IODP Proposal Cover Sheet

1012 - Pre

North Sea Late Cenozoic Environments

Received for: 2023-04-03

Title	Late Cenozoic Glaciers, LAndscapes, Climates, and Ecosystems of the North Sea (GLACE-NS)
Proponents	Andrew Newton, Georgina Heldreich, Mads Huuse, Heather Stewart, Margaret Stewart, Katrine Juul Andresen, Freek Busschers, Timme Donders, Gesa Kuhlmann, Johan ten Veen, Frank Wesselingh
Keywords	Glaciers, Landscapes, Climates, Ecosystems, Quaternary
Area	North Sea

Proponent Information

Proponent	Andrew Newton
Affiliation	Queen's University Belfast
Country	United Kingdom

☑ Permission is granted to post the coversheet/site table on www.iodp.org

Abstract

The intensification of glacial-interglacial cycles at the onset of the Pleistocene (~2.6 Ma) was a critical tipping-point in Earth's climate history. The increased severity of cold conditions triggered the development of continental-scale ice sheets, whose timing and extents are recorded in the North Sea Basin (NSB). Unlike the onshore record, the NSB preserves an almost complete record of glacial erosion and deposition from European ice sheets and Europe's large river systems. This has resulted in a 1.2-km-thick Pleistocene record of climatic and environmental change. Relatively little is known about global ice sheet fluctuations, except for estimates on ice volume with poor spatio-temporal control. There is evidence that Pleistocene ice sheet feedback loops affected the evolution of the global climate system through complex ocean-atmosphere-cryosphere linkages. Thus, the Pleistocene sequence preserved in the North Sea is a significant, and arguably unique, palaeo-climate archive capturing such linkages. While the NSB is covered by extensive seismic and borehole data, the late Pliocene-Pleistocene interval lacks samples providing geological control on existing interpretations. In this pre-proposal, we outline the merits of a NSB drilling expedition to unravel how glaciers, landscapes, climate, and ecosystems evolved and interacted through the late Pliocene and Pleistocene. The drilling campaign would contribute knowledge on natural climate variability and vulnerability, analogues of past warmer climates, tipping points, and rates of change. The mid-latitude location will allow for linkages between low- and high-latitude records, and the potential feedbacks and teleconnections of northwest European climate with other parts of the climate system – e.g., the influence of European Ice Sheets on the position of North Atlantic storm tracks. A particular focus on ecosystem evolution will reveal climate- and biology-related feedbacks, resilience, recovery, and carbon cycle dynamics. The results from a successful drilling campaign tie into IODP Strategic Objectives 3-5 and Flagship Initiative 1 (ground-truthing future climate change). It will contribute to better calibration of numerical Earth-system models, knowledge on climate sensitivity and variability, and a wider appreciation of feedbacks between different parts of the Earth-system. The ability to cover such a wide range of themes, at a scale that captures changes from across northwest Europe, can only be achieved through continuous coring of the uniquely-complete late Pliocene-Pleistocene NSB succession. The fact that such insight can be generated from a modest amount of drilling emphasises why the Plio-Pleistocene NSB should be considered a high-value target for the IODP.

1012 - Pre

Scientific Objectives

The overall aim of this drilling campaign is to unlock the late Pliocene and Pleistocene North Sea sedimentary record of climate and environmental evolution of northwest Europe. This will help us to unravel how Glaciers, Landscapes, Climate, and Ecosystems evolved and were coupled through the late Pliocene and Pleistocene. The specific objectives are:

1. To document when the first ice advance into the North Sea Basin (NSB) occurred, how many times it happened afterwards, what the geometries of those ice sheets were, how they evolved across and within different orbital cycles, and how these changes were linked with broader climatic change.

2. To unravel the different sources of sediments deposited in the NSB, how these link to changes in the regional hydrological cycle and ice sheet evolution, how these processes sculpted the surrounding landscapes and, in turn, how the landscape affected these processes, and what the wider implications are for theories of ice volume change, such as the regolith theory.

3. To investigate how the climate of northwest Europe evolved across the Pliocene-Pleistocene boundary, through the Early Pleistocene and the Middle Pleistocene Transition, between different glacial-interglacial cycles, and how these climate changes feed back into other parts of the Earth-system through oceanographic and ice sheet tipping points.

4. To document the nature and speed of turnover in marine and lowland terrestrial biota, investigate their relationship with carbon sequestration, and understand the response (and resilience) of communities to climate tipping points in successive glacial-interglacial cycles including super interglacials.

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

Have you contacted the appropriate IODP Science Operator about this proposal to discuss drilling platform capabilities, the feasibility of your proposed drilling plan and strategies, and the required overall timetable for transiting, drilling, coring, logging, and other downhole measurements?

yes

Science Communications Plain Language Summary

Using simple terms, describe in 500 words or less your proposed research and its broader impacts in a way that can be understood by a general audience.

