@geologi.uio.no

Professor Lawrence A. Lawver
Institute of Geophysics
University of Texas at Austin
Austin, TX 75759-8500
U.S.A.
phone: +1 512 471 0433
email: lawver@ig.utexas.edu

Dr. Arthur Grantz
US Geological Survey
GEO-WRG-VHZ
Menlo Park, CA 94025
U.S.A.
phone: +1 650 329 5709
email: agrantz@mojave.wr.usgs.gov

Dr. Steve Blasco
Geological Survey of Canada (Atlantic)
Bedford Institute of Oceanography
Dartmouth, Nova Scotia B2Y 4A2
CANADA
phone: +1 902 426 3932
email: blasco@agc.bio.ns.ca