IODP Expeditions 303 and 306
North Atlantic Climate I and II

2nd Post-Expedition Meeting
(& optional field trips to Kilauea Volcano)

Program & Abstracts

Kona, Hawai‘i
14-17 May 2007
Agenda of the 2nd Post-Expedition Meeting of
IODP Expeditions 303 and 306: North Atlantic Climate I and II

Expeditions Co-chiefs: Jim Channell, Toshiya Kanamatsu, Toki Sato, Rüdiger Stein
USIO Staff Scientist: Carlos Alvarez Zarikian
Meeting Host: Roy Wilkens

Saturday-Sunday, 12-13 May 2007
PRE-MEETING FIELD TRIP TO KILAUEA VOLCANO (Roy Wilkens)
Additional information on Hawai’i Volcanoes National Park: http://www.nps.gov/havo/

Monday, 14 May 2007
EIRIK DRIFT & ORPHAN KNOLL

0800  Coffee and breakfast snacks
0830  Introduction and welcoming remarks
       Roy Wilkens, Jim Channell, Rudy Stein, Toki Sato, Toshiya Kanamatsu, Carlos Alvarez Zarikian
IODP Post-Cruise Science Publications: Policy, Obligations, and Procedures
       Carlos Alvarez Zarikian
0850  1. The onset of Northern Hemisphere Glaciation and the Panama Paradox
       Gretta Bartoli, M. Sarnthein, M. Weinelt, N. Andersen, and D. Garbe-Schönberg
0905  2. A brief history of deep-water variability on Eirik Drift: IODP Sites U1305 and U1306
       Samuel Henderson, J.D. Wright, and D. DiGioia
0920  3. Contrasted sedimentation regimes during the late Quaternary on South Greenland slope
       and rise from stable isotope stratigraphies at IODP Sites U1305 and U1306
       Jim D. Wright, S. Henderson, C. Hillaire-Marcel, J. McKay, L. Neitzke, and A. de Vernal
        4. Stable isotope stratigraphy of IODP Site U1306
           Jim D. Wright, D. DiGioia, L. Neitzke, S.S. Henderson, and A.C. Elmore
0935  5. Magnetic measurements from composite section at IODP Site U1305 Expedition 303:
       Geomagnetic and Environmental records
           Alain Mazaud, Channell, J.E.T., Kissel, C., Stoner J.S., Laj, C.
0950  6. Upper and Lower Jaramillo polarity transitions recorded in North Atlantic sediments from
       IODP Expedition 303
           Alain Mazaud, Channell, J.E.T., Xuan, C., Stoner, J.S.
1005  7. Progressive microfabric changes in unconsolidated deep-sea sediments down to 300 mcd,
       Northwest Atlantic, IODP Expedition 303
           Kichiro Kawamura, N. Kawamura, R.H. Wilkens and IODP EXP 303 Science Party
1015  Coffee Break
1035  8. Diagenetic alteration of magnetic signals in Labrador Sea sediments
           Noriko Kawamura, K. Kawamura, A. Ennyu, N. Ishikawa, and M. Torii
1050  9. Glacial and interglacial sedimentary regimes at Sites U1305 and 646 (S Greenland Rise)
       under 40 vs. 100 ky forcings
           Claude Hillaire-Marcel, de Vernal, A., Fagel, N., Stevenson, R., McKay, J., Satte, Y.,
           Lamzioua, R.
1105 10. Paleomagnetic data from Site U1302/03 and Site U1306: relative paleointensity and secular variation on age models based on natural gamma radiation (NGR) and U-Channel magnetic susceptibility
   *Jim Channell, A. Mazaud and J. Stoner*

1120 11. Orphan Knoll (IODP Site U1302/U1303) record: linkage between the North Atlantic, the Laurentide ice-sheet (LIS) and the Atlantic Meridional Overturning (AMO) components
   *Anne de Vernal, C. Hillaire-Marcel, C., McKay, J., and Lefebvre, M.*

1135 12. High-resolution climatic record of the high-latitude Atlantic (Site U1302/03): Pleistocene occurrence of rapidly-deposited detrital layers
   *Oscar Romero and D. A. Hodell*

1150 13. Composite depth - How good is it away from the Splice?
   *Roy Wilkens*

1205 14. Centennial-scale variability in North Atlantic surface and deep-water properties during interglacial Stage 11: a new integrated micropaleontological and geochemical approach
   *Lucia de Abreu, L., I. Cacho-Lascorz, N. McCave, R. Schiebel, F. Abrantes, and M. Hall*

1220 Lunch

1350-1700 Poster Session (posters 1 to 16 only)
(1530 Coffee and snacks)

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**Tuesday, 15 May 2007**

**GARDAR REGION AND SITE U1315 (ODP SITE 642)**

0800 Coffee and breakfast snacks

0830 18. Stable isotope records from the Gardar Drift (Site U1304) reveal Interhemispheric coupling of climate between the North Atlantic and Antarctica
   *Dave Hodell, Channell, J.E.T., Curtis, J.H., Evans, H., Grudem, E., and Stoner, J.*

0845 19. Quaternary shell size variations in the planktonic foraminifera Neogloboquadrina pachyderma (sin.) in the North Atlantic: implication for the paleoceanographic relationship between the North Atlantic and the North Pacific
   *Makoto Yamasaki, Matsui, M. and Sato, T.*

0900 20. Coccolith evidence for the palaeoceanographic changes over the last 0.25Ma in the North Atlantic Ocean (IODP Site U1304)
   *Chuanlian Liu*

0915 21. Micropaleontology and sedimentology of laminated sediments from the northern North Atlantic Ocean (Site U1304): A scanning electron microscopy-based study
   *Oscar E. Romero*

0930 22. Paleomagnetic records from IODP Site U1304: the influence of diatoms on the magnetic record
   *Chuang Xuan, C., J.E.T. Channell, A. Mazaud and J. Stoner*

0945 23. Magnetic fabric induced by North Atlantic Bottom Currents
   *Toshiya Kanamatsu, T., Acton, G., Evans, H., Guyodo, Y., T., Ohno, M., and others*
1000      Coffee Break

1030      24. Geomagnetic field in the Matuyama and the Gauss Chron at IODP Site U1314 in the North Atlantic
          *Masao Ohno, Y. Guyodo, T. Kanamatsu, G.D. Acton, H.F. Evans, F. Murakami, and F. Komatsu*

1045      25. Preliminary results from XRF core scanning at IODP Sites U1313 and U1314
          *Jens Grützner*

1045      26. A 1.1 Ma long record of sediment provenance at the southern Gardar Drift: implications for millennial-scale changes in subpolar deep water hydrography (POSTER)
          *Jens Grützner and S.M. Higgins*

1100      27. Ostracod assemblage variability in the southern Gardar Drift (Site U1314) during the last glacial cycle
          *Carlos Alvarez Zarikian, Anna Yu. Stepanova and Jens Grützner*

1115      28. Polycystine radiolarian abundance changes in the North Atlantic during the last 1.5 Ma in relation to the climate system: IODP Expedition 306, Site U1314: Part 1
          *Kentaro Hatakeda and K R. Bjørklund*

1130      29. Rapid variations between polycystine radiolarian families and opal preservation in relation to climatic changes during the last 1.5 Ma: North Atlantic IODP Expedition 306, Site U1314: Part 2
          *Kjell Bjørklund, Kruglikova, S.B., Hatakeda, K.*

1145      30. Planktonic foraminifer assemblages and IRD during the Mid-Pleistocene from IODP Site U1314 (MIS 12 to MIS 30). Preliminary results
          *Alonso-Garcia, M., Hernández-Almeida I., Francisco Sierra and Flores, J.A.*

1200      32. Periodicity of Quaternary calcareous nannofossils in the North Atlantic Ocean- with special reference to the Monsoon area
          *Toki Sato, S. Chiyonobu, S. Toyoshima, M. Kudo, M. Watanabe, R. Naikiyo and M. Yamasaki*

1215      Lunch

1345-1700  Poster Session (*posters 18 to 33 only*)
          (1530 Coffee and snacks)
Wednesday, 16 May 2007

