IODP

INTEGRATED OCEAN DRILLING PROGRAM

UK newsletter 34

April 2009

NATURAL ENVIRONMENT RESEARCH COUNCIL

ECORD European Consortium for Ocean Research Drilling

IODP Highlights

JOIDES Resolution Returns to IODP

- After successfully completing sea trials in the South China Sea the JOIDES Resolution has begun its first IODP Expedition since 2005.
- Expedition 320 – Pacific Equatorial Age Transect will take place from March to May 2009.

INVEST 2009

- Multidisciplinary, international community meeting whose focus is to define the scientific research goals of the second phase of IODP, expected to begin in Autumn 2013.
- Hosted by the University of Bremen, Germany on 23-25 September 2009.

Editor:
H A Stewart, British Geological Survey, Edinburgh, EH9 3LA

Front Cover: The *JOIDES Resolution* alongside in Honolulu, Hawaii for the start of Expedition 320. *Photo courtesy of the USIO/IODP*

Foreword

Sir Geoffrey Allen, Former Chair of the UK-IODP Steering Committee

In 2003 NERC became a member of ECORD and hence IODP until 2013 and formed the UK-IODP. It has now been decided that the UK-IODP will continue to direct the activities of the UK ocean drilling community to the end of this period.

Since 2003, the UK-IODP programme has:

- Influenced IODP and ECORD strategy by active membership of IODP science advisory panels, ECORD Council and ESSAC.
- Sponsored UK scientists to be actively involved in drilling expeditions and in the formulation of new proposals.
- Funded post-cruise activities and research projects to further. understanding of the Earth System
- Formed an Industrial Liaison Panel (ILP) who's success has led to it now being expanded and adopted to include a European dimension.

The community is also served by workshops, conference etc, to debate and inform scientists of progress. Young scientists have been nurtured and supported through enabling post graduates and post docs to attend European Summer Schools, participate in expeditions and work on post-cruise projects, amongst other initiatives.

IODP was formed in 2003 when it had become clear from ODP that a more comprehensive drilling capability was required to further the development of the field and to extend our knowledge of the Earth System. It was agreed within IODP:

- The US would continue to operate the JOIDES Resolution for two years and then undertake a major refit of the vessel.
- Japan would commission the Chikyu, a riser-drilling vessel, and begin full-scale operations at the end of 2007.
- ECORD would contribute Mission Specific Platforms (MSPs) managed by the ECORD Science Operator.

The UK-IODP has aimed to have our scientists involved to provide leadership or gain experience in each activity.

Over these 5 years, the JOIDES Resolution operated successfully throughout 2004 and 2005. Its refit took a year longer than expected but the vessel is now ready to continue the planned operations with 5 expeditions planned for 2009. Chikyu completed its test operations at the end of 2007 and completed Stage 1 of the Nankai Trough Seismogenic Zone (NanTroSEIZE) experiment in 2008. Stage 2 of the NanTroSEIZE experiment will be undertaken through 2 expeditions in 2009. Two MSP expeditions, The ACEX and Tahiti, have been completed and two further MSPs, New Jersey and Great Barrier Reef, are scheduled for 2009.

There have been disappointments in 2008 but 2009 looks to be a very active year for IODP. The UK have a cohort of scientists ready to join the planned expeditions, including 2 co-chiefs from the UK. At conferences, workshops and in scientific publications, the UK community continues to be well-represented.

The output from out programme supports numerous elements of the NERC Strategy and of the three IODP Strategic themes, Environmental Change studies maintain their strong momentum; Solid Earth Cycle projects grow in strength, however, it is agreed that Deep Biosphere studies need more stimulation.

The programme for 2008-2013 will develop from the pattern of the first 5 years. There is no shortage of good proposals in the pipeline. In partnership with academy, the ILP has introduced a new form of site survey utilising seismological data from industrial archives to assess drilling sites for future proposals. Two are underway and show the potential for saving time and costs and enhancing current IODP proposals: the IODP appears to be almost full so the new proposals will have to be outstanding to gain acceptance.

The almost doubling of operational costs over the past two years means that IODP is faced with certain financial constraints. Resolution of these issues, with or without collaboration with industry, has wide implications reaching beyond 2013.

Past experience suggests strongly that in the current 5 year phase, the UK-IODP, ECORD and IODP must begin to think about the programmes, new technologies and recourses needed beyond 2013. Could this be an era in which seabed rigs become operational…?

My last foreword is an opportunity to thank the NERC administrators, the Science Coordinator and committee members involved in UK-IODP for their commitment and equally to congratulate the geoscience community for grasping with enthusiasm the opportunities presented and perceptively promoting new ones, within our membership of IODP.

Upcoming expeditions

IODP to operate three drilling platforms in 2009

Alan Stevenson (ESO Outreach Manager) and Nancy Light (IODP Director of Communications)

In 2009, IODP will conduct scientific ocean drilling operations aboard all three of its platforms from March until December. This is the first time since IODP began operations in 2004 that all three platforms will operate in the same year. Riser drilling will be conducted aboard the *Chikyu*; the newly modernised *JOIDES Resolution* will conduct riserless operations; mission-specific operations will be conducted using platforms customised for specific environments. The scheduled operations will explore climate change, sea level change, the Nankai Trough Seismogenic Zone, and oceanic plateau formation.

The first expedition in 2009 will be the Pacific Equatorial Age Transect (PEAT) expedition, operated by the U.S. Implementing Organisation. PEAT will mark the *JOIDES Resolution's* return to IODP operations following its upgrade in Singapore from 2006-2008. The ship set sail from Honolulu on the 5th March to conduct the first of two nine-week expeditions to the Equatorial Pacific. The expedition team aims to recover a continuous Cenozoic record (from 65.5 million years ago to present) by drilling at the paleoposition of the Equator at successive crustal ages on the Pacific plate. This will help scientists understand how the Earth was able to maintain very warm climates relative to the 20th century, even though solar radiation at the planet's surface remained nearly constant for the last 55 million years. The co-chief scientists for the first leg of PEAT (Expedition 320) are Heiko Pälike of the University of Southampton and Hiroshi Nishi of Hokkaido University, Japan. The second PEAT expedition (Expedition 321) will follow on immediately in May 2009 and will be grouped with Expedition 320 into one science programme.

In May 2009, the *Chikyu* will start work on Stage 2 of the NanTroSEIZE drilling project with Expedition 319 to the Nankai Trough, off Japan's Kii Peninsula. The objective is to prepare boreholes at two sites that will be used for future installation of the Long-Term Borehole Monitoring Systems (LTBMS), which will transmit earthquake data in real time.

Also in May, the ECORD Science Operator (ESO) will conduct the third IODP mission-specific platform (MSP) expedition off the east coast of the U.S.A. The New Jersey Shallow Shelf expedition (Expedition 313) will use the liftboat Kayd to drill three sites 45 and 60 km off the New Jersey coast in water depths of about 35 metres. This expedition is co-supported by the International Continental Scientific Drilling Program (ICDP). The research team will focus on collecting cores from early to mid-Miocene sedimentary sequences (14-24 million years old). Major developments in the Earth's climate system during this period include intense Arctic glaciation and the mid-Miocene 'Climatic Optimum', when ice sheets were at a relative minimum extent. The scientists aim is to estimate the timing and magnitude of global sea level in response to the climate variations during Miocene times and determine the relationship between sea-level change and the architecture of sediments.

The New Jersey Margin is an ideal location in which to investigate the history of sea-level change and its relationship to sediment stratigraphy because the sediments were deposited rapidly in an area that was tectonically stable, allowing fossils suitable for age control to be preserved throughout the time interval of interest. In addition, there are already large datasets of seismic, well log and borehole data with which to frame the geological setting from the coastal plain across the shelf to the continental rise.

From July onward, the *JOIDES Resolution* will conduct three further expeditions: to the Bering Sea; Shatsky Rise 1500 km to the east of Japan; and the Canterbury Basin off the east coast of New Zealand's South Island. The *Chikyu* will continue the next stage of the NanTroSEIZE expedition until mid-October.

ESO is planning to conduct the second MSP expedition of the year starting in October/November. The Great Barrier Reef Environmental Changes Expedition (Expedition 325) will core sites along successive reef terraces, relict reefs and the slope, from 40–200 m water depth. The scientific aims of this project are to establish the course of sea-level rise during the last deglaciation (~20-10 ka); reconstruct the nature and magnitude of seasonal millennial-scale climate variability (i.e. sea-surface temperature and sea-surface salinity) and to determine the biological and geological response of the Great Barrier Reef to past abrupt sea-level and climate changes as a possible template to improve predictions of ecosystem response to future global climate changes.

These nine expeditions indicate IODP's return to operations, and the fulfilment of IODP's original promise to conduct scientific investigations on multiple platforms. They will be followed in early 2010 by the Wilkes Land Expedition (Expedition 318) off the coast of Antarctica. Operation of all three platforms provide ample opportunity for research investigators to resume their work at sea. IODP is integral to climate change research and to the scientists who conduct climate change research. The IODP platforms provide key tools in investigating scientific questions related to Earth science, climate change, the deep biosphere, and geodynamics.

For summaries of Expeditions 313 and 320 please see *UK-IODP Newsletter 32* available online at www.ukiodp.bgs.ac.uk.

Expedition 325 Great Barrier Reef Environmental Changes (GBREC)

Alex Thomas (University of Oxford) and Sandy Tudhope (University of Edinburgh)

Following from the successful IODP Expedition 310 'Tahiti Sea Level', IODP will go to the Great Barrier Reef (GBR) during late 2009. Expedition 325 'Great Barrier Reef Environmental Changes (GBREC)' – led by chief scientists Yusuke Yokoyama (University of Tokyo) and Jody Webster (University of Sydney) – will target submerged fossil reefs seaward of the modern barrier reef.

The principal objectives will be to recover corals and other reef building material that will enable the early (20-10 ka) portion of the last deglacial sea level rise to be determined. The recovery of corals from throughout the deglaciation will also enable reconstruction of seasonal-millennial scale climate variability using high resolution trace element and isotope proxies for temperature, salinity and ocean chemistry. The suite of cores recovered will also be studied to determine the response of the reef ecosystem (and reef geometry) to the rapid rise of sea level and changes in climate during the deglaciation. This last objective is especially pertinent to our understanding of how the modern Great Barrier Reef (a World Heritage Site) will respond to future rising sea level and climate change.

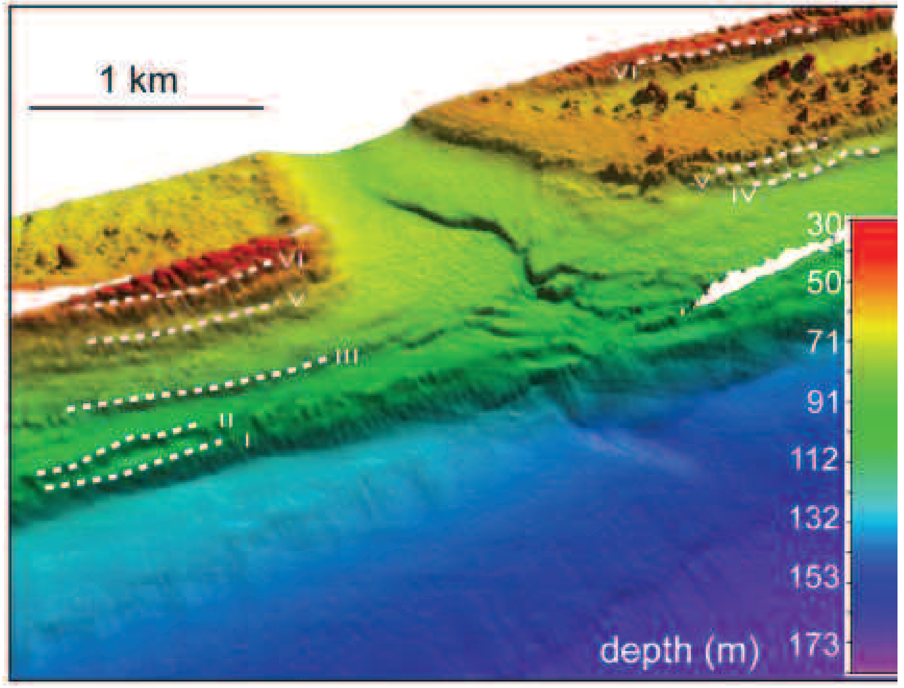

Figure 1: Perspective view of multibeam bathymetry, looking NW, of the submerged reefs at Noggin Pass (Webster, et al., 2008). Illustrated in white are submerged terraces, which potentially developed in a sequence (I – VI) in response to sea level changes.

