

IODP Proposal Cover Sheet

985 - Full 2

Eastern Fram Strait Paleo Archive

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| Title | Eastern Fram Strait Palaeo-archive | | |
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| Keywords | Fram Strait, NAW, Paleoceanography, SBSIS | Area | Eastern Fram Strait |

Proponent Information

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Abstract

The North Atlantic-Arctic Oceans are unquestionably major players in the climatic evolution of the Northern Hemisphere and in the history of the meridional overturning circulation of the Atlantic Ocean. The establishment of the modern North Atlantic Water has been indicated as one of the main forcing mechanisms for the onset of the North Hemisphere Glaciation. North Atlantic Water control the extent and dynamics of circum-Arctic and circum-North Atlantic ice sheets and sea ice in addition to deep water and brine production. How the ocean system and cryosphere worked during past warmer intervals of either/ both high insolation and/or high atmospheric CO₂ content, is still unknown and debated. The required information can only be attained by offshore scientific drilling in high-resolution, continuous and undisturbed sedimentary sequences at the eastern Fram Strait along the main pathway and northern penetration of the North Atlantic Water flowing into the Arctic Ocean. As a matter of fact, this area around Svalbard can be considered as a "sentinel of climate change". The reconstruction of the dynamic history of the paleo Svalbard-Barents Sea Ice Sheet, is important as it is considered the best available analogue to the West Antarctic Ice Sheet (WAIS), whose loss of stability is presently the major uncertainty in projecting future global sea level in response to the present global climate warming induced by the anthropogenic rising of atmospheric CO₂ content.

The lack of a robust marine sediment chronostratigraphy, caused by low and variable sedimentation rates on Arctic ridges and variable calcareous microfossil abundance due to low productivity and/or poor preservation, hampers a proper understanding of the past Arctic climate evolution. Moreover, limited or equivocal oxygen isotope stratigraphy and magnetostratigraphy represent major impediments. Potential high-resolution marine records from continental shelves and/or upper slopes rarely extend beyond the last glaciation and/or contain stratigraphic discontinuities related to ice sheet dynamics on the shelves and sediment dynamics on the slopes.

IODP Full-085 proposal is motivated by the necessity of retrieving long and inter-connected sedimentary records along the eastern side of the Fram Strait in order to establish a robust chronostratigraphy, and to improve our understanding of the boundary conditions and forcing mechanisms determining the evolution of the Northern North Atlantic and Arctic regions and their past and present connections with global climate.

Scientific Objectives

The general objective of FRAME is the reconstruction of the West Spitsbergen Current (North Atlantic Water) variability, its influence on climate changes particularly during key climate transitions (late Miocene–Pliocene transition, late Pliocene–Pleistocene Transition, Mid-Pleistocene Transition, Mid-Brunhes Transition, and sub-orbital Heinrich-like events), and its impact on the Arctic glaciations, ice shelves development and stability, and sea ice distribution.

The proposal will also contribute to tectonic objectives by aiming to constrain the spatial location of the Miocene-Pliocene transition between the Molloy mid-ocean ridge and the Svalbard continental shelf (relevant connection to Full-979), and by studying the spatial variation of the stress regime, evolving from dominantly-tectonic at the westernmost drill site, to dominantly-glacial towards the shelf. Further, we will investigate how variability in the WSC, ice coverage and its relation to climate might have influenced the microbial populations through time and to what extent this is still affecting contemporary geochemical fluxes.

Non-standard measurements technology needed to achieve the proposed scientific objectives

Proposal History

Submission Type **Resubmission from previously submitted proposal**

Review Response

Reply to SEP comments

SEP: SKEPTICAL OF CHRONOSTRATIGRAPHIC CONTROL WITHIN THE TARGETED INTERVALS BEYOND A RADIOCARBON CHRONOLOGY... NEED TO PROVIDE A CONVINCING CASE FOR HOW SEDIMENTS CAN BE DATED, ESPECIALLY TO THE STRATIGRAPHIC RESOLUTION THE PROPONENTS PROPOSE... ACKNOWLEDGE THE POTENTIAL LIMITATIONS

We indicated types and limitations of independent chronostratigraphic methods that will be applied, including methods not depending from microfossils carbonate preservation (see also Table-2). In addition, we would like to support the definition/improvement of a DNA-based chronostratigraphy that is still at pioneer stage and can be addressed together with geomicrobiology sampling/analyses.