MID-ATLANTIC REGION

0800  Coffee and breakfast snacks
0830  17. Pore-fluid carbon stable isotope data from the Eirik Drift sites
       Atsuhito Ennyu and Mitchell J. Malone
0845  34. Paleomagnetic data from Site U1308: relative paleointensity and magnetic excursions placed on an oxygen isotope age model
       Jim Channell, A. Mazaud, J.S. Stoner and D.A. Hodell
0900  35. Pliocene Intensification of Northern Hemisphere Glaciation
       Ian Bailey, Wilson, P.A., and Schieberl, R.
0915  36. A 1-Myr record of stable isotopic and elemental variations at Site U1308
       Dave A. Hodell, Curtis, J.H., Romero, O., and Röhl, U.
0930  37. Provenance of coarse detrital carbonate peaks since MIS 16
       Simon H.H. Nielsen and D.A. Hodell
0945  38. Was there a 1500-year cycle in hematite-stained grains during the Penultimate Glaciation?
       Stephen P. Obrochta
1000  Coffee Break
1030  39. Quaternary calcareous nannofossils from Site U1308: Its floral change relation to the Mid Brunhes Event
       Shun Chiyonobu, T. Sato, R. Narikiyo, M. Watanabe, and M. Yamasaki
1045  40. Geomagnetic field records of Site U1312, the southern flank of the King’s Trough
       Toshiya Kanamatsu, Acton, G., Evans, H., Guyodo, Y., T., Ohno, M. and others
1100  41. A continuous record of geomagnetic and rock magnetic variations spanning the past 2.4 m.y. from IODP Site U1313 in the North Atlantic
       Gary D. Acton, H.F. Evans, Y.J.B. Guyodo, M. Ohno, and T. Kanamatsu
1115  42. Magnetic stratigraphy and relative paleointensity from IODP Site U1313 from 2.4-6 Ma
       Helen F. Evans, G.D. Acton, Y.J.B. Guyodo, J.E.T. Channell, M. Ohno, T. Kanamatsu
1130  43. Short-term variability of surface-water characteristics and ice-sheet instability in the Late Neogene-Quaternary North Atlantic Ocean: Biomarker and XRD records from Site U1313
       Rüdiger Stein and J. Hefter
1145  44. The biomarker inventory, trace and source rock implications from Heinrich events (IODP Expedition 303/306)
       Jens Hefter and R. Stein
1200  45. Ice-rafter debris and deep water records for Marine Isotope Stages (MIS) 11 to 16 from IODP Site U1313 (41°N 33°W)
       Antje Völker
1215  46. Evidence for the collapse of upper water masses during ice-rafting events: a multispecies planktonic foraminiferal and δ¹⁸O approach
       Harunur Rashid, Lodestro, S., Rodgers, B., Flower, B., and Quinn, T.
1230  Lunch
1400-1700  Poster Session (*posters 17, and 34 to 47*)
            (1530 Coffee and snacks)

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**Thursday, 17 May 2007**

**GENERAL DISCUSSION, TITLES AND PUBLICATIONS PLANNING**

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**Friday-Saturday, 18-19 May 2007**

**POST-MEETING FIELD TRIP TO KILAUEA VOLCANO (Roy Wilkens)**

Additional information on Hawai‘i Volcanoes National Park: [http://www.nps.gov/havo/](http://www.nps.gov/havo/)
Poster Sessions

Monday, 14 May 2007

EIRIK DRIFT & ORPHAN KNOLL

[6] Mazaud, A., Channell, J.E.T., Xuan, C., Stoner, J.S. Upper and Lower Jaramillo polarity transitions recorded in North Atlantic sediments from IODP Expedition 303
[9] Hillaire-Marcel, C., de Vernal, A., Fagel, N., Stevenson, R., McKay, J., Satte, Y., Lamzioua, R. Glacial and interglacial sedimentary regimes at Sites U1305 and 646 (S Greenland Rise) under 40 vs. 100 ky forcings (TALK)
[10] Channell, J.E.T., A. Mazaud and J. Stoner: Paleomagnetic data from Site U1302/03 and Site U1306: relative paleointensity and secular variation on age models based on natural gamma radiation (NGR) and u-Channel magnetic susceptibility
[11] de Vernal, A., C. Hillaire-Marcel, C., McKay, J., and Lefebvre, M. Orphan Knoll (IODP Site U1302/U1303) record: linkage between the North Atlantic, the Laurentide ice-sheet (LIS) and the Atlantic Meridional Overturning (AMO) components (TALK)
[12] Romero, O.E. and D. A. Hodell. High-resolution climatic record of the high-latitude Atlantic (Site U1302/03): Pleistocene occurrence of rapidly-deposited detrital layers
[16] Stoner, J.S., J.E.T. Channell, A. Mazaud, and C. Kissel: Paleomagnetic secular variation from the Holocene Section of Site U1305: Toward a better understanding of the NRM recording process
[17] Atsuhito Ennyu and Mitchell J. Malone. Pore-fluid carbon stable isotope data from the Eirik Drift sites [*will be displayed on Wednesday*]
Tuesday, 15 May 2007

GARDAR REGION AND SITE U1315 (ODP SITE 642)


[20] Liu, C. Coccolith evidence for the palaeoceanographic changes over the last 0.25Ma in the North Atlantic Ocean (IODP Site U1304)

[21] Romero, O.E. Micropaleontology and sedimentology of laminated sediments from the northern North Atlantic Ocean (Site U1304): A scanning electron microscopy-based study

[22] Xuan, C., J.E.T. Channell, A. Mazaud and J. Stoner. Paleomagnetic records from IODP Site U1304: the influence of diatoms on the magnetic record


[25] Grußnitzner, J. Preliminary results from XRF core scanning at IODP Sites U1313 and U1314. (TALK)


[27] Alvarez Zarikian, C.A., A.Yu. Stepanova and J. Grußnitzner. Ostracod assemblage variability in the southern Gardar Drift (Site U1314) during the last glacial cycle


[29] Bjørklund, K.R., Kruglikova, S.B., Hatakeda, K.: Rapid variations between polycystine radiolarian families and opal preservation in relation to climatic changes during the last 1.5 Ma: North Atlantic IODP Expedition 306, Site U1314: Part 2


[31] Harris, R. and S. Higgins: A permeability estimate in 56 Ma crust at ODP Hole 642E, Voring Plateau Norwegian Sea [withdrawn]


Wednesday, 16 May 2007

MID-ATLANTIC REGION

[34] Channell, J.E.T., A. Mazaud, J.S. Stoner and D.A. Hodell: Paleomagnetic data from Site U1308: relative paleointensity and magnetic excursions placed on an oxygen isotope age model


[38] Obrochta, S.P.: Was there a 1500-year cycle in hematite-stained grains during the Penultimate Glaciation?


[40] Kanamatsu, T., Acton, G., Evans, H., Guyodo, Y., T., Ohno, M., at al. Geomagnetic field records of Site U1312, the southern flank of the King’s Trough

[41] Acton, G.D., H.F. Evans, Y.J.B. Guyodo, M. Ohno, and T. Kanamatsu. A continuous record of geomagnetic and rock magnetic variations spanning the past 2.4 m.y. from IODP Site U1313 in the North Atlantic

[42] Evans, H.F., G.D. Acton, Y.J.B. Guyodo, J.E.T. Channell, M. Ohno, T. Kanamatsu. Magnetic stratigraphy and relative paleointensity from IODP Site U1313 from 2.4-6 Ma

[43] Stein, R. and J. Hefter: Short-term variability of surface-water characteristics and ice-sheet instability in the Late Neogene-Quaternary North Atlantic Ocean: Biomarker and XRD records from Site U1313

[44] Hefter, J. and R. Stein. The biomarker inventory, trace and source rock implications from Heinrich events (IODP Expedition 303/306)

[45] Völker, A.: Ice-rafted debris and deep water records for Marine Isotope Stages (MIS) 11 to 16 from IODP Site U1313 (41°N 33°W)

[46] Rashid, H., Lodestro, S., Rodgers, B., Flower, B., and Quinn, T. Evidence for the collapse of upper water masses during ice-rafting events: a multispecies planktonic foraminiferal and δ¹⁸O approach

[47] Ferretti, P., S.J. Crowhurst, M.A. Hall, and I. N. McCave: Orbital and suborbital climate variability at IODP Site U1313 during the Early Pleistocene
ABSTRACTS
(in alphabetical order by first author)
CENTENNIAL-SCALE VARIABILITY IN NORTH ATLANTIC SURFACE AND DEEP-WATER PROPERTIES DURING INTERGLACIAL STAGE 11: A NEW INTEGRATED MICROPALAEONTOLOGICAL AND GEOCHEMICAL APPROACH

Lúcia de Abreu ¹, Isabel Cacho ³, Nick McCave ², Ralf Schiebel ⁴, Fátima Abrantes ¹ and Michael Hall ²