As sea level rose, during the last deglaciation, coral reefs will have responded by growing vertically into the new accommodation space. However, during periods of especially rapid sea level rise these reefs will have been 'drowned' and the location of most active reef growth will have stepped back and up the slope. In this way, a sequence of discontinuous terraces will have formed on the upper continental slope between the low stand level (~-120m) and present day sea level (Figure 1). Expedition 325 will drill this sequence of reef terraces to fully sample the deglaciation. By establishing chronologies for the cores, using U/Th and C14 dating, and determining the environment of deposition using faunal, floral, and sedimentological assemblages, a full and detailed history of sea level rise will be constructed. Such a record will compliment existing estimates for early deglacial sea level at the GBR based on sedimentary facies (*Yokoyama, et al*., 2006). Expedition 325 will drill five depth transects of holes (Figure 2). In the north, offshore of Ribbon Reef, two transects will be made on the narrow shelf. These two transects will compliment existing drill core investigations from the GBR (*International Consortium for Great Barrier Reef Drilling, 2001*; *Webster and Davies*, 2003) – jack up barge drilling into the modern reef – by providing the down slope compliment which will provide an archive from periods of lower sea level. Further transects to the southeast, at Noggin Pass and Hydrographer's Pass will enable the spatial as well as temporal variability of climate to be reconstructed. Additionally, the transects at Hydrographer's Pass are sited on a shallowly sloping shelf, which therefore allow the possibility that reefs could accumulate throughout the deglaciation, whereas the narrow shelf at Ribbon Reef may lead to portions of the deglaciation to be missing.

The construction of a deglacial sea level record from the GBR is of great importance to our understanding of the Earth's climate. The addition of a GBR sea level curve to the current ensemble of Barbados (*Fairbanks*, 1989; *Bard, et al*., 1990), *Papua New Guinea* (Chappell and Polach, 1991; *Edwards, et al*., 1993), and Tahiti (*Bard, et al*., 1996; *Camoin, et al*., 2007) will enable the global variation of relative sea level to be better constrained. This spatial variability of relative sea level will allow refined testing of models of glacial isostatic adjustment (*Lambeck*, 1993; *Fleming, et al*., 1998; *Bassett, et al*., 2005). Only with the combination of relative sea level records and robust isostatic modelling can the eustatic (ice volume equivalent) sea level be determined. In contrast to Barbados and Papua New Guinea the GBR is considered tectonically stable. This stability will enable the rapid changes in sea level, proposed for the last deglaciation, to be investigated without any potential bias from sudden land movements. These periods of rapid sea level rise (termed 'melt water pulses' (*Fairbanks*, 1989; *Yokoyama, et al*., 2000)) are particularly important for determining the response of reef ecology and geometry to rapid rates of sea level change, because they potentially can act as an analogue for the high projected rates for future anthropogenic sea level rise (*Pfeffer, et al*., 2008).

Paleoclimate reconstructions that will be produced from GBR drilling will provide crucial insights into how the climate system operates both at the last glacial maximum and across the deglaciation. In particular the amount that sea surface temperatures were lower than present at the last glacial maximum, is sparsely constrained spatially. Not only will Expedition 325 add to our understanding of the distribution of surface

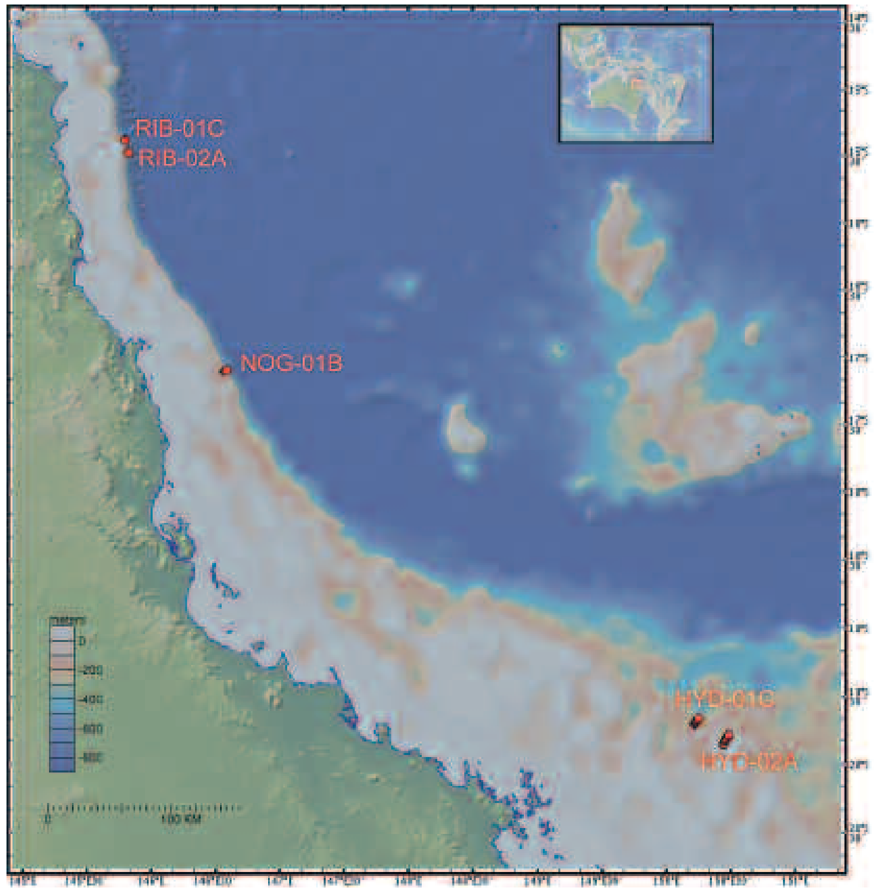

Figure 2. Map illustrating the positions of the proposed transects of drill holes at: Ribbon Reef (RIB), Noggin Pass (NOG), and Hydrogapher's Pass (HYD).

heat in the glacial ocean but will also provide time series' indicating when during the deglaciation temperatures rose in the southwest Pacific. Knowing the phasing of temperature change between high and low latitudes, and between northern and southern hemispheres, is important for us to understand the forcings that operated to drive the Earth's climate from its glacial state to the present interglacial warmth (*Bard, et al.*, 1997; *Beck, et al.*, 1997).

Drilling in such a sensitive environment as the GBR requires a careful approach. A mission specific platform will be utilised to enable drilling in 30-300 m water depth. This will be a dynamically positioned vessel similar to the DP Hunter used for Expedition 310 (the contract for providing the MSP is currently yet to be finalised). As part of the site survey (*Webster, et al.*, 2008), stereo photography of the sea bed was taken from an AUV. This data along with the through pipe video imagery will enable precise location of the drill holes away from living coral. This approach has been shown to be successful during expedition 310 drilling at Tahiti, with before and after comparisons using the down pipe video showing minimal-no adverse environmental damage.

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Expedition 323 - Bering Sea Paleoceanography and Climate History

The nine-week IODP expedition to the Bering Sea will employ the *JOIDES Resolution's* unique capabilities to recover seafloor sediments which will provide the first comprehensive, high-resolution records of environmental and oceanographic conditions in the Bering Sea over the past 5 million years. Scientists will use the results to reconstruct the history of this important marginal sea, connecting the Pacific and Arctic oceans, and its role in global changes.

Over the last 5 million years, global climate has evolved from being warm with only small Northern Hemisphere glaciers and ice sheets to being cold with major Northern Hemisphere glaciations occurring every 100 to 40 thousand years. The reasons for this major transition and the mechanisms controlling glacial/interglacial and millennial scale climate oscillations are unknown. Although there are data to show that the Pacific experienced oceanographic reorganizations that were just as dramatic as those in the Atlantic, the scarcity of data in critical regions of the Pacific (the largest ocean with arguably the largest potential to influence global climate) has prevented an evaluation of the role of North Pacific processes in global paleoceanography and climate evolution.

Specifically, the sedimentary records from the Bering Sea will provide an understanding of the evolution of Pliocene-Pleistocene surface water conditions, paleoproductivity, and sea-ice coverage, including millennial to Milankovitch scale oscillations; the history of past production of the Pacific intermediate and/or deep water masses within the marginal sea, and its link to surface water processes; the interactions between marginal sea conditions and continental climate and the Pacific Ocean; and an evaluation of how the history of ocean/climate of the Bering Strait gateway region may have had an effect on North Pacific and global conditions.

Expedition 324 - Shatsky Rise Formation

The nine-week IODP expedition to the Shatsky Rise, 1500 km east of Japan will penetrate ~1000 m into the Shatsky Rise to examine the history, sources, and evolution of this plateau. Scientists anticipate the results will help to address one of the most fundamental questions of modern geodynamics – the process of mantle convection and its impact on the Earth's surface through volcanism, and whether oceanic plateaus like Shatsky Rise were formed from deep-sourced mantle plumes or solely by interaction of plate boundaries and the lithosphere with the shallow mantle.

Shatsky Rise is the best location on Earth to test plume versus plate-tectonic origin hypotheses of ocean plateau formation. Shatsky Rise is the only large oceanic plateau formed during a time of magnetic reversals, permitting its tectonic setting to be resolved. Magnetic lineations show that the plateau formed along the trace of a triple junction and its formation was intimately related to ridge tectonics. Existing data demonstrate that several aspects of Shatsky Rise's history (e.g., massive, rapid initial growth, transition from large to small magma flux, capture of ridges) fit the plume head model. On the other hand, the coincidence of volcanism with the triple junction, ridge jumps, and the lack of isotopic evidence for a hotspot-type mantle source can all be taken as favoring a plate-controlled origin.

Expeditions Schedule for 2009

USIO

Expedition	Number	Dates
Pacific Equatorial Age Transect	320	March 5 - May 5, 2009
Pacific Equatorial Age Transect/ Juan de Fuca	321	May 5 - July 5, 2009
Bering Sea	323	July 5 - September 4, 2009
Shatsky Rise	324	September 4 - November 4, 2009
Canterbury Basin	317	November 4, 2009 - January 4, 2010
Wilkes Land	318	January 4 - March 9, 2010

CDEX

NanTroSEIZE Stage 2: Riser/Riserless Observatory 1	319	5 May - 31 August 2009
NanTroSEIZE Stage 2: Subduction Input	322	1 September - 10 October 2009

ESO

New Jersey Shallow Shelf	313	May - August 2009*
Great Barrier Reef Environmental Changes	325	September - December 2009*

** exact dates in this time frame to be confirmed*

www.iodp.org/expeditions/

Expedition 317 - Canterbury Basin Sea Level

In November 2009, an international team of scientists will use the *JOIDES Resolution* to collect and analyze geological data to investigate the history of global sea level change over the last 30 million years. The expedition party will travel to the Canterbury Basin, off the eastern coast of the South Island of New Zealand, to recover sediment samples from as deep as 5,900 feet beneath the seafloor.