SEP: ENCOURAGES THE PROPONENTS TO ENVISION OTHER PROXIES. FOR EXAMPLE, WE NOTE THAT PULSES OF GLACIALLY REWORKED MICROFOSSILS, WHICH MAY BE BROADLY CORRELATIVE, WERE FOUND IN SOME LEG 151 CORES (SCHERER & KOC, 1996), WHICH MAY PROVIDE EVIDENCE OF DISCREET GLACIAL EROSION AND TRANSPORT EVENTS.

Better reported in the text. Glacially reworked microfossils are usually incorporated in plumes and IRD. We will address the presence of IRD in sediments for the reconstruction of the SBSIS dynamics as their recurrence can indicate either growth or decay of the ice sheet (depending on the co-presence of other sediment facies). The recognition of particular IRD-events (i.e. Heinrich events) can be used as marker-bed for chronostratigraphic correlations, but we will not consider the reworked microfossils for stratigraphic or provenance purposes (instead, XRD, heavy minerals, Nd-isotope, etc.)

SEP: IN GENERAL, THE GEOMICROBIOLOGY COMPONENT OF THE PROPOSAL, INCLUDING METHODOLOGIES, SHOULD BE BETTER DEVELOPED.

We incorporated the geomicrobiology (Hypothesis 4) that will be undertaken on a dedicated Hole (Holes-D) to avoid problems of contamination.

SEP: WE ALSO THINK THAT THE PROPONENTS SHOULD CONSIDER BROADENING THEIR AGE TARGETS, GIVEN THAT THERE ARE IMPORTANT QUESTIONS TO BE ADDRESSED WITH REGARD TO MIOCENE TRANSITIONS THAT MAY BE ACCESSIBLE AT OR NEAR THE DEFINED DRILLING TARGETS.

Following SEP suggestion we target the Late Miocene-Pliocene transition at the northernmost sites (northernmost penetration of NAW to the Arctic), for which we slightly changed the sites in order to have the best resolution thought XCB will produce more sediment disturbance. We agreed that the information that can be extracted can be beneficial for Plio-Quaternary reconstructions that is the most feasible high-resolution target.

SEP: COMPARISONS WITH THE WEST ANTARCTIC ICE SHEET IS WORTH MAKING THEMATICALLY, BUT FUNDAMENTAL DIFFERENCES SHOULD BE ACKNOWLEDGED.

We better acknowledged the fundamental differences.

SEP MINOR COMMENTS:

We also checked editorial mistakes, and incongruities of nomenclature in the "Site specific objectives".

SEP SITE-SPECIFIC COMMENTS: ASSESSMENT OF ICEBERGS IN THE DRILLING AREA.

We addressed better this point and identified additional alternate sites

SEP COMMENTS ON CORING OPERATIONS: DROPSTONES AND IRD ...

We considered this aspect in the text. In this area were collected over 23-m long, single barrel, piston cores containing abundant IRD. The drill sites are located on distal, expanded, contouritic sequences where IRD are sparse/diluted, so we don't think this should represent an impediment for JR drill.

Finally, additional site survey have been provided to meet criticisms and complete the SSBD

Proposed Sites (Total proposed sites: 17; pri: 5; alt: 12; N/S: 0)