(1) INETI – Departamento de Geologia Marinha, Estrada da Portela, Zambujal, 2720 Alfragide, Portugal (luciaabreu@yahoo.com); (2) Godwin Laboratory for Palaeoclimate Research, University of Cambridge, Department of Earth Sciences, Downing Street, Cambridge CB2 3EQ; (3) Universitat de Barcelona – Facultat de Geologia Estratigrafia i Geociencies Marines, c/ Martí Franques s/n, 08028 Barcelona, España; (4) University of Southampton, School of Ocean and Earth Sciences, National Oceanography Centre, European Way, Southampton

To disentangle NADW variability and climate change forcing mechanisms during Stage 11 (420-360 ka B.P.), high-resolution proxy records were generated for sediments from IODP Sites U1305 and U1308. Results capture centennial-scale variability and U1305 is without doubt one of the highest-resolution isotope records existing so far for high-latitudes. At Site U1305 Mg/Ca ratios-derived SST from *N. pachyderma* reached 13-14ºC during peak interglacial off Greenland and show an abrupt 9ºC temperature rise during Termination V. Cooling episodes, on the other hand seem to be frequently associated with the discharge from nearby Greenland and Laurentide ice-sheets as indicated by the broad variety of lithic particles. Ice-rafting events were equally recorded at Site U1308, which will provide a record of central North Atlantic detrital layer stratigraphy. Multiple temperature drops of shorter magnitude followed by rapid recovery seem to characterize most of this interglacial at Site U1305, but work is still in progress. Benthic fauna proved to be very scarce in both sites and was only available for stable isotopes.

A CONTINUOUS RECORD OF GEOMAGNETIC AND ROCK MAGNETIC VARIATIONS SPANNING THE LAST 2.4 M.Y. FROM IODP SITE U1313 IN THE NORTH ATLANTIC

Gary D. Acton*, Helen F. Evans, Yohan J. B. Guyodo, Masao Ohno, and Toshiya Kanamatsu

(*) acton@geology.ucdavis.edu

A continuous record of geomagnetic field behavior that includes paleosecular variation, excursions, reversals, and paleointensity changes over the past 2.4 m.y. has been obtained from 126 U-Channel samples (2 cm x 2 cm cross-section and up to 150 cm long) augmented by 28 discrete samples from Site U1313. The record comprises the upper 120 m of the composite stratigraphic section. These new observations help refine the paleomagnetic record from split-core samples obtained during Expedition 306. Rock magnetic properties were also measured every 1 cm along the U-Channel samples. These can be tied to other paleoceanographic, paleoenvironmental, and paleoclimate proxies to provide insights about the conditions in the North Atlantic since the late Miocene.
OSTRACOD ASSEMBLAGE VARIABILITY ON THE SOUTHERN GARDAR DRIFT (SITE U1314) DURING THE LAST GLACIAL CYCLE

Carlos A. Alvarez Zarikian¹, Anna Yu. Stepanova² and Jens Grützner³

(1) IODP-Texas A&M University, College Station, Texas (zarikian@iodp.tamu.edu); (2) Paleontological Institute, Russian Academy of Sciences, Moscow, Russia; (3) Bremen University, MARUM, Geosciences Department, Bremen, Germany

We examined variations in ostracod species composition, CaCO₃, and IRD content in sediments from Site U1314 over the last glacial cycle to study the interaction between deep sea benthic assemblage composition and North Atlantic climate variability. The most abundant taxa are Krithe, Rockallia, Henrihowella, Oxycythereis, Cytheropteron and Thalassocythere. Preliminary results reveal high variability in ostracod abundance and diversity that appears to be associated with increased IRD input, fluctuations in CaCO3 content, and deep water circulation. Climate related assemblages were identified in connection to interglacial and peak glacial periods. An interglacial assemblage occurs during MIS 1 and 5 and consists of Oxycythereis, Ambocythere, Pelecocythere and Echinocythereis. In contrast, a glacial assemblage occurs primarily in MIS 2 and consists of Bythocythere, Polycyope, Pseudocythere, and some species of Cytheropteron. These taxa are also associated with peaks in IRD content in the sediment record, which is related to ice-sheet instability. In addition, few shallower water species were recognized during Termination 1 and their occurrence in deep sea sediments is inferred to originate from ice-rafting. The most abundant taxa: Krithe, Rockallia, and Henrihowella do not exhibit any clear preference for climatic conditions and are considered the ‘background’ assemblage.

PLANKTONIC FORAMINIFER ASSEMBLAGES AND IRD DURING THE MID-PLEISTOCENE FROM IODP SITE U1314 (MIS 12 TO MIS 30). PRELIMINARY RESULTS

Alonso-García, M., Hernández-Almeida, I., Sierro, F. J.*, and Flores, J. A.

Department of Geology, Faculty of Sciences University of Salamanca, 37008 Salamanca, Spain (*sierro@usal.es

With the aim of studying the interaction between ice-sheet dynamics and climate variability in the North Atlantic during the Middle Pleistocene we analyzed variations in the planktonic foraminifer assemblages and IRD contents in IODP Site U1314 from Gardar Drift. Preliminary samples were taken every 16 cm. The assemblage is dominated by Neogloboquadrina pachyderma left during glacial periods and Globigerina bulloides accompanied by N. pachyderma right and Globorotalia inflata at interglacial times. Subtropical species, such as Globigerinoides ruber are very sporadic in the samples.

Various intervals rich in IRD were found with high concentration of quartz and volcanic grains which are usually linked to maximum values in N. pachyderma left. High values of natural gamma radiation are well correlated with glacial periods, indicating more terrigenous input at those times. However, the record of magnetic susceptibility provides a more complicated signal that is mainly controlled by the nature of the clastic input, especially the lithology of the IRD component.
PLIOcene Intensification of Northern Hemisphere Glaciation

Ian Bailey*, Paul A. Wilson, Ralf Schiebel

National Oceanography Centre, Southampton, School of Ocean and Earth Science, European Way, Southampton SO14 3ZH, UK; (*) izb@noc.soton.ac.uk

Late Pleistocene climate records show pronounced millennial time-scale (D-O type) variability with salinity perturbations arising from iceberg influx to the North Atlantic implicated in their origin. Recent studies offer fragmentary evidence from the Early Pleistocene and latest Pliocene to suggest that D-O type variability is not peculiar to the ‘100 kyr’ world but apparently at least conditioned by the extent of continental glaciation.

IODP Site U1308 presents us with an opportunity to evaluate the sensitivity of North Atlantic climate at the millennial-scale to glacial-interglacial state during Pliocene intensification of Northern Hemisphere Glaciation (ultimately within the framework of a PAC). To this end, we will report new high-resolution stratigraphies of IRD and geochemistry of foraminiferal calcite between 3.0 and 2.5 Ma (MIS G18-99).

The Onset of Northern Hemisphere Glaciation and the Panama Paradox

G. Bartoli ¹*, M. Sarnthein ¹, M. Weinelt ¹, N. Andersen ², D. Garbe-Schönberg ¹

(1) Institut für Geowissenschaften, Kiel University; (*) now at ETH Zentrum, Mikropaläontologie, Zürich (gretta.bartoli@erdw.ethz.ch); (2) Leibniz Laboratory for Radiometric Dating and Stable Isotope Research, Kiel University

Pliocene records from Site U1307 (Labrador Sea) give crucial information on the history of the East Greenland Current as major outflow and hence tracer of the Arctic Ocean during the onset of Northern Hemisphere Glaciation (NHG) 3.2-2.6 Ma. Our evidence may solve the “Panama Paradox” (Berger & Wefer, 1996, Klöcker et al., 2005) as we observed after the closure of Panama at 3.2 Ma an increased in heat transport to the northern high latitudes via the Gulf Stream coeval with a cooling and freshening of the Arctic Ocean. Thus, our results confirm that the closure of Panama did not delay the onset of NHG but fueled it by increasing the moisture supply to the high latitudes via increased precipitation over Eurasia, which, in turn, lowered the sea surface salinity in the Arctic Ocean, thus promoting sea-ice formation and albedo in the northern hemisphere; being a positive feedback for the NHG.
RAPID VARIATIONS BETWEEN POLYCYSTINE RADIOLARIAN FAMILIES AND OPAL PRESERVATION IN RELATION TO CLIMATIC CHANGES DURING THE LAST 1.5 MA: NORTH ATLANTIC IODP EXPEDITION 306, SITE U1314: PART 2

Kjell R. Bjørklund¹, Svetlana B. Kruglikova², Kentaro Hatakeda³

(1) University of Oslo; (2) P.P. Shirshov Institute of Oceanology; (3) Tohoku University

The set of samples, covering the last 1.5 Ma, and analyzed for polycystine radiolarians, show great differences between samples with respect to their: 1) abundance, 2) species richness, 3) quality of preservation, and 4) assemblages in the North Atlantic IODP Site U1314.