The expedition focuses on understanding the relative importance of global sea level versus local tectonic and sedimentary processes in controlling continental margin depositional cyclicity. The emphasis is on the last 30 million years when global sea level change was dominated by glacial/interglacial ice volume fluctuations, primarily on Antarctica. The expedition offers the opportunity for expanded study of the complex interactions between processes responsible for the preserved stratigraphic record of sequences and provides information on the early history of the Alpine Fault plate boundary. The deepest target of this expedition is the early Oligocene Marshall Paraconformity hypothesized to mark the initiation of thermohaline circulation and the proto-Antarctic Circumpolar Current.

Melting of Antarctic ice increases the volume of water in the oceans and therefore influences sea level globally. However, other processes, most notably vertical movement of the Earth's crust, can also affect sea level locally. In order to extract the global sea level signal from a sedimentary basin that has also been influenced by local processes, it is necessary to correlate results from that basin with similar data from other disparate locations. The Canterbury Basin is an ideal location for this study because it is far from sites previously drilled in global sea level exploration, primarily located in the North Atlantic. Also, Canterbury Basin sediments were laid down on the seafloor rapidly, resulting in a detailed historical record.

Expedition 318 - Wilkes Land Glacial History

The first Expedition of 2010, will utilize the *JOIDES Resolution* taking an international team of scientists to the Wilkes Land margin off the coast of Antarctica. There they will recover sediment samples from 1150 meters beneath the seafloor, in waters up to 3705 meters deep, to broaden our understanding of the Antarctic cryosphere. This is not only of major scientific interest but also is of great importance for society.

The transition from Greenhouse to Icehouse Earth impacted global sea level, albedo, and oceanographic and biotic evolution, among other changes. State-of-the-art climate models combined with paleoclimatic proxy data suggest that the main triggering mechanism for inception and development of the Antarctic glaciation was the decreasing levels of CO_2 concentration in the atmosphere. With current rising atmospheric greenhouse gases resulting in rapidly rising global temperatures, studies of polar climates, and the Antarctic cryosphere behavior in particular, are prominent on the research agenda.

Drilling the Antarctic Wilkes Land margin is designed to provide a long-term record, obtained from sedimentary archives along an inshore to offshore transect, of Antarctic glaciation and its intimate relationships with global climatic and oceanographic change. Principal goals are to obtain:

- The timing and nature of the onset of glaciation at the Wilkes Land margin
- High-resolution record of Antarctic climate variability during the late Neogene and Quaternary, and
- An unprecedented, ultrahigh resolution (i.e., annual to decadal) Holocene record of climate variability.

Expedition 319 - Nankai Trough Seismogenic Zone Experiment Stage 2 'Riser/Riserless Observatory 1'

This expedition will prepare the boreholes at two sites to be used for future installations of the Long-Term Borehole Monitoring Systems. At the first site at the accretionary prism in the Kumano Basin (Site NT2-11), riser drilling and casing operations will proceed down to approximately 1,600 m below seafloor. Coincident with the drilling, LWD/MWD (Logging While Drilling/Measuring While Drilling), wireline logging will be conducted in order to assess hole conditions and formation properties of the cover sediments of the Kumano Basin and the underlying accretionary prism. Additionally, spot coring and downhole measurements – at casing size changing locations – will be also operated.

At the second site, NT2-01J (near C0004), riser-less drilling and casing will proceed to 525 m, coincident with LWD. No coring or downhole measurements will be conducted from the riserless drilling site. Contingency drilling sites are NT1-01 (coring) and near C0002 (casing installatioin).

Expedition 322 - Nankai Trough Seismogenic Zone Experiment Stage 2 'Subduction Input'

This expedition will investigate input material entering the seismogenic zone, by characterizing the composition, architecture, and state of sediments that will be transported by the subduction system offshore the Kii Peninsula, Japan. Site NT1-07 will drill up to 1200 m below the seafloor through turbidite-rich strata overlying smooth oceanic basement. The data will provide key constraints on the initial conditions for the 'subduction conveyor', which transports the incoming sediments and ocean crust to higher P-T conditions and hypothesized to be an important factor for drive the onset of seismogenic fault behavior.

Getting involved in IODP

Application forms and instructions are available at the websites of each Implementing Organization. For UK scientists and scientists from other ECORD countries applications must be submitted to the ECORD Science Support Advisory Committee (ESSAC). ESSAC has been appointed by ECORD as the 'National Office' for ECORD participation in IODP.

Staffing decisions are made in consultation with, co-chief scientists, the implementing organizations (JOI Alliance for the JOIDES Resolution, ECORD Science Operator for mission-specific platforms, and CDEX for the riser vessel Chikyu), and reviewed by the IODP Central Management Office. Final staffing authority lies with the respective implementing organization.

The IODP is a unique scientific endeavour. One of the most unusual aspects is the opportunities it presents for people at all stages of their academic careers to be involved, from distinguished professor to undergraduates.

Applying

Anyone interested in participating in an expedition is encouraged to complete an application as instructed on the ESSAC website (www.essac.ecord.org/participation). Calls for applications to sail are made regularly and interested parties are asked to consult the ESSAC and IODP websites for information on upcoming expeditions.

All UK applicants must complete the online application to sail on the ESSAC website. Please inform the UK IODP Science Coordinator (ukiodp@bgs.ac.uk) when you make your application. Applicants will be notified in due course.

If you have any comments or questions then please do not hesitate to contact the UK Science Coordinator (ukiodp@bgs.ac.uk).

Scientific results

Linking Solid Earth and Oceanic Circulation Cycles in the North Atlantic: New Impetus to IODP Proposal 646

Stephen M Jones (Trinity College Dublin, Ireland), Bramley J Murton (National Oceanography Centre (NOC), Southampton, UK), Nicky White (University of Cambridge, UK), Godfrey Fitton (University of Edinburgh, UK).

The oceanic region surrounding Iceland provides one of the best natural laboratories for studying spatial and temporal and variations in mantle convection. These solid earth fluctuations also modulate the strength of oceanic meridional overturning circulation. In order to understand these linked cycles, geochemical and geophysical records of melt production and chemical and physical records of ocean circulation are all required. IODP proposal 646 was designed to measure the chemical composition of a set of bathymetric ridges known as V-Shaped Ridges (VSRs) that straddle the Mid-Atlantic Ridge south of Iceland and record spatio-temporal variations in melt production.

In April-May 2008, Irish R/V *Celtic Explorer* cruise CE0806 obtained basalt samples at some of the younger proposed drill sites by dredging. This success allowed us to re-focus the drilling proposal, and has already resulted in securing funding from UK-IODP for a multichannel seismic survey of the reduced number of drill sites. Meanwhile, chemical compositions of basalts obtained during cruise CE0806 will begin to establish the relative roles of thermal and compositional heterogeneity within the head of the Iceland mantle plume over the past 9 million years. These results will guide interpretation of the seismic site survey data and, potentially, the drill samples that will extend the geochemical record of V-Shaped Ridges over space and time.

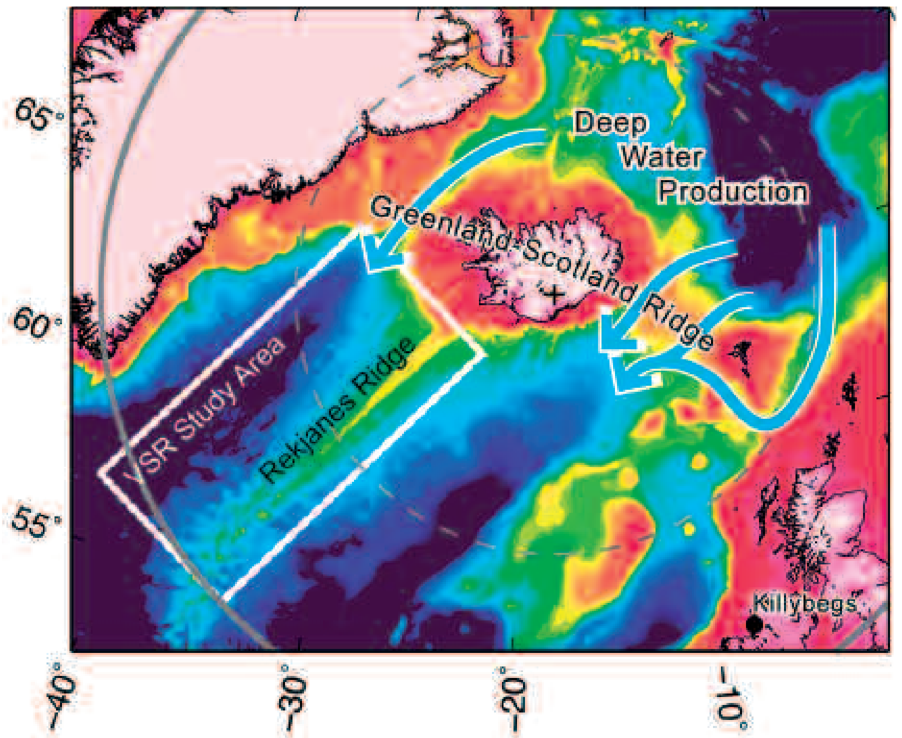

Figure 1. Topography of the North Atlantic Region. The Reykjanes Ridge is part of the Mid-Atlantic Ridge system and the Greenland-Scotland Ridge is the Iceland hotspot track. The V-Shaped Ridge (VSR) survey area is shown in detail in Figure 2. Blue arrows show where Northern Component Water flows into the global ocean. Grey circles show estimates of the Iceland plume head size: the solid circle is the minimum size supported by the new dredge samples; the dashed circle is the size modelled by Sleep (1990) and Ito et al. (1999).

Scientific Basis for IODP proposal 646

The North Atlantic V-Shaped Ridges (VSRs) provide a long, spatially extensive and clear record of unsteady mantle convection over time periods of 0.1 to 10 million years. VSRs are ridges of thick crust formed at the Mid Atlantic Ridge to the north and south of Iceland (Figures 1 & 2). The VSRs lie slightly oblique to the spreading axis and converge on the axis both north and south of Iceland. Ever since their discovery (*Vogt*, 1971), it has been generally agreed that this diachronous geometry results from melting anomalies that propagate outward from Iceland within the asthenosphere.

The history of mantle flow recorded by the VSRs is correlated with variation in the Atlantic oceanic conveyor (*Wright & Miller*, 1996; *Poore et al.*, 2006). Over the past 12 million years at least, periods of enhanced crustal production at a location about 500 km from Iceland correspond with periods of reduced influence of Northern Component Water (NCW) in the global ocean. The inverse correlation probably arises because the mantle fluctuations that generate the VSRs also affect the elevation of the Greenland-Scotland Ridge (GSR), the shallow sill that intersects the Mid Atlantic Ridge at Iceland. The Norwegian Sea to the north of Iceland is an important production site for NCW, but only at times when the GSR lock gate sinks enough to permit communication with the global ocean.

One implication of the inverse correlation between VSR and NCW records is that higher degrees of mantle melting are mainly caused by higher temperature, rather than more fertile composition. Another implication is that pulsing of the Iceland mantle plume may have played a role in controlling the late Pliocene intensification of the Northern Hemisphere Glaciation.