| Site Name | Position (Lat, Lon) | Water Depth (m) | Penetration (m) | | | Brief Site-specific Objectives |
|---------------------|----------------------------|-----------------|-----------------|-----|-------|---|
| | | | Sed | Bsm | Total | |
| BED-01A (Primary) | 76.521597 12.738673 | 1647 | 397 | 0 | 397 | BED-01A is located on the Bellsund Drift on the western margin of Svalbard (eastern side of the Fram Strait) along the pathway of the deep core of the WSC (1700 mbsl). The site is characterised by a continuous, extremely high-resolution (sub-centennial) paleo-archive since the onset of shelf-edge glaciation (R4A, 1.3 Ma). This site appear ideal to particularly fulfil Objective 7: comparison between land surface (ice cores) and marine (sediment cores) records to establish feedbacks between atmospheric and marine realms in relation to palaeoclimatic changes. |
| BED-02A (Alternate) | 76.5290 12.5522 | 1805 | 365 | 0 | 365 | Site BED-02A is the alternate of Site BED-01A. The site is located on the Bellsund Drift (western margin of Svalbard) along the pathway of the deep core of the WSC, and crossing a very expanded (centennial) palaeoarchive since the onset of shelf-edge glaciation (R4A, 1.3 Ma). Although the resolution is lower with respect of primary site BED-01A, and the sequence locally contains Mass Transport Deposits, BED-02A appears suitable for FRAME purposes and adequate to fulfil also Objective 7: comparison between the record of ice and sediment cores. |
| BED-03A (Alternate) | 76.555122 12.930062 | 1502 | 372 | 0 | 372 | Site BED-03A is the alternate of Site BED-01A. The site is located on the Bellsund Drift (western margin of Svalbard) along the upslope limit of the deep core of the WSC. Site BED-03 contain an expanded sequence since the onset of shelf-edge glaciation (R4A, 1.3 Ma) and because of its proximal location can record better meltwater events and the SBSIS dynamics (objectives 4 and 5). |
| ISD-01B (Primary) | 77.59036 10.08552 | 1325 | 258 | 0 | 258 | Site ISD-01B is located on the Isfjorden Drift (western margin of Svalbard) along the upslope limit of the pathway of the deep core of the WSC. This site cross an expanded (sub-millennial) paleo-archive since the onset of shelf-edge glaciation (R4A, 1.3 Ma). Because of its closer location to the shelf edge, with respect to the sites located on the Bellsund drift, Site ISD-01A can give both complementary palaeoceanographic information about the variability of the deep core of the WSC, and more detailed information on the SBSIS dynamics after the onset of shelf-edge glaciation in this area. |
| ISD-02A (Alternate) | 77.52639 9.82167 | 1665 | 381 | 0 | 381 | Site ISD-02A is alternate to site ISD-01B both located on the Isfjorden Drift (western margin of Svalbard) along the pathway of the deep core of the WSC. This site cross an expanded (sub-millennial) paleo-archive since the onset of shelf-edge glaciation (R4A, 1.3 Ma), and can give complementary palaeoceanographic information about the variability of the deep core of the WSC, and information on the SBSIS dynamics after the onset of shelf-edge glaciation in this area. |
| ISD-03A (Alternate) | 77.497322 9.702931 | 1734 | 387 | 0 | 387 | Site ISD-03A is located on the Isfjorden Drift (western margin of Svalbard) along the downslope limit of the pathway of the deep core of the WSC. This site cross an expanded paleo-archive since the onset of shelf-edge glaciation (R4A, 1.3 Ma). ISD-03A is located in a distal area similar to sites BED-01A and BED-02A. However, given its northern location, the palaeoceanographic information that can be extracted from site ISD-03A can be considered complementary to the Bellsund sites, allowing to distinguish between local and regional climatic changes. |
| ISD-04A (Alternate) | 77.531608 9.603071 | 1713 | 402 | 0 | 402 | Site ISD-04A is located on the Isfjorden Drift (western margin of Svalbard) along the downslope limit of the pathway of the deep core of the WSC. This site cross an expanded paleo-archive since the onset of shelf-edge glaciation (R4A, 1.3 Ma). ISD-04A is located in a distal area similar to sites BED-01A and BED-02A. However, given its northern location, the palaeoceanographic information that can be extracted from site ISD-04A can be considered complementary to the Bellsund sites, allowing to distinguish between local and regional climatic changes. |
| VRE-01B (Alternate) | 79.03208272 7.057734589 | 1293 | 618 | 0 | 618 | VRE-01B penetrates flat, stratified, undisturbed sediments down into Late Pliocene sediments and through to the Plio-Pleistocene boundary, which is at 385 mbsf. Objectives relate to Plio-Quaternary chronostratigraphy, main climatic transitions (Plio-Pleistocene transition, MPT, MBT), identification of orbital, sub-orbital, millennial scale climate variations and the onset of northern hemisphere glaciations. |
| VRE-03A (Primary) | 78.94844856 7.473105204 | 1201 | 738 | 0 | 738 | VRE-03A penetrates flat, stratified, undisturbed sediments down into Late Pliocene sediments and through to the Plio-Pleistocene boundary, which is at 370 mbsf. Objectives relate to Plio-Quaternary chronostratigraphy, main climatic transitions (Plio-Pleistocene transition, MPT, MBT), identification of orbital, sub-orbital, millennial scale climate variations and the onset of northern hemisphere glaciations. |