Values in the radiolarians/g sediment varies between 0 and >70 000. Highest numbers of radiolarian taxa are observed in the interglacial periods, lowest in the glacial periods. A radiolarian opal refractive index was established (visual impression), showing that opal is generally well preserved in the lower part (1.5 -1.0 Ma) (LIR=low index of refraction), the upper part (1.0-0 Ma) is characterized by bad opal preservation (HIR=high index of refraction), with mixed in LIR horizons.

Abrupt changes between Plagiacanthidae, Eucyrtidiinae, Artostrobiinae, Porodiscidae, Spongodiscidae, and Astrosphaeridae, do define radiolarian assemblages’ characteristic for different water masses, and therefore, rapid assemblage changes do indicate rapid migration of the water masses or current systems. Classification follows Petrushevskaya (1971).


PALEOMAGNETIC DATA FROM SITE U1302/03 AND SITE U1306: RELATIVE PALEOINTENSITY AND SECULAR VARIATION ON AGE MODELS BASED ON NATURAL GAMMA RADIATION (NGR) AND U-CHANNEL MAGNETIC SUSCEPTIBILITY

James .E.T. Channell¹*, A. Mazaud² and J. Stoner³

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The natural remanent magnetizations (NRM) measured in u-Channel samples from Site U1302-U1303 and Site U1306 yield well-defined magnetization components down-section to the base of the Brunhes Chronozone. The initial age models are based on the correlation of the natural gamma radiation (NGR) and u-Channel susceptibility to an oxygen isotope reference curve. The relative paleointensity records are based on the slopes of NRM-lost versus ARM-lost, and NRM-lost versus ARM-gained, and, when placed on the age model, can be satisfactorily correlated to other records from the North Atlantic. NRM directional excursions include the Iceland Basin excursion. Several other potential geomagnetic excursions are recorded on the Brunhes Chron. The fidelity of the magnetic records is illustrated by detailed records of the Matuyama-Brunhes (M-B) transition (Site U1306) and several well-defined directional magnetic excursions.
PALEOMAGNETIC DATA FROM SITE U1308: RELATIVE PALEOINTENSITY AND MAGNETIC EXCURSIONS PLACED ON AN OXYGEN ISOTOPE AGE MODEL

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The paleomagnetic record based on u-Channel data from the composite section at Site U1308 extends back into the Gauss Chron (~3.3 Ma). Magnetization components, determined by stepwise AF demagnetization, are accompanied by low MAD values (i.e. components are well-defined). Benthic oxygen isotope data, measured at 2-cm intervals on Cibicidoides, provides the age model down to marine isotope stage 31, close to the base of the Jaramillo Subchronzone. Below the Jaramillo, the age model is based on correlation of the reflectance record to an oxygen isotope reference curve. Anomalous low inclinations at the base of the Matuyama Chron complicate the record of the Matuyama-Gauss boundary, and are interpreted as being affected by slumping that manifests as inclined bedding in Cores U1308A-19H and U1308F-19H. The relative paleointensity record from Site U1308 is the longest continuous record yet produced, and can be correlated to magnetic excursions in the Matuyama and Gauss Chrons.

QUATERNARY CALCAREOUS NANNOFOSILS FROM SITE U1308: ITS FLORAL CHANGE RELATION TO THE MID-BRUNHES EVENT

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The Quaternary calcareous nannofossils from Site U1308 were analyzed to clarify the changes in surface water conditions during 0.5 Ma. The uppermost Quaternary sediments in Site U1308 are composed of abundant and high species diversity nannofossils. The assemblages are characterized by rapid increase and higher amplitude fluctuations of relative abundance of Coccolithus pelagicus between 0.4 Ma and 0.2 Ma (the Mid-Brunhes Event). From these facts, the past 0.2 Ma is indicated by cold period based on ecology of C. pelagicus, which is presently found in high latitude regions such as the subarctic to arctic oceans. In this report we discuss the global surface water change during the Mid Brunhes Event, which is superimposed on results the equatorial Pacific region and the Oman Margin.
PORE-FLUID CARBON STABLE ISOTOPE DATA FROM THE EIRIK DRIFT SITES

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We have measured carbon stable isotopic compositions (δ13C) of dissolved inorganic carbon (DIC) and DIC concentrations in pore-fluid samples from IODP Sites U1305, U1306, and U1307 on the Eirik Drift. A total of 84 samples were analyzed from the three sites. In general, the δ13C records exhibit downcore decreasing trends from the near-sediment top to the depths of sulfate-methanogenesis interface (SMI) inferred from the shipboard sulfate and methane profiles. The most depleted δ13C value of −34.1‰ is recorded at 79.15 mbsf at Site U1307. Below the depth of SMI, δ13C values generally increase to ~−3‰ towards the bottom of the cored interval. The δ13C profiles of DIC at these sites further support the inferred biogenic origin of methane and sulfate consumption by anaerobic oxidation of methane (AOM) at the SMI. Our new data in conjunction with the shipboard interstitial chemistry data will provide insights into the rates of microbial activities and carbonate diagenesis associated with the remineralization of organic carbon.

MAGNETIC STRATIGRAPHY AND RELATIVE PALEOINTENSITY FROM IODP SITE U1313 FROM 2.4-6 Ma

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The 2.4-6 Ma interval at Site U1313 has produced a magnetic reversal stratigraphy, from u-Channel samples, that defines all the subchrons of the Gauss and Gilbert chrons. The sediments carry a weak low-coercivity magnetization most likely carried by magnetite. Volume magnetic susceptibility, although very weak when measured on the u-Channel samples, is reproducible as demonstrated by replicate measurements. The magnetic susceptibility from u-Channel samples can be correlated to a benthic oxygen isotope stack. The resulting age model based on this correlation and the reversal chronology is applied to the normalized remanence record between 2.4 and 4 Ma. Three relative paleointensity proxies have been calculated: NRM/ARM, NRM/IRM and the slope of NRM/ARM-acquisition. Consistency among the three proxies and acceptable correlation to Pacific records of the same age implies that the site has yielded a useful a paleointensity record for the Gauss and Gilbert chrons.
ORBITAL AND SUBORBITAL CLIMATE VARIABILITY AT IODP SITE U1313 DURING THE EARLY PLEISTOCENE

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Continuous oxygen and carbon isotopic records were obtained using planktonic (Globigerina bulloides) and benthic (Cibicidoides wuellerstorfi) foraminifera at Site U1313, covering part of the early Pleistocene. According to our preliminary age model, the record spans the time interval from 788 ka to 900 ka (MIS 22-20).

Our data indicate millennial scale climatic instabilities during all the observed climate states. The amplitude of the oxygen isotopic signal during the MIS 22–21 transition, considered the first “large” glacial-interglacial climate shift of the Pleistocene, is ~1.7‰ and is greater than previously observed at Site 607. The oxygen isotope records, and in particular the planktonic record, show that MIS 21 stands out as an interglacial abruptly interrupted by cool periods, documenting the occurrence of at least three events of isotopic enrichment (0.5-1‰), which ended with rapid warming phases. These results suggest that MIS 21 was not a time of relative climatic stability and, on a broader perspective, contribute to further evidence for relative climate instability during interglacial intervals.

PRELIMINARY RESULTS FROM XRF CORE SCANNING AT IODP SITES U1313 AND U1314

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The chemical element composition of the sediments at Sites U1313 (northwest of the Azores) and U1314 (southern Garðar Drift) was analyzed using an X-ray fluorescence (XRF) core scanner. Based on these 1-cm resolution XRF measurements it is possible to obtain multi-centennial resolution records of biogenic (e.g. %CaCO3) and siliciclastic (e.g. TiO2, K2O) mineral phases. Especially molar ratios such as K/Ti or Al/Ti can be used to track changes in terrigenous provenance in different sedimentary settings. The high resolution elemental records are suitable to investigate how millennial scale changes in the climate system evolved over the last few Ma. The data sets are an ideal complement to rock magnetic, sedimentological, and stable isotope analyses conducted by other cruise participants.
A 1.1 Ma LONG RECORD OF SEDIMENT PROVENANCE AT THE SOUTHERN GARDAR DRIFT: IMPLICATIONS FOR MILLENNIAL-SCALE CHANGES IN SUBPOLAR DEEP WATER HYDROGRAPHY

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Sediment physical property records of the orbitally dated ODP Site 983 (northern Gardar Drift) and IODP Site U1314 (southern Gardar Drift) reveal a high similarity and allowed deriving a new age model of orbital resolution for the last 1.8 Ma at Site U1314. High resolution XRF-core scanning measurements of major elements K and Ti are used to track changes in terrigenous provenance during the last 1.1 Ma. Low K/Ti ratios are typical for interglacials and millennial scale warm events with sediment delivery mainly through the ISOW from the Icelandic basaltic province. Glacials and stadials are characterized by more acidic sediment sources transported by enhanced NEADW/LDW flow. Suborbital changes are a pervasive feature of the K/Ti time series during the last 1.1 Ma. Enhanced millennial scale variability in siliciclastic supply occurs during ice growth phases when global benthic $\delta^{18}O$ is within the range of ~4.1 to 4.6 per mil.