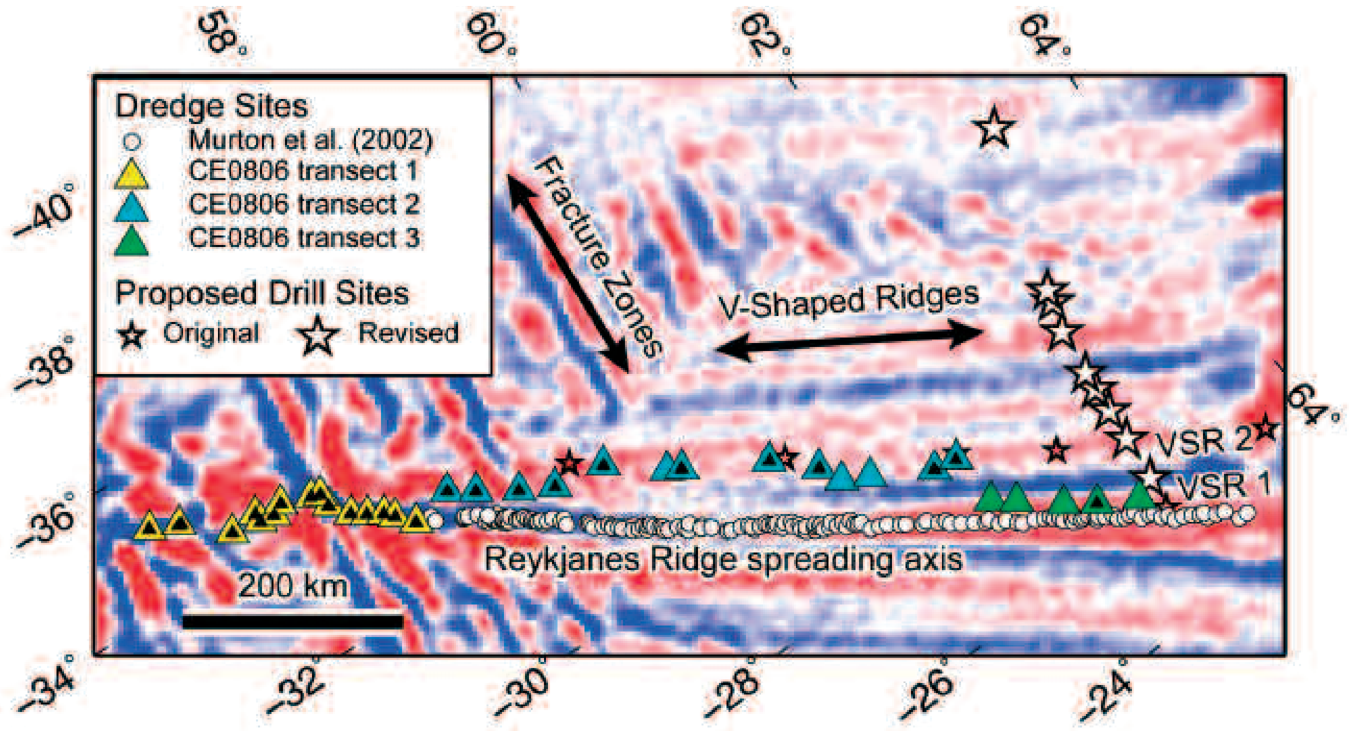

Figure 2. V-Shaped Ridges (VSRs) and oceanic fracture zones are visible in the short-wavelength component of the satellite free-air gravity field (after Jones et al., 2002). VSR gravity anomalies do not show up in the south-west of the region because their signal is swamped by the fracture zone anomalies. However, the new geochemical results show that the melting anomalies that built the VSRs also affected the fractured crust to the south-west. Black-filled CE0806 dredge sites yielded in situ basalt. Samples collected from the remainder of the CE0806 sites turned out to be basaltic dropstones; recovering in situ basalt is a major problem away from the spreading axis, particularly close to Iceland.

Drilling the North Atlantic VSRs is an attractive proposition because it addresses two of the three IODP themes: Solid Earth Cycles and Geodynamics, and Processes and Effects of Environmental Change. IODP proposal 646 (lead proponent BJM) identified that knowledge of geochemical variability associated with the VSRs is lacking in comparison with available geophysical and oceanographic records. Good quality geochemical and geophysical measurements are both required in order to determine whether the VSR melting anomalies are caused by thermal or compositional variability in the asthenosphere.

Early versions of proposal 646 suggested two drilling transects. One transect along the crest of a VSR would effectively track a packet of more fusible mantle as it moved outward from Iceland. A second transect along a plate spreading flowline would sample the variations between successive mantle pulses back to the early Oligocene (Figure 2).

Relationship between CE0806 and IODP proposal 646

Irish R/V *Celtic Explorer* cruise CE0806 (lead scientist SMJ) was conceived to determine whether basalt samples could be retrieved from some of the younger, relatively unsedimented sites by dredging. Dredging successes would allow the drilling programme to the streamlined, while dredging failures would underline the case for drilling. The survey corridor extended along the Reykjanes Ridge (RR) and the western crests of the two most recent VSRs, from 55° to 62°N. 47 dredges were made at 33 locations over a period of 12 days, and 37 dredges returned local basaltic rock suitable for chemical analysis (Figure 2). UK-IODP provided an urgency support grant to fund the mobilization and operation of a portable multi-beam echo sounder system, in order to locate dredge target in depths up to 3 km in the southern part of the area.

The dredge sites can be grouped into 3 transects. Transect 1 targeted very young rock along the Reykjanes Ridge axis. This dataset extends southward a set of samples collected along the Reykjanes Ridge in 1993 (*Murton et al.*, 2002). The combined sample set records the geochemical variation associated with the intersection of the Reykjanes Ridge with VSR-1 (the youngest V-shaped ridge crest), VSR-1' (the adjacent V-shaped trough), VSR-2 and VSR-2'.

Transects 2 & 3 sampled along the crests of the western arms of VSRs 2 & 1 respectively. Transect 2 was designed to replace one of the proposed drilling transects, and proved successful in this regard. Owing to sterling effort by the crew of the *Celtic Explorer* in difficult and sometimes extreme weather conditions, time remained to dredge along Transect 3. These two sets of samples track the chemical changes as two packets of mantle propagated southward from Iceland beneath the Reykjanes Ridge and were progressively sampled by melting.

Plume Pulsing: Temperature versus Composition

Background

Convective circulation within the upper mantle is expected to be strongly time-dependent because the Rayleigh number is super-critical by more than 3 orders of magnitude. Numerical and analogue experiments provide some insight into unsteady convective flow. However, the material properties of real rock are known to be more complex than can be simulated in computer models or employed in the laboratory. There is therefore no substitute for direct measurements of unsteady flow.

Iceland is the classic example of a hotspot centred on a mid-ocean ridge. The Mid-Atlantic Ridge provides a window to the Iceland Plume head, and plate spreading makes a tape recording of changes in the plume head in terms of variations in crustal thickness, structure and chemical composition.

The North Atlantic VSRs provide the longest lasting and most spatially extensive record of all these hotspots (back to 55 million years and out to over 1500 km from Iceland).

Variations in magma flux over time and space are commonly associated with mantle plumes. Examples of diachronous melting anomalies are known to be associated with other hotspots that interact with mid-ocean ridges, such as the Azores hotspot (*Escartín et al.*, 2001), but the North Atlantic has the largest number of diachronous ridges. Major mantle plumes that rise beneath intact plates (such as Hawaii, Réunion and Tristan) are also thought to vary in flux through time because they generate discrete seamounts rather than ridges of constant cross-section (*White*, 1993). However, in these intra-plate cases the volcanic constructions are related to magma transport processes as well as to variation in melt production, and spatial variation in the plume head is not recorded. Therefore, time-dependent mantle convection is a general process but it is particularly well recorded in the North Atlantic.

The VSRs reflect variations in melt productivity, but it is not clear whether the melting variations result from thermal or chemical variations in the mantle source. Crustal thickness changes and sparse compositional data from DSDP holes on the flanks of the Reykjanes Ridge can be modelled using thermal fluctuations of about 30°C and no change in source composition (*White et al.*, 1995; *Smallwood & White*, 1998). Onshore Iceland, detailed records of trace element and isotopic compositions spanning 13 to 2 Ma show temporal variations with the same periodicity as the VSRs (*Hanan & Schilling*, 1997; *Kitagawa et al.*, 2008). These correlations have been used to highlight the role of source variability associated with the variable melt production.

Although it is cheap and straightforward to construct detailed geochemical records back to the Middle Miocene by sampling onshore Iceland, it is still necessary to collect similarly detailed records from the offshore region. Many solid earth and climatic processes are known to affect the relationship between melt productivity and chemical composition in the Icelandic records, including rift relocations (*Hardarson & Fitton*, 1997), deglaciation (*Maclennan et al.*, 2002), and forced upwelling in the plume conduit (*Maclennan et al.*, 2001). These factors do not complicate the interpretation of geochemical and geophysical records at the Reykjanes Ridge. Therefore, construction of detailed geochemical records offshore south of Iceland should allow us to unravel the relative roles of mantle thermal and chemical variability in controlling melt flux.

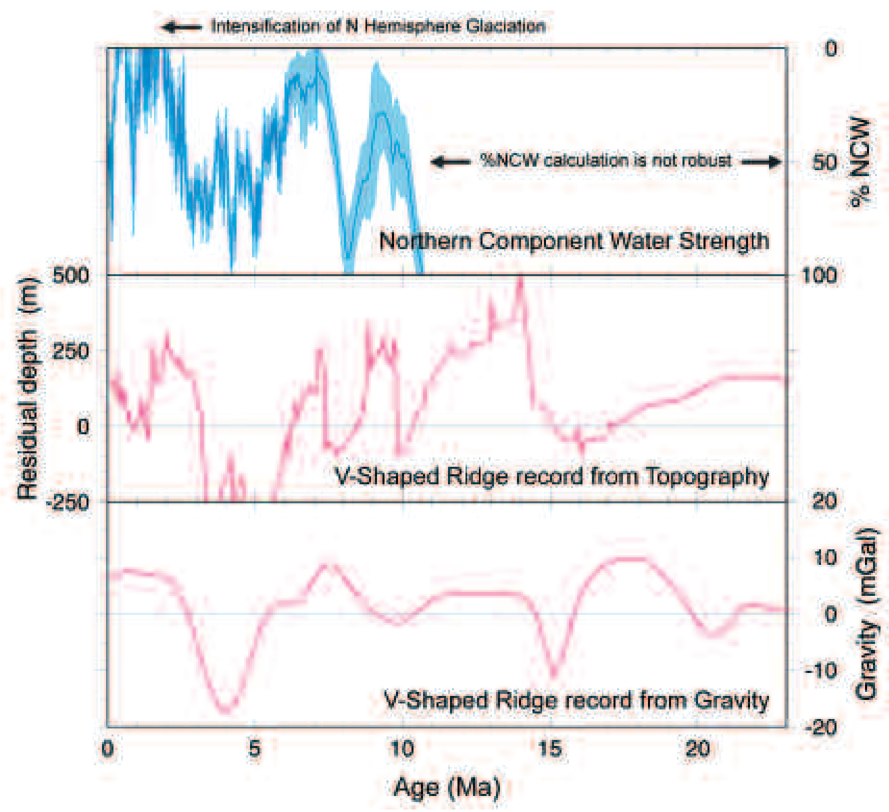

Figure 3. Relationship between time-dependent convection within the Iceland plume head and oceanic circulation (from Poore et al., 2006). %NCW measures the influence of Northern Component Water in the global ocean, from comparison of carbon isotope records in the Atlantic, Pacific and Southern Oceans. The V-Shaped Ridge records are proxies for melt production at the Reykjanes Ridge (the gravity record has less temporal detail than the topographic record).