Proposed Sites (Continued; total proposed sites: 17; pri: 5; alt: 12; N/S: 0)

| Site Name | Position (Lat, Lon) | Water Depth (m) | Penetration (m) | | | Brief Site-specific Objectives |
|---------------------|----------------------------|-----------------|-----------------|-----|-------|--|
| | | | Sed | Bsm | Total | |
| VRE-04A (Alternate) | 78.99280404 7.275998559 | 1252 | 730 | 0 | 730 | VRE-04A penetrates flat, stratified, undisturbed sediments down into Late Pliocene sediments and through to the Plio-Pleistocene boundary, which is at 378 mbsf. Objectives relate to Plio-Quaternary chronostratigraphy, main climatic transitions (Plio-Pleistocene transition, MPT, MBT), identification of orbital, sub-orbital, millennial scale climate variations and the onset of northern hemisphere glaciations. |
| VRW-02B (Alternate) | 79.15870357 4.621647776 | 1607 | 677 | 0 | 677 | VRW-02B lies at the western termination of the Vestnesa Ridge. Important objectives are extending the stratigraphic and paleoclimate record into the Pliocene and possibly the Miocene over a condensed Pleistocene sedimentary succession. Objectives relate to study the Earth climate system during Pliocene Earth orbital changes and the significant climate changes in the Arctic from a much warmer climate with ephemeral ice sheets to a colder climate with the onset of extensive glaciation over Greenland and the formation of an Arctic ice cap. |
| VRW-03A (Primary) | 79.15984991 4.488738388 | 1681 | 696 | 0 | 696 | VRW-03A lies at the western termination of the Vestnesa Ridge. Important objectives are extending the stratigraphic and paleoclimate record into the Pliocene and possibly the Miocene over a condensed Pleistocene sedimentary succession. Objectives relate to study the Earth climate system during Pliocene Earth orbital changes and the significant climate changes in the Arctic from a much warmer climate with ephemeral ice sheets to a colder climate with the onset of extensive glaciation over Greenland and the formation of an Arctic ice cap. |
| VRW-04A (Alternate) | 79.15592813 4.49752965 | 1690 | 740 | 0 | 740 | VRW-04A lies at the western termination of the Vestnesa Ridge. Important objectives are extending the stratigraphic and paleoclimate record into the Pliocene and possibly the Miocene over a condensed Pleistocene sedimentary succession. Objectives relate to study the Earth climate system during Pliocene Earth orbital changes and the significant climate changes in the Arctic from a much warmer climate with ephemeral ice sheets to a colder climate with the onset of extensive glaciation over Greenland and the formation of an Arctic ice cap. |
| VRW-05A (Alternate) | 79.14326611 4.729996632 | 1621 | 669 | 0 | 669 | VRW-05A lies at the western termination of the Vestnesa Ridge. Important objectives are extending the stratigraphic and paleoclimate record into the Pliocene and possibly the Miocene over a condensed Pleistocene sedimentary succession. Objectives relate to study the Earth climate system during Pliocene Earth orbital changes and the significant climate changes in the Arctic from a much warmer climate with ephemeral ice sheets to a colder climate with the onset of extensive glaciation over Greenland and the formation of an Arctic ice cap. |
| SVR-01B (Primary) | 78.26695725 5.890275089 | 1565 | 618 | 0 | 618 | SVR-01B site penetrates stratified, undisturbed sediments through the Plio-Pleistocene boundary in a sediment drift on the western flank of the northern Knipovich Ridge. This drift is hypothesized to be once part of the drifts on the western flank of the Svalbard margin but has since been separated by mid-ocean spreading. Objectives relate to understanding the role of tectonics and the opening of the Fram Strait with respect to and as potential drivers for paleoclimate evolution, ice-sheet dynamics and stratigraphy. |
| SVR-02A (Alternate) | 78.26834063 5.876599618 | 1554 | 559 | 0 | 559 | SVR-02A site penetrates stratified, undisturbed sediments through the Plio-Pleistocene boundary in a sediment drift on the western flank of the northern Knipovich Ridge. This drift is hypothesized to be once part of the drifts on the western flank of the Svalbard margin but has since been separated by mid-ocean spreading. Objectives relate to understanding the role of tectonics and the opening of the Fram Strait with respect to and as potential drivers for paleoclimate evolution, ice-sheet dynamics and stratigraphy. |
| SVR-03A (Alternate) | 78.27182091 5.889664598 | 1581 | 616 | 0 | 616 | SVR-03A site penetrates stratified, undisturbed sediments through the Plio-Pleistocene boundary in a sediment drift on the western flank of the northern Knipovich Ridge. This drift is hypothesized to be once part of the drifts on the western flank of the Svalbard margin but has since been separated by mid-ocean spreading. Objectives relate to understanding the role of tectonics and the opening of the Fram Strait with respect to and as potential drivers for paleoclimate evolution, ice-sheet dynamics and stratigraphy. |