A PERMEABILITY ESTIMATE IN 56 Ma CRUST AT ODP HOLE 642E, VØRING PLATEAU NORWEGIAN SEA

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Temperature measurements made in Ocean Drilling Program (ODP) Hole 642E are used to estimate bulk crustal permeability. Hole 642E is located on the Voring Plateau, a sediment covered passive margin. Hole 642E penetrates 56 Ma crust. Temperatures were measured 20 years after the Hole was drilled and indicate fluid flow from the basement into the ocean. This flow regime suggests that the basement is naturally overpressured with respect to hydrostatic. We estimate the flow rate to be approximately 6 - 12 m hr-1. This flow rate couple with an estimated minimum overpressure of 10 - 20 kPa, and an estimated aquifer thickness of 100 m, yields a bulk permeability of 10-13 m2. This result, in combination with a global dataset of basement permeabilities, suggests that old upper oceanic crust remains permeable enough to allow flow, and that crustal fluid flow is ultimately limited by driving forces.
POLYCYSTINE RADIOLARIAN ABUNDANCE CHANGES IN THE NORTH ATLANTIC DURING THE LAST 1.5 MA IN RELATION TO THE CLIMATE SYSTEM: IODP EXPEDITION 306, SITE U1314: PART 1

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The total number of radiolari/a/g sediment and the relative occurrence of Cycladophora davisiana from IODP Exp. 306 Site U1314 in the northern North Atlantic were determined and compared to the globally integrated δ¹⁸O record (Lisiecki and Raymo, 2005) over the last 1.5 My.

Both total radiolaria and C. davisiana abundance curves are well synchronized with the 100-ky glacial-interglacial cycles during the last 800 ky. The total radiolaria number increases in the warm interglacial periods and decreases in the cold glacial periods, whereas C. davisiana shows the opposite trend.

From 1500 to 800 ka, dominated by 41-ky climate cycles, the relationship is rather ambiguous. The total radiolaria abundance curve shows small and short fluctuations during the transitional period from 800 to 1000 ka, the Mid- Pleistocene Climate Transition (MPCT). The system that controls the climate before and after the MPCT is different, run by 41 ka cycles and 100 ka cycles respectively, which may cause the observed radiolarian low abundance values.

THE BIOMARKER INVENTORY, TRACE AND SOURCE ROCK IMPLICATIONS FROM HEINRICH EVENTS (IODP EXPEDITION 303/306)

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The qualitative and quantitative biomarker compositions of identified and presumed Heinrich layers (HL) from Sites U1305, U1308 and U1313 were investigated and compared to ambient (glacial / interglacial) sediments.

HL-samples are clearly distinguishable from samples between those layers due to the abundance of a multitude of "petrogenetic" compounds such as benzohopanes, D-ring monoaromatic 8,14-secohopanes, mono- and triaromatic steranes, and isorenieratene-derivatives. This specific biomarker association provides circumstantial evidence that the organic matter present in HL´s derives from a relatively immature, marine carbonate rock deposited under occasional photic zone anoxic conditions, and that the potential source is a Paleozoic rock from the Laurentide/Canadian shield.

Coincident with e.g. peak values of magnetic susceptibility and bulk density, biomarker compositions from Site U1308 indicate the presence of Heinrich-type events also during older glacials, with the strongest event of the samples analyzed so far occurring during MIS 16.
A BRIEF HISTORY OF DEEP-WATER VARIABILITY ON EIRIK DRIFT: IODP SITES U1305 AND U1306

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Down-core records of deep-water variability are being created using %CaCO$_3$, %SiO$_2$ and mean sortable silt (SS) proxies at Sites U1305 and U1306 on the Eirik Drift. Initial results show a marked change in deposition centers on Eirik Drift on glacial/interglacial timescales as noted by other researchers (e.g., Hillaire-Marcel et al., 1994; Stoner et al., 1995). Sedimentation rates in the interglacial sections at Site U1305 reach 50 cm/kyr, and are characterized by low (early Holocene) to high (mid to late Holocene) %CaCO$_3$ and SS values. These proxies indicate that the deep current axis descends and/or intensifies during interglacial periods on Eirik Drift. Calcium carbonate sedimentation during the interglacial periods ranges from ~10-25 cm/kyr, implying that there is considerable reworking of sediments from higher up or upstream on Eirik Drift that is focused around Site U1305. These results show that the deep water system not only changed over the glacial to interglacial cycles but also varied significantly within the interglacials.

GLACIAL AND INTERGLACIAL SEDIMENTARY REGIMES AT SITES U1305 AND 646 (S GREENLAND RISE) UNDER 40 vs. 100 KYR FORCINGS

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Early studies at ODP Site 646 (isotopes, clay minerals, radiogenic isotopes, pollen dinocysts) led to conclude that all interglacials were different from each other, either in relation with sea-surface, deep-current, and terrestrial conditions over Greenland. New data from IODP Site U1305 spanning Oxygen Isotope Stages (OIS) 31 to 1 provide a means to compare glacial vs. interglacial (G vs. IG) regimes under 40-kyrs forcing (e.g. OIS 27-31; ca. Jaramillo chron) to those observed under 100-kyrs forcing, notably during OIS 1-11. This later interval shows large amplitude G vs. IG fluctuations with an enhanced western boundary undercurrent (WBUC), carrying mineralogical (smectite vs. illite) and isotopic (Nd) signatures from Iceland basalts and the Reykjanes Ridge, during interglacials. In contradistinction, the OIS 27-31 interval depicts lesser amplitude G vs. IG oscillations and more importantly, interglacial signatures with relatively high chlorite and kaolinite contents, and Sm-Nd systematics differing from those of the OIS 1-11. Sedimentary supplies from soils developed over volcanic rocks from a largely deglaciated Eastern Greenland could be a good rock source candidate.
STABLE ISOTOPE RECORDS FROM THE GARDAR DRIFT (SITE U1304) REVEAL INTERHEMISPHERIC COUPLING OF CLIMATE BETWEEN THE NORTH ATLANTIC AND ANTARCTICA


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Gravity core GGC-12 and piston core JPC-13 were taken at the same location as Site U1304 on the Gardar Drift and used to create a composite section. The benthic δ18O record at Site U1304 closely matches Core MD95-2042 on the Portuguese Margin, which has been correlated to the GISP ice core via planktonic δ18O and indirectly to Antarctic ice cores via methane synchronization. In contrast, the planktonic δ18O record of *N. pachyderma* at Site U1304 correlates with similar records from the Labrador Sea (e.g., MD95-2024) and shows strong decreases during Heinrich events. Benthic δ18O values at Site U1304 also decrease during each of these events, but with reduced amplitude compared to the planktonic signal. Benthic δ13C values at Site U1304 decrease during most of the H-events supporting a slowdown of Atlantic Meridional Overturning Circulation (AMOC). The stable isotopic records from Site U1304 links low salinity of surface water during Heinrich events in the North Atlantic with reductions in AMOC, decreased continental ice volume, and warm events in Antarctica. Our results add further support for a one-to-one, anti-phase coupling of climate variability between the high-latitude North Atlantic and Antarctica during the last glaciation.