Emerging results from cruise CE0806

We are in the process of completing full set of chemical analyses on the new set of dredge samples. Initial results are promising. Along the Reykjanes Ridge, spatial variations in trace element ratios involving Nb, Zr and Y correlate very well with VSR records from bathymetry and gravity. These ratios have previously been used to distinguish thermal and compositional variations in the mantle source (*Fitton et al.*, 1997). Earliest analysis suggests that thicker crust is generated by hotter mantle. We await the results of isotopic analyses and of more detailed melt productivity modelling.

The new geochemical data also show that VSR-forming melting anomalies propagate out to at least 1300 km from Iceland, well into the region where fracture zones obscure the topographic and gravitational expressions of the VSRs. A value of >1300 km for the radius of plume head measured at the mid-ocean ridge is >500 km more than the value commonly used in estimating plume volume flux. Furthermore, the VSR geometry indicated by combined geochemical and geophysical records implies relatively high asthenosphere flow speeds of >100 km/Myr out to 1300 km. Both the larger plume head diameter and the high outflow speeds strongly suggest that some well-known estimates of Icelandic plume flux (e.g. *Sleep*, 1990; *Ito et al.*, 1999) could be too small by up to an order of magnitude. If confirmed, a higher plume flux could make the Icelandic plume more vigorous than Hawaiian plume.

Implications for ocean circulation

If the Icelandic melt production pulses are indeed of predominantly thermal origin, then the hypothesis of a direct link between plume pulsing and the fluctuating strength of meridional overturning circulation is strengthened. Hotter mantle has a lower density, so locations of higher melt production correspond with locations of increased dynamic support at the mid-ocean ridge. (The opposite correlation would result if the pulses were entirely compositional). When the same hotter pulses travel beneath the Greenland-

Figure 4 Top Celtic Explorer cruise CE0806 scientific party: Gareth Roberts (Cambridge), Gavin Elliott (NOC Southampton), Godfrey Fitton (Edinburgh), Bramley Murton (NOC), Stephen Jones (Trinity College Dublin), Nicky White (Cambridge), Cora McKenna (University College Cork), Sarah Nixon (Cambridge), Stephanie Ingle (ex NOC), Zara Archibald (NUI Galway), Samantha Unsworth (NOC), Catherine Breheny (NUI Galway), Janine Guinan (Marine Institute, Galway).

Left: A haul of fresh glassy basalt from Site 6B on the Re

Scotland Ridge (GSR), they should cause temporary uplift of the oceanic spillways across the GSR. Comparison of the shapes of the VSR gravity field record and the isotopic %NCW (Northern Component Water) record supports this conclusion (*Poore et al.*, 2006; Figure 3). Another implication is that pulsing of the Iceland mantle plume may have played a role in controlling the late Pliocene intensification of the Northern Hemisphere Glaciation.

Revised Status of IODP Proposal 646

The immediate outcome of the *Celtic Explorer* cruise was to reduce the number of drill holes required to address the remaining scientific objectives. The remaining holes (the plate spreading flow line transect) can be completed within a single drilling expedition. The *Celtic Explorer* cruise also showed that drilling is the best way to retrieve fresh in situ basalt from these sites. Half of the drill targets are in V-shaped troughs, where we now know basement rocks to be inaccessible to dredging. New multibeam bathymetric data shows that even the youngest trough, between VSRs 1& 2, is floored with sediment. Furthermore, in spite of the overall success of dredging on the crests of VSRs 1 & 2, off-axis success rates were significantly lower than axial dredges. Three dredges were lost or damaged, and many sites yielded only large quantities of coral. Worse, basaltic rock returns are contaminated by basaltic glacial dropstones derived from Greenland and Iceland. We found it difficult to distinguish basaltic dropstones from *in situ* basalt cobbles away from the ridge axis. All of these problems are expected to become more severe on older oceanic crust.

The proposed new drilling transect will extend the geochemical VSR record from about 6 Ma back to 38 Ma, in the late Eocene. The long record will sample multiple V-shaped ridges and troughs, so that the chemical differences between the two types of mantle source will be known with confidence. It will also show longer term changes in the plume head. Finally, plume head activity can be compared with oceanic circulation back to the late Eocene. Although the %NCW proxy cannot be used before 12 Ma, when the Atlantic and Pacific $\delta^{13}C$ compositions are too similar, other longer records of deep-water flow are available from the North Atlantic sediment drifts.

We hope that the success of cruise CE0806 will help to intensify research into mid-ocean ridge/mantle plume/oceanic circulation interaction in the North Atlantic.

Acknowledgements

25 days' use of the R/V *Celtic Explorer* was granted to SMJ by the Marine Institute under its SSTI (*Strategy for Science, Technology and Innovation*) Integrated Marine Exploration Ship-Time Programme 2008, funded under the Irish Government's National Development Plan. General mobilization costs, operation of a portable Reson 8160 multi-beam echo sounder system and initial data analysis were funded through a UK-IODP grant

NE/G001251/1 to BJM. The Geological Survey of Ireland (Koen Verbruggen) and the Department of Geology, Trinity College Dublin also contributed to the cost of mobilization and demobilization of the Reson system. We thank John Davis and Tim LeBas (NOC Southampton) and Danny Wake (Reson Offshore Ltd) for assistance in installing and calibrating the Reson system, and Janine Guinan (Marine Institute's Integrated Marine Exploration Team) for help operating the system. We are indebted to the captain, officers and crew of the Celtic Explorer, and to all the RV operations staff at the Marine Institute and P&O Maritime for their hard work to ensure a successful cruise.

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UK-IODP Site Survey Cruise JC007: A study of melt delivery and tectonic spreading at 13°N, Mid-Atlantic Ridge

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Introduction

Delivery of melt to oceanic crust is fundamental to determining its structure and architecture. Normally, melt is delivered from a mid-ocean spreading ridge and accretes symmetrically to each diverging plate boundary in response to plate separation, mantle upwelling and decompression melting (McKenzie & Bickle,1988). However, at slow spreading rates, the resulting magmatic crust is heterogeneous with variations in thickness along strike (Cannat, 1996). In places, little or no melt is delivered resulting in 'tectonic spreading' – i.e. where plate separation is accommodated by fault slip rather than by volcanic accretion. For areas where tectonic spreading is long-lived, oceanic core complexes (OCCs) are formed with horizontal displacements accumulating on single fault detachments for many kilometres and over hundreds of thousands of years (Cann *et al.*, 1997; Tucholke *et al.*, 1998). The exposure of residual upper-mantle lithologies on the footwalls of these detachments, and their related basalts exposed on the hanging walls, provide an excellent opportunity to study variations in melt generation and delivery processes throughout the oceanic crust (MacLeod *et al.*, submitted).

Here we summarise a detailed sonar imaging and sampling programme of the Mid-Atlantic Ridge (MAR) between 13°N and 16°N that contains a mixture of magmatic and OCC spreading styles. The OCCs were recently identified by Smith *et al.* (2006) and offer an excellent opportunity to study a variety of different spreading styles, and along-strike exposures of mantle rocks, in close proximity.

Methods

Our study, funded by UK-IODP, is directed at understanding melt delivery along slow-spreading mid-ocean ridge segments and includes three of the OCCs previously

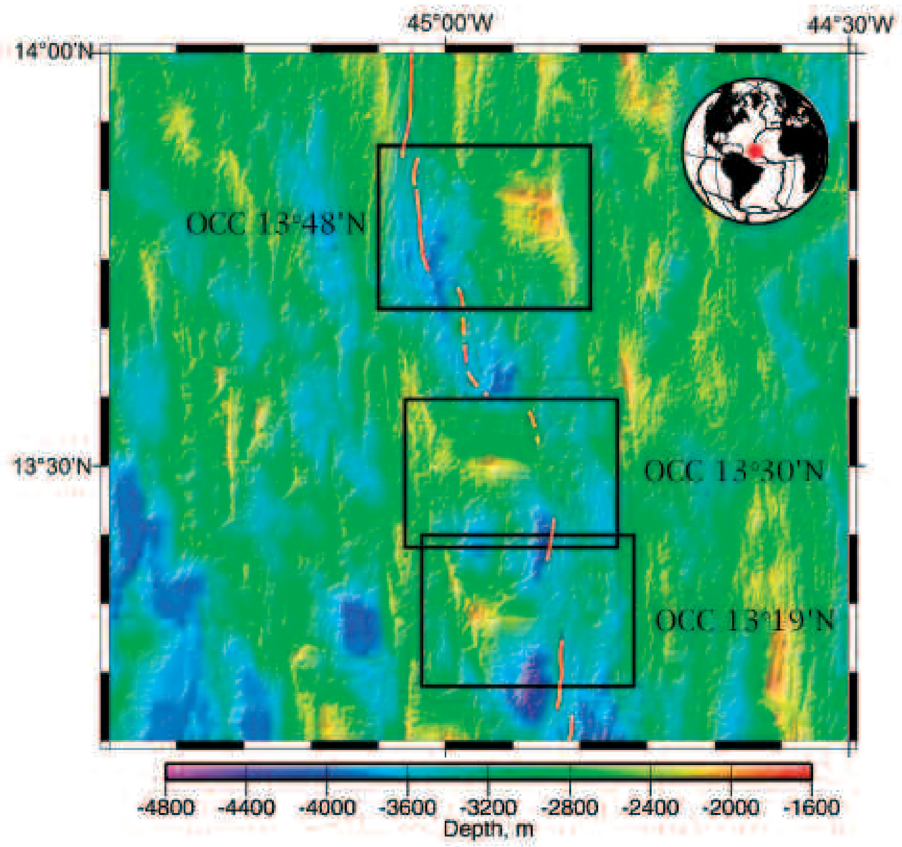

Figure 1: Location map and bathymetry of the study area showing the position of the three ocean core complexes studies here (OCC 13°19'N, OCC 13°30'N, OCC 13°48'N) and the location of the magmatic spreading axis of the Mid-Atlantic Ridge (red line).

recognised in the 13°N MAR area (Figure 1). During RRS *James Cook* cruise JC007 (March-April 2007), we acquired multibeam bathymetry (EM120), sidescan sonar imagery (TOBI), and dredge and rock drilled samples from the MAR between 13°14'N and 13°52'N. The bathymetry data was acquired at slow speeds (2Kts) while towing the TOBI deep-tow vehicle. As a result, we acquired bathymetry that we were able to grid at 50m, a considerably higher resolution than usual, and simultaneous sidescan imagery that we processed at 3m resolution. The bathymetry and sidescan imagery yield detailed views of the seafloor (Figure 2). These sonar images, combined with the petrology of the recovered rock material, reveals in unprecedented detail the nature of the varying spreading processes at the ridge axis, including the OCCs.

Observations

Our data reveal significant changes in the neovolcanic zone, its width, orientation of volcanic ridges and relative age that coincides with the presence or absence of active OCCs. While the OCCs share a number of common features, their differences also reveal each OCC to be at a different stage of development. These differences are summarised below.

Breakaway Zone

All of the OCCs we studied have a common type of boundary located outboard from the spreading ridge. This, the so-called 'breakaway zone' (Tucholke *et al*., 1998), appears as a steep-sided, sharply crested ridge formed from an uplifted footwall and inward-facing fault scarp (marked BZ in Figure 2). The inner slope of the breakaway zone comprises a faulted surface, typically showing eroded and gullied faces, that dips inwards (towards the MAR axis) at angles of ~20º, while the outward facing slope comprises old volcanic seafloor. This breakaway zone is the initial location of the faulting that grew to form the extended slip surface of the OCC detachment.