The shape of the Earth's orbit around the Sun is not static and changes on different timescales. This effects the amount of energy received from the Sun through time. From about 3.3 to 2.8 million years ago, Earth's climate transitioned from warmer conditions to colder conditions as greenhouse gas levels decreased and reduced the warming blanket that it ordinarily provides. This made the Earth more susceptible to those changes in the Earth's orbit, eventually leading to the onset of the ice ages at about 2.6 million years ago. Since then, the Earth experienced ~50 ice ages, with warmer periods in between. The North Sea Basin (NSB) is an area that was heavily impacted by these ice age cycles as it fluctuated between fully glacial to warmer-than-present conditions. A major consequence of glaciation is that it can remould the landscapes beneath it, as a result, evidence for one glaciation can be wiped out by the next. In a marine setting with ample space for continuous sediment accumulation, this pattern does not always hold true, resulting in greater potential to preserve these records. In the NSB, this record is preserved in a 1.2-km-thick sediment package beneath the contemporary seafloor. These sediments should be thought of as a 'tape recorder' that contains an almost complete record of these ice ages, providing insight on Europe's past climate and its large river systems over the last 2.6 million years. Relatively little is known about how Europe evolved during repeated ice age cycles, except for that we know roughly when the ice ages occurred and what impact it possibly had on sea level. In this drilling campaign, we aim to collect geological samples from three boreholes that can be used to unlock the North Sea 'tape recorder' and the environmental and ecological information it contains. This will help us to unravel how glaciers, landscapes, climate, and ecosystems evolved and interacted through these ice age cycles. This is crucial because we know that ice sheets of the past, and present, have feedbacks loops whereby one part of the Earth's climate system can impact another. Unfortunately, in the context of contemporary change, our records of observation are too short in time to get a handle on the rates of change that we are documenting. While there is much excellent science that has gone into understanding these changes, we are currently unable to know whether such rates were also common in the past, and what the potential consequences were of such changes. Our campaign to collect samples from beneath the North Sea will contribute detailed knowledge on natural climate variability and vulnerability, and provide analogues of past warmer climates, tipping points, and rates of change. We would also be able to extract information on how climatic changes were linked with ecosystem feedbacks, resilience, and recovery. These results would help us to ground-truth future climatic change – a key aim of the IODP – making for better projections of how the climate might evolve in the future and its consequences.

1012 - Pre

Proposed Sites (Total proposed sites: 11; pri: 3; alt: 8; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
NSN-01A (Primary)	57.6967 1.5550	94	1200	0	1200	Recover a high-resolution palaeo-climatic/environmental record of Early-Middle Pleistocene succession in the North Sea Basin. Site NSC-01A is targeting stratigraphic units SU4 to Brunhes-Matuyama magnetic reversal event representing an expanded Calabrian interval and the Mid-Pleistocene Transition (MPT).
NSN-02A (Alternate)	57.5118 1.2290	90	1200	0	1200	Recover a high-resolution palaeo-climatic/environmental record of Early-Middle Pleistocene succession in the North Sea Basin. Site NSN-02A is targeting stratigraphic units SU4 to Brunhes-Matuyama magnetic reversal event representing an expanded Calabrian interval and the Mid-Pleistocene Transition (MPT).
NSN-03A (Alternate)	57.6756 1.6819	90	1200	0	1200	Recover a high-resolution palaeo-climatic/environmental record of Early-Middle Pleistocene succession in the North Sea Basin. Site NSN-03A is targeting stratigraphic units SU4 to Brunhes-Matuyama magnetic reversal event representing an expanded Calabrian interval and the Mid-Pleistocene Transition (MPT).
NSN-04A (Alternate)	57.5078 1.3908	91	1200	0	1200	Recover a high-resolution palaeo-climatic/environmental record of Early-Middle Pleistocene succession in the North Sea Basin. Site NSN-04A is targeting stratigraphic units SU4 to Brunhes-Matuyama magnetic reversal event representing an expanded Calabrian interval and the Mid-Pleistocene Transition (MPT).
NSC-01A (Primary)	55.3042 3.6715	28	1200	0	1200	Recover a high-resolution palaeo-climatic/environmental record of late Pliocene and Early Pleistocene successions in the North Sea Basin. Site NSC-01A is targeting seismic stratigraphic units SU3 to SU9 representing the Plio-Pleistocene transition and an expanded Gelasian sections.
NSC-02A (Alternate)	55.2189 3.7026	37	1200	0	1200	Recover a high-resolution palaeo-climatic/environmental record of late Pliocene and Early Pleistocene successions in the North Sea Basin. Site NSC-02A is targeting seismic stratigraphic units SU3 to SU9 representing the Plio-Pleistocene transition and an expanded Gelasian sections.
NSC-03A (Alternate)	55.3494 3.6812	28	1200	0	1200	Recover a high-resolution palaeo-climatic/environmental record of late Pliocene and Early Pleistocene successions in the North Sea Basin. Site NSC-03A is targeting seismic stratigraphic units SU3 to SU9 representing the Plio-Pleistocene transition and an expanded Gelasian sections.
NSC-04A (Alternate)	55.8990 3.5534	60	1200	0	1200	Recover a high-resolution palaeo-climatic/environmental record of late Pliocene and Early Pleistocene successions in the North Sea Basin. Site NSC-04A is targeting seismic stratigraphic units SU3 to SU9 representing the Plio-Pleistocene transition and an expanded Gelasian sections.
NSS-01A (Primary)	52.8975 3.6242	32	980	0	980	Recover a high-resolution palaeo-climatic/environmental and expanded record of the late Pliocene and Early Pleistocene succession in the North Sea Basin. Site NSS-01A also targets super interglacials (e.g. MIS 11, 31), coupling to on shore graben continental records (Rhine catchment).
NSS-02A (Alternate)	52.9057 3.6062	26	980	0	980	Recover a high-resolution palaeo-climatic/environmental and expanded record of the late Pliocene and Early Pleistocene succession in the North Sea Basin. Site NSS-02A also targets super interglacials (e.g. MIS 11, 31), coupling to on shore graben continental records (Rhine catchment).
NSS-03A (Alternate)	52.9091 3.4113	30	980	0	980	Recover a high-resolution palaeo-climatic/environmental and expanded record of the late Pliocene and Early Pleistocene succession in the North Sea Basin. Site NSS-03A also targets super interglacials (e.g. MIS 11, 31), coupling to on shore graben continental records (Rhine catchment).