A 1-MYR RECORD OF STABLE ISOTOPIC AND ELEMENTAL VARIATIONS AT SITE U1308

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We report a benthic oxygen isotope stratigraphy at 2-cm resolution (~200 years) for the top 74 mcd of Site U1308 that spans MIS 1 to 31 (base of the Jaramillo Subchron at ~1.07 Ma). The shipboard splice for Site U1308 has been revised to avoid disturbed cores. Using the Avaatech XRF core scanner at the University of Bremen, we also measured elements between Al and Ba (e.g., Al, Si, P, S, K, Ca, Ti, Mn, Fe, Sr, Ba) at 1-cm resolution (~100 years) in the upper 100 m of the revised spliced composite section of Site U1308. We found that Ca/Sr is an excellent proxy for detrital carbonate layers, and distinct Ca/Sr peaks coincided with Heinrich Events 1, 2, 4, and 5 during the last glacial period. The first occurrence of detrital carbonate at Site U1308 is found at ~640 kyr in MIS 16. Wavelet analysis of the isotopic and elemental data reveals an abrupt increase in 100-ka power at this time. Detrital carbonate events appear to be a feature of the “100-k world” at Site U1308, and limited to periods of large continental ice volume.
IRD ABUNDANCES FROM IODP EXPEDITIONS 303/306 SITES U1305 AND U1314 IN THE NORTH ATLANTIC OCEAN

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Abrupt climate change has been well-documented in the North Atlantic Ocean through a variety of paleoceanographic proxies. One of the goals of IODP Expeditions 303/306 was to develop more detailed records of specific proxies, including ice-rafted debris (IRD), in order to understand the mechanisms and patterns of abrupt climate change for the last few million years. This study examines sediment from Sites U1305 (~last 1.0 Ma) and U1314 (~last 1.5 Ma) in order to establish the abundance of IRD (i.e., lithic grains > 150 μm) and to generate a paleoclimate history for the North Atlantic. Site U1305 is located at the southwestern end of the Eirik Drift, while Site U1314 is located on the southern part of the Gardar Drift. Peaks in IRD abundance from these two sites record times of glacial expansion and are effectively compared to other proxy data such as δ18O, L*, and magnetic susceptibility.

GEOMAGNETIC FIELD RECORDS OF SITE U1312, THE SOUTHERN FLANK OF THE KING’S TROUGH


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Paleomagnetic study of Site U1312 is performed in order to obtain paleointensity record for providing chronological information on cores. Sedimentary sequence of this site is characterized by a relatively slower sedimentation rate than the other sites drilled during IODP Expeditions 303 and 306 (e.g. 1.69 cm/ky through 0-50 mbsf). However, comparing with previous published intensity data, the record has still useful information for stratigraphic correlation in spite of its slow sedimentation. Although Brunhes interval is noisy probably due to inconstant of magnetic mineral content through cores, the record between B-M to Jaramillo shows a good agreement to that of ODP Site 983. We will report the paleointensity result to make fine adjustment on the age of this site.

MAGNETIC FABRIC INDUCED BY NORTH ATLANTIC BOTTOM CURRENTS


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Anisotropy of magnetic susceptibility and other magnetic properties were measured on sample from Site U1314. The objective is to obtain depositional information induced by bottom current using the magnetic technique. The studied interval corresponds to 0.4Ma-1.6Ma. Magnetic fabric reveals weak magnetic lineation but strong foliation. Dip direction of magnetic plan formed by K1 and K2, which are re-orientated by paleomagnetic declination, shows a southwestward imbrication. Magnetic granular parameter such as SIRM/k or ARM/k suggests a gradual grain size decreasing of magnetic grain upward. These changes may be key for understanding of the NADW history through Pleistocene.
PROGRESSIVE MICROFABRIC CHANGES IN UNCONSOLIDATED DEEP-SEA SEDIMENTS DOWN TO 300 MCD, NORTHWEST ATLANTIC, IODP EXPEDITION 303

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303 Science Party

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Progressive change of microfabric of unconsolidated deep-sea sediment was studied. The sediments were collected by coring from the sea bottom about 300 meters composite depth (mcd), at the Sites U1305 and U1306 in the northwest Atlantic Ocean, during the IODP Expedition 303. Shapes, sizes and dispositions of pores and grains of the sediments were analyzed by SEM. Anisotropy of magnetic susceptibility (AMS) was also calculated. Void ratios decrease gradually downward from > 3.0 at near surface, > 2.0 at ~50 mcd, ~1.5 at ca. 150 mcd and finally to ~1.0 at ~300 mcd due to compaction. The microfabric changes rapidly up to ~50 mcd from non-directional fabric to preferred horizontal orientation, and changes gradually down to ~50 mcd.

DIAGENETIC ALTERATION OF MAGNETIC SIGNALS IN LABRADOR SEA SEDIMENTS

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Stability of iron oxides and sulfides in marine sedimentary environments are susceptible to changing redox conditions with burial depth. Therefore, the original magnetic signals are subject to post-depositional diagenetic alteration. In order to test the early diagenetic effects on magnetic signals, we measured magnetic properties, energy dispersive spectrometer, and interstitial water in the unlithified silty clay sediments from Sites U1305, U1306, and U1307 in the Labrador Sea. Our preliminary results indicate general downward (1) decreasing trends in remanent magnetization, (2) increase in grain size of magnetic minerals, and (3) changes in magnetic mineralogy. Magnetite is recognized at all depths, whereas maghemite is found only above the iron reduction depth zone. Furthermore, greigite appears to occur below the sulfate-methanogenesis interface. We assume that anaerobic methane oxidation and associated change in interstitial redox condition induce preferential dissolution of relatively small sized magnetic grains of maghemite and magnetite, and authigenic precipitation of greigite.
COCCOLITH EVIDENCE FOR THE PALAEOCEANOGRAPHIC CHANGES OVER THE LAST 0.25 Ma IN THE NORTH ATLANTIC OCEAN (IODP SITE U1304)

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Coccoliths can reflect the millennial timescale climate changes in the North Atlantic Ocean. Using SYRACO (Systeme de Reconnaissance Automatique de coccolithes, Beaufort & Dollfus, 2004), quantitative analysis of nannofossil assemblage have been carried out on the samples from Site U1304 over the past 0.25Ma. We find that the variations in coccolith assemblages have a good relationship with millennial timescale climate changes, especially to some climate events occurred in the late Pleistocene, such as Heinrich events and Dansgaard/Oeschger (D/O) cycles.

MAGNETIC MEASUREMENTS FROM COMPOSITE SECTION AT IODP SITE U1305 EXPEDITION 303: GEOMAGNETIC AND ENVIRONMENTAL RECORDS

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The composite section at Site U1305 was sampled with u-Channels through the entire Brunhes and part of the Matuyama Chronozone. The Natural Remanent Magnetization (NRM), Anhysteretic Remanent Magnetization (ARM), Isothermal Remanent Magnetization (IRM) and low field susceptibility (k) were measured every cm at the LSCE in Gif-sur-Yvette using small access 2G pass-through magnetometers (spatial resolution ≈ 4cm). An initial stratigraphy was derived by correlation of the low field susceptibility to a stable isotope reference curve. The Matuyama-Brunhes polarity transition is recorded at ~130 mcd. Boundaries of the Jaramillo Subchronozone are recorded at 157, and 168 mcd. The Iceland Basin excursion is recorded at 35 mcd, and another excursion is recorded at 49 mcd. Bulk magnetic parameters (ARM, IRM, and k) indicate a high magnetic concentration (of magnetite) during the Holocene and during interglacials (Holocene, 5e, 7, 9, 11, 17, and 19). ARM/k, which traces the size of the magnetite grains, shows episodes of marked size increase during interglacials, possibly related to bottom current activity.
UPPER AND LOWER JARAMILLO POLARITY TRANSITIONS RECORDED IN NORTH ATLANTIC SEDIMENTS FROM IODP EXPEDITION 303

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Progressive alternating field (AF) demagnetization of Jaramillo polarity transitions reveals strong magnetizations, with median destructive fields and coercivity spectra consistent with magnetite as the dominant carrier of the natural remanent magnetization (NRM). Component declinations were adjusted according to the shipboard "Tensor Multishot" orientation tool, and also by rotation so that the mean declination of stable polarity was aligned to 0° or 180°. Records of the upper Jaramillo transition obtained at Sites U1305, U1304, and U1306 exhibit VGP paths over Indian Ocean and Asia followed by a loop over the Americas. This is similar to the records previously obtained at ODP Site 983/984. Site U1308 record shows a large VGP loop after a path near the Americas. The lower Jaramillo transitions obtained at Site U1305 are complex, with VGP clusters over South America as in some volcanic records. Sites U1304 and U1308 document less complex VGP paths, possibly due to a larger degree of smoothing of the geomagnetic record by the sedimentation process.

PROVENANCE OF COARSE DETRITAL CARBONATE PEAKS SINCE MIS 16

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A prominent feature of North Atlantic glacial sediment records is the presence of detrital carbonate layers. For IODP Site U1308, detrital carbonate layers are present in MIS 16-8 and MIS 5-2 according to scanning-XRF Ca/Sr ratios. Here, we attempt to evaluate the carbonate sources and their relative contributions in these layers during the last 400 ka, based on grain counts and Pb isotope analysis of large single grains.