OCC detachment surface

At each OCC, a domed surface extends away from the breakaway zone towards the MAR axis. Immediately inboard (i.e. towards from the MAR axis) of the breakaway zone, this surface is characterised by a rugged massif that returned samples of peridotite, basalt and dolerite. Beyond the rugged massif, the OCC detachment surface has a smooth and corrugated surface that curves from ~30° away from the MAR axis to ~20º towards the MAR axis over several kilometres (marked DS on Figure 2). The spreading-parallel length of the OCC detachment surfaces exposed at the sea floor indicate a duration of tectonic spreading of between ~500Ka and ~1Ma depending on the relative contributions to magmatic and tectonic spreading at the time of OCC activity. Sampling of these surfaces recovered predominately serpentinised ultramafic rocks of upper mantle origin (foliated harzburgite and dunite). Fault rocks including abundant talc schist and talc mud were also recovered from this dome.

Termination or Emergence Zone

Closest to the spreading ridge, the youngest boundary, the so-called 'termination zone', of the OCCs forms a structural boundary (marked EZ on Figure 2) between the exposed expanse of the OCC detachment surface and the volcanic seafloor forming the axis of the MAR. For most OCCs studied to date, this boundary marks the point at which slip on the detachment fault has terminated. Bathymetric profiles of the 13°N OCCs show these termination zones are the boundary where the corrugated, domed and smooth surface of the OCC detachment surfaces plunge beneath the volcanic sea floor at the MAR axis at angles of 10-15°. Hydrothermal deposits (massive sulphides, pyrite, ochres, and breccias) as well as mineralised talc mud were recovered from the OCC surfaces close to these boundaries and are a result of high temperature hydrothermal fluids focused along the detachment fault planes, probably mining heat from the adjacent magmatic MAR axis.

For two of the OCCs studies here (at 13°19'N and 13°30'N) these boundaries are rooted at the MAR axis, without any evidence for a structural break in the detachment fault surface. We interpret these as still actively slipping and hence the OCCs are still in the process of emerging. Hence we term these active termination zones 'emergence zones' (i.e. the loci of emergence of deep-crustal/upper mantle lithologies from beneath their overlying volcanic hanging walls).

Although the MAR axis opposite each of the OCCs studies here is volcanic, there are crucial differences between them. Opposite the emergence zones of the OCCs at 13°19'N and 13°30'N, the MAR axis comprises low-backscatter, older, sedimented, fissured and extinct volcanic seafloor (marked EVZ in Figure 2) indicating a hiatus in recent volcanism immediately opposite these OCCs. This older seafloor is flanked to the north and south by high-backscattering and hummocky neovolcanic zones (NVZ) indicative of recent volcanic activity at the ridge axis (marked by the red line on Figure 2).

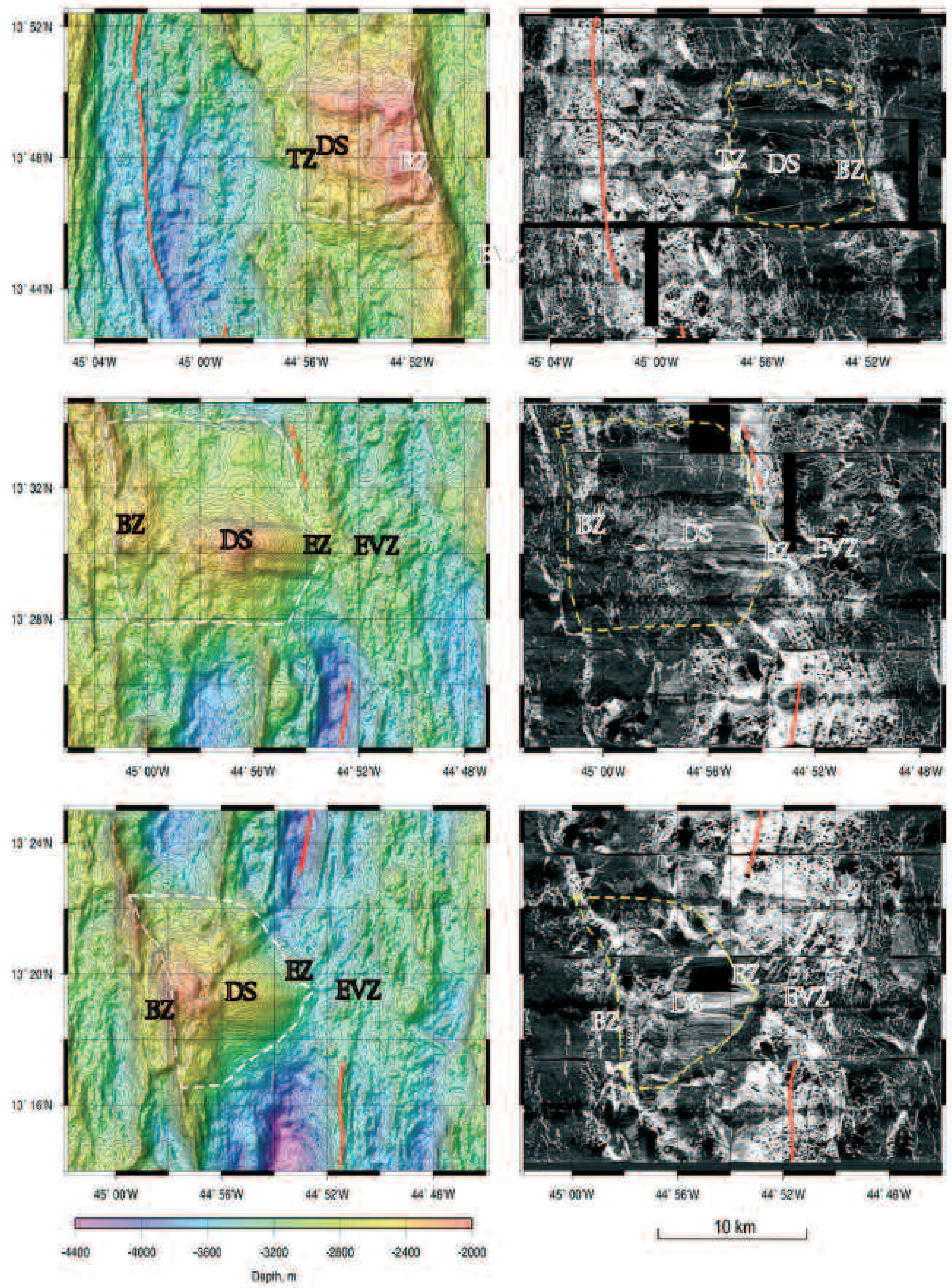

Figure 2: Bathymetry (LHS) and TOBI sidescan sonar (RHS – high backscatter is white, low is black) for the three OCCs studied here (from top to bottom: OCC 13°19'N, OCC 13°30'N, OCC 13°48'N). Notation: BZ is the breakaway zone or fault formed during OCC initiation; DS is the domes surface, with corrugations on its lower flanks, formed from peridotite exposed on the OCC detachment fault surfaces; EZ is the emergence zone where the OCC detachment fault is actively emerging from beneath its hanging wall; TZ id the termination zone, where the emergence zone was but is now inactive; EVZ is the extinct volcanic zone where magmatic accretion was once located at the spreading ridge axis before OCC formation accommodated plate separation; red line shows the loci of active volcanism on the spreading ridge axis

Opposite the OCC at 13°48'N the MAR axis contains a continuous and high-backscattering seafloor with an uninterrupted NVZ, also indicative of recent volcanic activity. In addition, the 13°48'N OCC detachment surface has smooth and low-intensity sonar-backscatter, indicative of thick sediment cover, and is hence considered to be no longer actively emerging.

Discussion

Based on the differences between the three OCCs described here, we suggest that the OCCs in the 13°N region of the MAR form part of a continuum in a common process of evolution, from initiation to termination.

The initial stage in OCC formation involves continued slip on a typical axial wall fault, located at the outer-edge of the axial valley. Normally, slip on such an axial fault ceases after 10-20% extension (Escartin *et al.*, 1999) and a new axial valley wall fault initiates in-board from the now inactive one, giving rise to a cyclic process of extension, uplift, fault-termination and initiation of a new fault.

Where an OCC detachment fault develops, extension continues for 100s to 1000s of metres, inhibiting the in-board jump to a new fault. As slip accumulates, accommodating up to several kilometres of heave, flexural bending causes the weak emerging lithosphere to rotate upwards resulting in the domed shape typical of OCC footwalls (Buck *et al.*, 2005).

Continued slip on the OCC detachment fault will only be favoured while less stress is required to maintain slip along the fault plane than is required to form a new fault or separate the plates at the MOR axis. We think the abundance of talc schist and mud found on the OCC detachment surfaces is a key to how this happens. Coupled with silica-rich hydrothermal fluids, the emerging peridotite undergoes serpentinisation and talc formation. Both minerals act to dramatically weaken the fault zone (Escartin *et al.*, 1997). As a consequence, plate separation is accommodated at the detachment fault rather than at the MAR axis (Tucholke *et al.*, 2008; Buck *et al.*, 2005). Although mantle decompression upwelling continues, its new off-axis location beneath older and colder lithosphere leads to a dramatic decrease in melt flux.

If magmatic accretion of new crust at the MAR axis contributes to less than 50% of the plate separation, then the emergence zone will migrate towards the spreading ridge axis. As it reaches the MOR-axis, magmatism propagates laterally from the adjacent NVZs across the detachment fault, terminating further slip and restoring magmatic accretion as the dominant process accommodating plate separation at the MOR axis. This situation is illustrated by the close proximity of the neovolcanic zone to the emergence zone at the dying OCC at 13°30'N and the continuous neovolcanic zone in front of the termination zone at the extinct OCC at 13°48'N (Figure 2).

Ongoing Work

Geochemical analyses of the peridotites and basalts from the 13°N region of the MAR is the subject of intensive study by Unsworth (at NOCS) and Casey (at Houston). Initial results show that the crust formed at the position now occupied by the breakaway zone was generated from low melt fractions, whereas crust in the neovolcanic zones at the MAR axis are derived from higher melt fractions. Low melt fractions are likely to have resulted in thin magmatic crust, exposing shallow mantle lithologies to serpentinisation and talc formation during breakaway zone formation, weakening the detachment fault surface, thereby focusing strain and allowing detachment faulting to run away. Isotope studies are aimed at discriminating between temperature or mantle compositional controls on this low melt productivity as postulated by Niu and O'Hara (2008). We also hope to date basalts at the breakaway ridge and extinct neovolcanic seafloor opposite the OCCs in order to determine the duration of slip on the OCC detachment faults and hence estimate the proportion of plate separation accommodated by tectonic spreading at the OCC detachment compared with magmatic accretion at the MAR axis. Detailed analyses of the sonar, bathymetry, magnetic and gravity data are also being made by Searle and Mallows (at Durham University) to understand the spreading history at 13°N while MacLeod is investigating the deformational history of the OCCs through structural and magnetic studies of the recovered rocks. A paper describing in detail the OCCs and their tectonic evolution has recently been submitted to *Earth and Planetary Science Letters* (MacLeod *et al.*).

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News

The next phase of UK IODP

Heather Stewart and Katie Waiters (UK IODP Programme Coordinator and Administrator)

The first phase of the Integrated Ocean Drilling Program began in October 2003. To enable the UK participation in the Program NERC set up the UK IODP in 2003 with a total NERC allocation to the programme of approx £14m over 5 years (2003-2008). This included support for UK membership of IODP ($17.6m committed until September 2008). The remaining NERC funding was for a £3.5m UK Directed Programme that has supported a portfolio of research grants, training, and site surveys and UK scientific and managerial participation in IODP.