Two main groups of carbonate grains are present: A yellow-light grey group of Ordovician age, which is always present but dominant in the younger stages. It is similar to Baffin Bay carbonate dropstones. The other group consists of tan to dark brown grains that may be Permian or younger, and is important in MIS 16-10. These grains are similar to clasts in tills from the Scottish glaciation, but the method needs further refinement to establish the provenance of this erratics component.
WAS THERE A 1500-YEAR CYCLE IN HEMATITE-STAINED GRAINS DURING THE PENULTIMATE GLACIATION?

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Early work by G. Bond identified a 1.5-k.y. cycle, best expressed in hematite stained quartz and feldspar grains (HSG) during portions of the last glacial cycle (MIS 1-5) in the North Atlantic. This result triggered a great deal of interest into possible causes for such variability. One way to explore this issue is to examine millennial variability from other glacial stages. DSDP Site 609 was central to the identification of this 1500-year cycle. However, most analyses of Site 609 were not extended into the penultimate glaciation (MIS 6) due to the lack of a continuous, undisturbed composite record. During IODP Exp. 303, a continuous Pliocene-Quaternary record was recovered from Site U1308, a reoccupation of Site 609. Here we report preliminary petrologic results from the MIS-6 interval of Site U1308, which indicates that cycles in the abundance of HSG and Icelandic volcanic glass (IG) exhibit a differing character from those of the last glaciation (primarily MIS 3), the Holocene (MIS 1), and the Eemian (MIS 5e).

GEOMAGNETIC FIELD IN THE MATUYAMA AND THE GAUSS CHRON AT IODP SITE U1314 IN THE NORTH ATLANTIC

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We report the result of paleomagnetic study of a sediment core at IODP Site U1314 in ca. 1.7-2.7 Ma interval. Stepwise AF demagnetizing experiments were made for NRM and ARM of the U-Channel samples. Most of the drill-string overprint was removed at 20-30 mT, and a well defined characteristic magnetization component was obtained. Thermomagnetic curves indicate magnetite as the dominant mineral. Hysteresis ratios lie in the pseudo-single domain field in the Day plot. VGP paths of the transition of the Gauss/Matuyama boundary and of other geomagnetic reversals in this period are obtained. Values of NRM divided by ARM, a possible proxy of relative paleointensity, show several lows accompanied by large directional changes, which suggests geomagnetic excursions.
EVIDENCE FOR THE COLLAPSE OF UPPER WATER MASSES DURING ICE-RAFTING EVENTS: A MULTISPECIES PLANKTONIC FORAMINIFERAL $\delta^{18}$O APPROACH

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We have measured $\delta^{18}$O in three planktonic foraminiferal taxa *Neogloboquadrina pachyderma* (s), *Globigerina bulloides*, *Globigerinoides ruber* and benthic foraminifera *Cibicidoides wuellerstorfi* from IODP Site U1313. Concentration of the ice-rafted debris (IRD) and benthic foraminiferal assemblages were also counted. We found similar $\delta^{18}$O values from mixed-layer and thermocline-dwelling planktonic foraminifera during the large amplitude IRD-events suggesting the collapse of upper water masses. These data suggest that the planktonic foraminifera taxa calcified their shells at similar temperatures in a homogenized upper water column. Similar collapse can be seen from the northern margin of the IRD-belt, implying that this homogenization of water masses were widespread in the region. We suggest that an increase in storminess during large IRD event intensifies vertical mixing of meltwater from ice-rafting in the upper ocean. Lighter $\delta^{13}$C values correspond to those large IRD-events suggesting coupled perturbation of both surface and deep waters at the subtropical latitude.

MICROPALEONTOLOGY AND SEDIMENTOLOGY OF LAMINATED SEDIMENTS FROM THE NORTHERN NORTH ATLANTIC OCEAN (SITE U1304): A SCANNING ELECTRON MICROSCOPE-BASED STUDY

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This report documents the nature of Pleistocene laminated sediments at Site U1304. Mat deposition was episodic and discontinuous but present throughout the recovered sequence. The sediment fabric of selected ooze intervals from the composite section was analyzed using scanning electron microscopy and has shown that (i) mat thickness ranges 50 – 500 µm, and (ii) the sediment mainly consists of an irregular alternation between diatom-rich laminae; mixed-sediment laminae comprising silt grains, clays, and nannofossils; and horizontal to subhorizontal burrows that are similar to sediment deposited above and below the diatom-rich intervals. The occurrence of mats is localized to a narrow Subarctic convergence zone between the cold surface water associated with the Labrador Sea current and the warmer North Atlantic current. Long sequences of pelagic laminated sediments at high-latitudes have important implications for the export and sequestration of opal and organic matter, and represent vast sinks of silica and carbon to the sediments.
HIGH-RESOLUTION CLIMATIC RECORD OF THE HIGH-LATITUDE ATLANTIC (SITE U1302/03): PLEISTOCENE OCCURRENCE OF RAPIDLY-DEPOSITED DETRITAL LAYERS

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Site U1302/03 shows the occurrence of numerous carbonate-rich detrital layers within and prior to the last glacial interval. These layers, recognizable visually as well as with gamma ray attenuation density and magnetic susceptibility, have now been characterized by high-resolution analysis of X-ray fluorescence (XRF) and diatom assemblages. At least eight distinct Ca peaks, coeval with Ti:Al minima, these indicative of non-biogenic sediments, occurred during the last glacial period corresponding to Heinrich events. Similar detrital layers are identified and tentatively assigned to MIS 6, 8, 10, 12, 14 and 16. Accumulation time for these layers roughly range 500-2500 y. Strong decreases in diatom concentration are coeval with the layers’ occurrence, mirroring either low siliceous productivity or dissolution events due to meltwater pulses. Our results suggest that centennial-to-millennial scale variability of both climate and surface water conditions in the Northern Atlantic have been the rule rather than the exception over the past 900 k.y.

PERIODICITY OF THE QUATERNARY CALCAREOUS NANNOFOSILS IN THE NORTH ATLANTIC OCEAN WITH SPECIAL REFERENCE TO MONSOON AREA

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We analyzed the Quaternary calcareous nannofossils from Sites U1304, U1306, and U1308 to detect the periodicity of paleoenvironment change. The assemblages from these sites are characterized by common to abundant occurrences of warm water species and by few occurrences of cold water species Coccolithus pelagicus. FFT analysis shows that the 100 ky and 40 ky cycles are clearly detected in the assemblages from the sequence above MPR. Although the relative abundance of Calcidiscus leptoporus also shows 100 kyrs cycle after MPR, only 40 kyr cycles are found before it. These characteristics are opposed to the assemblages in Monsoon area such as Sites 723 and 807, in which these cycles are not detected.
DIATOM STRATIGRAPHY IN THE NORTH ATLANTIC OCEAN, IODP EXP. 303

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Using the materials of IODP Exp. 303, the Northeastern Atlantic, a quantitative diatom biostratigraphy has been established for the middle to upper Quaternary horizons. During the Mid-Pleistocene Transition (MPT), diatom productivity increased particularly in U1305 and U1306, the northern sites of the studied area, by the contribution of mainly Neodenticula seminae, a planktonic species recorded exclusively in the 1.25-0.85 Ma sediments in the Atlantic. So far none of possible ancestors of the species have been reported in this ocean. Then, it was also revealed that the concentration of the species had been extraordinarily high in the North Pacific during the same interval, indicating that the “N. seminae Ocean” had appeared in the widespread area of the high latitudes in the Northern Hemisphere during MPT. The presentation will give one of the paleontological evidences of a certain paleoceanographic event to impact on the micro-organism biosphere in the high latitudinal oceans during MPT.

SHORT-TERM VARIABILITY OF SURFACE-WATER CHARACTERISTICS AND ICE-SHEET INSTABILITY IN THE LATE NEOGENE-QUATERNARY NORTH ATLANTIC OCEAN: BIOMARKER AND XRD RECORDS FROM SITE U1313

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Overall goal of our study on material of Expedition 303/306 is the high-resolution reconstruction of the short-term variability of sea-ice cover, sea-surface temperature, sea-surface salinity, and sea-surface productivity in the late Neogene and Quaternary North Atlantic Ocean and its relationship to ice sheet instabilities, using organic-geochemical (biomarker) proxies and XRD data. Here, we focus on the (sub-) Milankovitch variability of IRD, CaCO₃, alkenone SST, and organic-carbon (OC) input at Site U1313, MIS 9 to 13(16). Within this time interval, SST vary between 8 and 20°C, with distinct minima coinciding with major IRD events, maxima in terrigenous OC, and minima in CaCO₃. Distinct maxima in alkenones interpreted as proxy for primary production, occur during the interstadials of glacial intervals, collapsing near Terminations V and IV. As based on XRD analysis, IRD events are characterized by high concentrations of dolomite, quartz, and feldspars.
PALEOMAGNETIC SECULAR VARIATION FROM THE HOLOCENE SECTION OF SITE U1305: TOWARD A BETTER UNDERSTANDING OF THE NRM RECORDING PROCESS

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Our understanding of the NRM recording process in deep-sea sediments has been hindered by a lack of knowledge of the geomagnetic input that can be compared to the paleomagnetic output. Holocene paleomagnetic secular variation (PSV) studies from high-resolution Icelandic sediments provide a high quality PSV template that can be used for such assessments. The natural remanent magnetizations (NRM) measured in u-Channel samples from the Holocene sections of Site U1305 provide a perfect target for such a comparison. Sites are proximally located, component magnetizations of Site U1305 are well-defined and prior work in the region allow an independent chronology to be constructed. Comparison of the directional record show substantial similarities and allow the Icelandic chronology to be transferred U1305 sediments. Assessment of the correlation between geomagnetic input and pale magnetic output will be made.