In its first period of operation UK-IODP aimed to:

- Use participation in the IODP to advance NERC's strategic research priorities.
- Fund membership of IODP through ECORD.
- Make UK scientists, industry and stakeholders aware of the opportunities in, and the results of, the IODP.
- Facilitate participation of UK scientists in IODP research and drilling.
- Provide grant support to enable UK scientists to exploit the results of IODP drilling.
- Facilitate participation of UK scientists in the science advisory structures of IODP and ECORD.
- Contribute towards the training of research scientists.

During 2003-2008 UK IODP has funded 3 Site Survey Investigations in support of IODP drilling proposals led by UK based investigators; 4 post-doctoral researchers and 2 post-graduate researchers who participated on IODP Expeditions; 2 virtual site surveys where researchers utilised existing site survey data from industry rather than acquiring site survey data using a chartered vessel; 21 small and standard grants supporting researchers in more than 14 universities from all over the UK; 29 UK participants on IODP Expeditions.

The NERC Programme continues in the second phase of the international programme (2008-2013) with a total NERC allocation of approx £22m. Again this includes support for UK membership of IODP (£12.6m committed until September 2013). With the remaining £7m NERC funding for the UK Directed Programme that will continue to support a portfolio of research grants, training, and site surveys and UK scientific and managerial participation in IODP.

NERC's Directed Science Programme is supporting the UK's membership in IODP, enabling UK scientists to:

- help ensure that IODP carries out the best and highest priority science
- participate in and obtain material from drilling expeditions
- capitalize on the results of IODP drilling and UK Technologies, allowing them to benefit from technological advances in deep sea drilling
- address challenges in the NERC strategy.

The second phase of the UK-IODP has already committed funding to two Site Survey Investigations, strengthening their related UK-led IODP Proposals. The first of these will explore mid-ocean V-shaped ridges in the North Atlantic, South of Iceland thought to be related to the Icelandic plume. The second will investigate the area around the island of Montserrat, specifically emplacement processes and timings of large volcanic debris avalanches and implications for volcanic and tsunami hazards. It is hoped to run one more Site Survey Investigation round later in the second phase of the UK programme.

As the UK IODP is a Directed Programme, instead of having open grant rounds where grants were sought from all aspects of IODP related science, future UK IODP grant rounds will be directed in that grant applications will be in response to a specific theme or topic in line with the 2007-2012 NERC Strategy. UK IODP held its first grant round in November 2008 under the theme of "Feedbacks and Forcings in the Earth System" with awards to be made in Spring/Summer 2009. Future grant rounds will be announced in a timely manner and will include themes such as ice sheets and sea level, dynamics of the Earth's interior and plate boundary processes.

The UK-IODP and NERC continue to maintain strong links to the international programme and take an active role in the Council for the European Consortium for Ocean Research Drilling and the European Science Operator (via BGS).

www.ukiodp.bgs.ac.uk,
www.iodp.org, www.ecord.org,
www.eso.ecord.org

Forthcoming events

UK IODP Symposium

Royal Society, London, 18-19 May 2009

www.nerc.ac.uk/research/programmes/ukiodp/events/090518.

This event is aimed at the UK IODP science community and is an opportunity to highlight important scientific achievements from the current IODP phase, and to solicit contributions and challenges that will take Ocean Research Drilling forward post 2013, when the existing programme ends. A number of NERC Theme Leaders will be present at the event, this will give the UK IODP community a chance to demonstrate and influence the future value and direction of the programme.

The two-day conference will cover a range of scientific themes:

- Geological Hazards, Seismogenic Zones and beyond.
- Evolution of the Planet.
- Climate, Sea-level, ice-sheets and Greenhouse/Icehouse states.
- New Adventures into the Subsurface and Deep Biosphere.

The conference aims to showcase post-graduate, PhD and post-doctorate research which has made use of the extensive wealth of data collected during the varied IODP Expeditions. A session of the conference will be an open discussion on the future IODP Programme beyond 2013.

Poster sessions form an integral part of the 2-day event, please indicate on your registration form if you plan to submit a poster.

Travel and subsistence funds are available for 40 student and post-doctorate participants who present a poster and will be allocated on a first-come, first-served basis.

For a number of posters we will invite an oral contribution to the open session of the programme where you will have a chance to introduce your poster. Individuals invited will have their travel costs reimbursed.

In addition, during the open session conference participants will have the opportunity to present their thoughts on what IODP should focus on in the future.

Please be aware that places for this event are limited and we recommend that you register as soon as possible to avoid disappointment.

Please use our online registration form to register. Registration deadline is **3 April 2009**.

Directions to meeting:
The Royal Society
6 – 9 Carlton House Terrace
London
SW1Y 5AG

For further details of this event please contact Katie Waiters (kawa@nerc.ac.uk) or Sasha Leigh (snbl@nerc.ac.uk).

Monday 18th May

10:00-10:15	Welcome and Introduction	Sir Geoffrey Allen
10:15-10:45	*KEYNOTE:* Science and Society: Volcanic Hazards	Steve Sparks (Bristol)
10:45-11:00	IODP Overview and News	UK-IODP representative

Geological Hazards, Seismogenic Zones and beyond (CHAIR: Tim Henstock, NOCS)

11:00-11:30	*KEYNOTE:* NanTroSEIZE	Harold Tobin (USA)
11:30-11:50	Sumatra: Survey Results and Drilling	Lisa McNeill (NOCS)
11:50-12:30	*COFFEE BREAK and POSTERS*	
12:30-12:50	Overpressure and fluid flow processes in the deepwater Gulf of Mexico: slope stability, seeps, and shallow-water flow	Peter Flemings (USA)
12:50-13:40	*LUNCH BREAK*	

Evolution of the Planet (CHAIR: Damon Teagle, NOCS)

13:40-14:00	Results from Superfast Spreading Crust Drilling	John MacLennan (Cambridge)
14:00-14:20	Accretion of the lower oceanic crust at fast-spreading ridges: Hess Deep Survey	Chris MacLeod (Cardiff)
14:20-14:40	Geological and Geophysical Studies of the Mid-Atlantic Ridge, 12°30'N to 14°30'N	Bramley Murton (NOCS)
14:40-15:00	Hydrological response to a seafloor spreading episode on the Juan de Fuca ridge	Earl Davis (Geological Survey of Canada)
15:00-15:30	*COFFEE BREAK and POSTERS*	

Biogeochemical cycles and sea-water chemistry (CHAIR: Tim Elliott, Bristol)

15:30-15:50	Variable Quaternary Weathering Budgets and Ocean biogeochemical cycles	Derek Vance (Bristol)
15:50-16:10	The Lesser Antilles: Interaction between Volcanism and Ocean Chemistry	Martin Palmer (NOCS)
16:10-16:30	What fractured oceanic crust can tell us about sea-water chemistry in the past	Ros Coggon (Imperial College)
16:30-17:00	NERC Theme Leader forum: discussion and Q&A	Contribution from NERC theme leaders
17:00	End Day 1 Nibbles, drinks and posters	

Tuesday 19th May 2009

Climate, Sea-level, ice-sheets and Greenhouse/Icehouse states (CHAIR: Gideon Henderson)

09:00-09:30	*KEYNOTE:* High-resolution palaeoclimate records	Dave Hodell (Cambridge)
09:30-09:50	The Timing and Form of the Penultimate Deglaciation: New Coral Constraints from IODP Expedition 310 "Tahiti Sea Level"	Alexander Thomas (Oxford)
09:50-10:10	Changes in ocean circulation and the global carbon cycle during the last interglacial-glacial transition: Marine Isotope Stage 5a to 4	Stephen Barker (Cardiff)
10:10-10:30	Using corals for sea-level and palaeoclimate reconstruction (Barrier Reef?)	Sandy Tudhope (Edinburgh)
10:30-11:15	*COFFEE BREAK and POSTERS*	

Climate, Sea-level, ice-sheets and Greenhouse/Icehouse states (cont) (CHAIR: Rachael James)

11:15-11:45	First Results from IODP Expedition 320: Pacific Equatorial Age Transect	Heiko Pälike (NOCS)
11:45-12:05	Results from Site Survey for Tanzania Paleogene Drilling	Dick Kroon (Edinburgh)
12:05-12:25	Monsoons and Climate	Peter Clift (Aberdeen)
12:25-13:20	*LUNCH BREAK*	

New Adventures into the Subsurface and Deep Biosphere (CHAIR: Ros Rickaby)

13:20-13:50	*KEYNOTE:* Significant contribution of Archaea to extant biomass in marine subsurface sediments	Kai-Uwe Hinrichs (Bremen)
13:50-14:10	Bioalteration in volcaniclastic rocks	Neil Banerjee (Canada)
14:10-14:30	Energy in the Dark: Fuel for Life in the Deep Ocean and Beyond	Wolfgang Bach (Bremen)

14:30-14:40	**IODP Challenges and Priorities post 2013: Renewal (CHAIR: Heiko Pälike)**	
14:40-15:10	The Future of IODP: Unsolicited Contributions (5 min duration, 1 Overhead) and Panel Discussions	Contributions from NERC Theme Leaders
15:10-15:40	*COFFEE BREAK and POSTERS*	
15:40-16:20	The Future of IODP: Panel Discussions What should be IODP prioritites? New science fields? Exciting unfinished business?	
16:20-16:30	Student Poster Prize Awards	Heather Stewart/Sasha Leigh
16:30	Closing Remarks	Mike Bickle/Geoffrey Allen
16:35	*MEETING CLOSE*	

INVEST
IODP New Ventures in Exploring Scientific Targets

University of Bremen, Germany, 23-25 September 2009
www.marum.de/iodp-invest.html

INVEST is being organized as a large, multidisciplinary, international community meeting, whose focus is to define the scientific research goals of the second phase of the IODP, expected to begin late in 2013. INVEST is open to all interested scientists and students as the principal opportunity for international science community members to help shape the future of scientific ocean drilling. The goals of INVEST are to:

- synthesize and summarize the state of knowledge across major interdisciplinary geoscience themes;
- identify emerging science fields;
- develop new research initiatives and recommend scientific implementation strategies;
- address societal relevance of future drilling; and
- outline fiscal and technological needs.

Meeting format
The INVEST conference will comprise plenary and breakout-group sessions as well as keynote lectures. A detailed conference program will be made available on June 30, 2009.

Opening address
Vincent Courtillot Ocean Drilling: A 21st Century Endeavor to Understand the Earth System

Keynote lectures
Andrew Fisher Achievements and Challenges in Subseafloor Hydrogeology during Scientific Ocean Drilling

David Hodell Paleoclimate Opportunities to Constrain Abrupt and Rapid Climate Change

Tori Hoehler The View from Space: What Ocean Drilling can Tell us About Habitability, Life's Limits, and the Possibilities for Life Beyond Earth

Bo Barker Jørgensen Microbial Life in the Deep Seabed – the Starving Majority

Jeff Kiehl Paleoceanography: Providing Critical Knowledge to Improve Climate Model Predictions

Naohiko Ohkouchi Future Directions in Probing Global Biogeochemical Cycles

Terry Plank Down and Back Again: Cycles and Growth at Convergent Margins

Kiyoshi Suyehiro Ocean Borehole Observatories: Scanning and Sounding the Earth in Motion

Doug Toomey Outstanding Questions of Crust-Mantle Interaction Below the Ocean Basins: What can Deep Earth Sampling Tell us?