ORPHAN KNOLL (IODP SITE U1302/U1303) RECORD: LINKAGE BETWEEN THE NORTH ATLANTIC, THE LAURENTIDE ICE-SHEET (LIS) AND THE ATLANTIC MERIDIONAL OVERTURNING (AMO) COMPONENTS

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Sheltered from direct influence of the western boundary undercurrent (WBUC) by Orphan Knoll, the IODP Site U13202/U1303 provides uniform and continuous record of linkages between the northeastern LIS surge areas (cf. Heinrich events), the AMO properties since all constitutive water masses still preserve their identity in the overlying water column, and the North Atlantic. We report here on the oxygen isotope stage (OIS) 6-1 interval with special attention to the last interglacial (OIS 5e). The oxygen and carbon isotope record in N. pachyderma left-coiled carry a typical North Atlantic signature, notably with regard to well developed stratigraphies of the OIS 5e to 5a interval. A most interesting feature during termination II (end of OIS 6) is seen in the recording of a major surge event not unlike the H1 event of the last termination. Isotopic measurements in G. bulloides suggest a warming trend in surface water toward the end of OIS 5e, in contrast to the present interglacial that shows an early thermal optimum. Preliminary dinocyst data and comparison with Sites U1305 and 646 from the southern Greenland rise suggest no intermediate water formation in the Labrador Sea during OIS 5e.
ICE-RAFTED DEBRIS AND DEEP WATER RECORDS FOR MARINE ISOTOPE STAGES (MIS) 11 TO 16 FROM IODP SITE U1313 (41°N 33°W)

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For the interval from 16 to 32 m corrected–mcd, which covers the period from MIS 10.4 to 16.2, ice-rafted debris (IRD) data, a benthic stable isotope record for the period from MIS 10.4 to 13.3 and planktonic (G. inflata) isotope data for MIS 13.1 so far exist. Based on the IRD data it was evident that the shipboard splice was incorrect at both transitions within the studied interval and a new c–mcd scale was established. IRD was deposited at the site during all the colder periods with maxima during glacials 10, 12 and 16. During MIS 12, three major ice-rafting periods occurred. Lithics during MIS 15 are mainly fresh tephra grains, probably from a nearby Azores source and at least partly airborne. The benthic data shows orbital to centennial-scale frequency and confirms the presence of AABW during glacial periods. The most important finding, however, are three short oscillations during MIS 12 indicating NADW presence at the site.

COMPOSITE DEPTH - HOW GOOD IS IT AWAY FROM THE SPLICE?

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I used digital core images from Sites U1305 - U1308 to test how well MCD in the spliced record correlates to MCD assigned to cores, or sections of cores, not included in the splice. Individual core images were compared to a composite spliced image and multiple correlation points were chosen within each core. Results varied widely, but on average, approximately 20% of the depths for material not in the splice were greater than 20cm away from their "correct" splice MCD location. Given that the cores often contained layers on the order of 20cm thickness, the same MCD in different holes may well be in different lithologies.

STABLE ISOTOPE STRATIGRAPHY OF IODP SITE U1306

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A stable isotope stratigraphy is being generated for Site U1306 on the Eirik Drift using the planktonic foraminifer Neogloboquadrina pachyderma (s). Results to date show expanded intervals (20 to 30 cm/ky), representing Marine Isotope Chrons (MIC) 2-4, 6-7.3, and 8. Moderately high sedimentation (>10cm/kyr) was recorded in MIC 5a-5d. Very little, if any, Holocene is present and other recent interglacials, MIC 5e and 7.5, are represented by <10cm. Interestingly, the deglacial intervals appear to maintain relatively high sedimentation rates. E.g., the isotope stratigraphy indicates that ~1m of Younger Dryas sediments are present on the upper parts of Eirik Drift. This pattern of accumulation contrasts with that of the deeper parts of Eirik Drift which record high accumulation during the warmest intervals. Comparison of sedimentation rates from shallow and deep locations on the drift may afford the opportunity to construct high-resolution records over climatic cycles.
CONTRASTED SEDIMENTATION REGIMES DURING THE LATE QUATERNARY ON SOUTH GREENLAND SLOPE AND RISE FROM STABLE ISOTOPE STRATIGRAPHIES AT IODP SITES U1305 AND U1306

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Stable isotope analyses in Neogloboquadrina pachyderma left-coiled (Npl) are used to compare stratigraphies of cores raised from the southern Greenland rise and slope and along Eirik Ridge. Cores KN166-14-15JPC, HU90-013-012P, MD99-2242 and IODP 1306 were raised between water depths of 2230-2900 m, whereas cores HU90-013-013, MD99-2227, ODP 646 and IODP U1305 illustrate conditions between depths of 3380-3460 m. At the shallower sites, interglacial stages are characterized by reduced sedimentation rates and winnowing linked to an intense western boundary undercurrent (WBUC), a feature which we associate with a high production of Denmark Strait Overflow Water (DSOW). On the contrary, glacial and interstadial intervals are represented by expanded records suggesting a reduced WBUC velocity. Conversely, down-slope records show very high sedimentation rates during interglacials, in particular during oxygen isotope stage (OIS) 1, and to a lesser extent during OIS 5e. This suggests sediment focusing below the high velocity core of the WBUC during such intervals. Sedimentological and geochemical features provide complementary insights into deep current properties and sources of deep water masses, and illustrate distinct paleo-current patterns from one interglacial to the other (cf. Henderson et al.; Hillaire-Marcel et al.).

PALEOMAGNETIC RECORDS FROM IODP SITE U1304: THE INFLUENCE OF DIATOMS ON THE MAGNETIC RECORD

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Paleomagnetic records that extend back to ~1.5 Ma were produced from u-Channel samples at IODP Site U1304, where episodic deposits of laminated diatom ooze were found throughout the recovered sediments. Magnetic concentration parameters such as volume magnetic susceptibility, ARM, and IRM, in diatom-rich intervals are ~2 orders of magnitude lower than in clay-rich intervals. Anhysteretic and volume susceptibility imply a magnetite grain size of ~1-5 µm throughout, and diatom-rich intervals tend to contain relatively fine-grained magnetite. S-ratio data indicate higher coercivities in samples from diatom-rich intervals, although paleomagnetic directions and paleointensities appear well preserved in diatom-rich intervals. The Matuyama-Brunhes boundary, Jaramillo and Cobb Mountain subchrons are clearly recorded. Two directional excursions appear in the Matuyama Chron. Based on an initial age model established by correlating shipboard natural gamma (NGR) data to an oxygen isotope stack, diatom-rich intervals are characterized by markedly elevated sedimentation rates.
QUATERNARY SHELL SIZE VARIATIONS IN THE PLANKTONIC FORAMINIFERA NEGLOBOQUADRINA PACHYDERMA (SIN) IN THE NORTH ATLANTIC: IMPLICATION FOR THE PALEOCEANOGRAPHIC RELATIONSHIP BETWEEN THE NORTH ATLANTIC AND THE NORTH PACIFIC

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*Neogloboquadrina pachyderma* (sinistral) is one of the most important species because the species allows us to reconstruct the history of polar-subpolar surface conditions where it thrives and evolves. Size variation in *N. pachyderma* (s) was examined in the Quaternary sediments from IODP Site U1304 in the North Atlantic. A distinct increase of shell size of the species ca. 1.0 Ma and a sudden, temporal decrease of it around at 0.4 Ma were both recorded. These shell size changes were reported both in the Norwegian - Greenland Sea (Huber et al., 2000) and the eastern North Pacific (Kucera et al., 2000). Those findings indicate shell size variations were modulated by paleoclimatic changes over the Northern Hemisphere.
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