Jim Zachos The Potential and Promise of Studies of Past Warm Worlds

Registration
Registration dates are from April 4 to August 3, 2009.

Please find the registration form on the INVEST conference website and return the completed form either online (preferred method), by fax to +49 (0)421 6491 0780, or by mail to Witago/Agentur für Kongress- und Eventmanagement, Am Deich 61-62, 28199 Bremen, Germany.

Registration fee is 50 € for regular participants and 20 € for students.

Payment
Payment of the full registration fee is due upon submitting the registration form. Payment must be in Euro and can be made by credit card, VISA and MasterCard only.

Cancellation
For written cancellations received before August 31, 2009, the registration fee less 20% will be refunded. After that date no refund will be possible.

Poster presentations
We encourage student participants to present a poster. Maximum poster size is 120 cm (height) by 94 cm (width). Posters will be up for the duration of the conference.

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Email: agst@bgs.ac.uk

IODP Panel Members from the UK

Science Advisory Structure Executive Committee (SASEC)
No current UK representative on this panel. The previous UK representative was Mike Bickle, Department of Earth Sciences, University of Cambridge

Science Planning Committee (SPC)
Hugh Jenkyns, Department of Earth Sciences, University of Oxford

Science Steering and Evaluation Panel liaison (SSEP)
Tim Elliott, Department of Earth Sciences, University of Bristol
Heiko Pälike, National Oceanography Centre, Southampton

Scientific Technology Panel liaison (STP)
Marc Reichow, Department of Geology, University of Leicester

Engineering Development Panel liaison (EDP)
John Thorogood, Drilling Global Consultant

Site Survey Panel liaison (SSP)
Neil Mitchell, School of Earth, Atmospheric and Environmental Sciences, University of Manchester

Environmental Protection and Safety Panel liaison (EPSP)
Bramley Murton (NOCS) will continue to report to the Steering Committee in his role as

ECORD Science Operator Science Manager
Dan Evans, British Geological Survey

UK Industrial Liaison Panel Chairman
Richard Hardman, Consultant

IIS-PPG liaison
Richard Davies, Director CeREES
Department of Earth Sciences, University of Durham

UK IODP Grants

UK IODP Grants and FEC Guidance for Expedition Participants

To support UK membership in the Integrated Ocean Drilling Program NERC has established a Directed Science Programme to enable: UK scientists to ensure that IODP carries out the best and highest priority science; UK scientists to participate in and obtain material from drilling expeditions; and finally to allow UK scientists to capitalize on the results of IODP drilling and UK technologies to benefit from technological advances in deep-sea drilling.

Please see below for a summary of the grants available through UK-IODP. Please note that PDRA, PGRA, Urgency and Rapid Response Grants will be running outside normal grant rounds.

Applicants should refer to the current conditions and eligibility requirements, which can be found on the NERC website at www.nerc.ac.uk/funding/application/forms.asp where application forms, procedural information and a research grant guideline booklet can also be obtained. Applicants may also wish to consult the IODP Science Programme that can be found at www.iodp.org/isp. All successful applicants are asked to fully acknowledge support from the UK IODP Programme in their work and submit an article summarising the main outcomes of their research to the UK-IODP Newsletter (ukiodp@bgs.ac.uk). If you would like any further information or advice on the funding opportunities discussed below please contact the Science Coordinator (ukiodp@bgs.ac.uk) or the Programme Administrator (snbl@nerc.ac.uk)

NERC IODP Small Research Grants

Small grants provide funding for small discrete projects, proof-of-concept studies, pump-priming exercises etc. This scheme is not intended to extend research assistants' employment once a standard grant has ended.

Up to £25,000 may be sought for the total directly incurred costs (i.e. the limit applies to 100% of costs under this heading). In addition, NERC will pay the standard proportion (80%) of directly allocated and indirect costs.

Essential information for applicants please see: www.nerc.ac.uk/funding/application/researchgrants/. All normal small grant rules and guidelines apply regarding page limits, eligibility etc. Proposals will be reviewed by external referees and assessed by the UK IODP steering committee.

The next UK-IODP grant round will be announced shortly. Interested parties are reminded that the UK-IODP grant rounds are directed and grants are invited on specific topics; therefore please remember that the NERC Blue Skies grant round is also available to researchers (www.nerc.ac.uk/funding/available/).

If you would like any further information or advice please contact the Science Co-ordinator (ukiodp@bgs.ac.uk) or the Programme Administrator (snbl@bgs.ac.uk).

UK-IODP Rapid Response Grants

UK-IODP Rapid Response Awards are for the purpose of supporting a limited number of small-scale, short research activities specifically related to IODP Expedition objectives. Rapid research grants are typically awarded to assist with initial sample processing costs or small equipment purchases related to IODP involvement. Proposals (no more than 2 pages long) should clearly state the aims, deliverables and the case for support. Where relevant, the proposal should be supported by a statement from an IODP Expedition Co-Chief Scientists and/or (for students) from an appropriate member of the departmental academic staff.

Please note that applications for Rapid Response Grants will now need to be costed under FEC requirements. The maximum amount, to include all FEC costings, is now £2,750 for Rapid Response Grants.

Rapid Response proposals will be reviewed by members of the UK IODP Committee and awards will be limited by the funds available for this scheme. Although there is no closing date, applications should be submitted by e-mail to the Science Coordinator (ukiodp@bgs.ac.uk) as early as possible in advance of the proposed starting date.

Post-cruise support for Post-Doctoral and Post-Graduate Research Assistants

This scheme provides additional support for Post-Doctoral Research Assistants (PDRA) and Post-Graduate Research Assistants (PGRA) who sail with IODP on behalf of the UK. The scheme aims to ensure that more PDRAs and PGRAs have access to funding to complete up to 6 months post-cruise research between grant rounds. Application procedures are subject to the following conditions:

- As with applications to any other NERC grant scheme, applications must be led by a Principal Investigator from an eligible UK institution. The PDRA or PGRA should be named as the Recognised Researcher for the application. All eligibility criteria are the same as for all other NERC thematic grant applications.
- Applications must be on behalf of a PDRA or PGRA who has been accepted (not simply applied to) as a UK shipboard participant on a forthcoming IODP leg. No shore-based contributors will be considered under any circumstances.
- Applications for both PDRAs and PGRAs will be subject to peer review.
- The application for this scheme must be a discrete body of work based only on material collected during an IODP cruise. It must not be a continuation of any other unrelated project funded by the NERC or other bodies.
- On return to port the candidate will have to write confirming that the necessary samples to complete the work have been successfully obtained during the cruise, otherwise funding will not be made available.
- Candidates should apply to the Science Coordinator Heather Stewart (ukiodp@bgs.ac.uk) for this funding prior to sailing. Applicants will need to give a brief description of the post-cruise work that they intend to perform using the NERC small grants application form. The deadline for an application is two months prior to the scheduled departure of the IODP leg.
- At least one first-authored peer-reviewed publication should result from the work.
- All other conditions and eligibility requirements are the same as for other NERC funding and can be found on the Forms and Handbooks section of this website

Special criteria for PDRA applications:

- Applications for Post Cruise Grants will now need to be costed under FEC requirements. The maximum amounts, to include all FEC costings is now £16,500 to cover up to 6 months of post-cruise research. Extra time will be allowed only if another funding source is procured.
- To be eligible for this funding, a PDRA must hold a recognised PhD. PhD students are entitled to apply for this scheme if they are close to submission or have submitted at the time of sailing but will not be eligible to receive any funding until they have successfully defended their PhD.
- UK IODP will fund two PDRA positions per year.

Special criteria for PGRA applications:

- Applications for Post Cruise Grants will now need to be costed under FEC requirements. The maximum amounts, to include all FEC costings is now £8,250 to cover up to 6 months of post-cruise research. Extra time will be allowed only if another funding source is procured.
- To be eligible for this funding, a PGRA must be at least 18 months into their PhD before taking up the award.
- UK IODP will fund two PGRA positions per year.

UK IODP Urgency grants

These allow researchers to exploit scientific opportunities where the normal grant application procedures are likely to be too slow.

Application procedures (separate from the main UK-IODP Special Topic grant rounds) are subject to the following conditions:

- Topics must relate to IODP-supported science, and awards will be considered only in exceptional circumstances.
- Only small sums will be considered.
- Applications must be led by a principal investigator from an eligible UK institution. Eligibility criteria are the same as for all other NERC directed grant applications.
- You should contact the UKIODP Science Coordinator (ukiodp@bgs.ac.uk) with a brief resume of your case, to check whether an urgent application process is appropriate.
- Apply using NERC's small grant application forms (i.e. including a two-page case for support) under the published rules for research grants.
- You can apply at any time.
- No studentships will be awarded under this scheme.
- Only aspects of the research that are time-limited will be considered. For example, collecting data or samples during a window-of-opportunity could qualify for funding, whereas support for subsequent analyses, interpretation or publication would not.
- Your application should justify both the science and the resources sought. Only those applications that are urgent, receive a high science grade, and are likely to obtain resources for follow-up work and publication will be funded (later funding should either be in place or be sought subsequently through the normal application process).
- Submit your application via email to the UK IODP Programme Administrator at NERC (snbl@nerc.ac.uk).
- Applications will be sent to three external reviewers, and selected members of the UK-IODP Committee will make a final decision. The Programme Administrator will oversee the application/review process and ensure that it is completed promptly.
- All other conditions and eligibility requirements are the same as for other NERC funding, and can be found on the Forms and Handbooks section of the NERC website.

UK-IODP Full Economic Costing Guidance for Expedition Participants

Under FEC, all IODP expedition participants from the UK are eligible to apply to NERC for funding to cover their time on board ship. As with research grants, awards will be made at 80% FEC.

The different categories of expedition participant and eligible costs are listed below:

Co-chief

- Directly Incurred costs:
  - Staff Time (for offshore and onshore co-chief activities)
  - Travel and Subsistence (for expedition, sampling parties and post-cruise meetings)
- Directly Allocated costs:
  - Estates Costs (only for time spent onshore)
- Indirect costs:
  - Only for time spent onshore

Expedition participant (sailing)

- Directly Incurred costs:
  - Staff Time (for offshore only)
  - Travel and Subsistence (for expedition, sampling parties and post-cruise meetings)
- Directly Allocated costs:
  - Estates Costs – not eligible
- Indirect costs – not eligible

Expedition participant student (sailing)

- No costs eligible
- Expedition, sampling party and post-cruise meeting Travel and Subsistence costs should be claimed via the UKIODP Science Coordinator

Applications for FEC must be submitted via the Research Councils' Joint electronic-Submission system (Je-S) at least 1 month ahead of the expedition start date. The 'scheme' should be completed as 'Directed FEC' and the 'call' as 'IODP'.

See the Je-S website (https://je-s.rcuk.ac.uk/Jes2WebLoginSite/Login.aspx) for information on the Je-S process. Further information, including details on Full Economic Costing, is also available in the NERC Research Grants Handbook for Full Economic Cost Grants. Potential applicants are reminded that they and their institution must be registered with Je-S, in order to submit applications.

Standard NERC rules for institutional and investigator eligibility apply to all components of the call. For example, submissions must be made via UK universities or NERC-recognised bodies.

Advice on application and administrative arrangements is available from the Programme Administrator, Katie Waiters (kawa@nerc.ac.uk) or Sasha Leigh (snbl@nerc.ac.uk).

Any queries regarding the Je-S system and submission of applications should be directed to the dedicated Je-S Helpdesk.

Useful websites

Integrated Ocean Drilling Programme (UK)
www.ukiodp.bgs.ac.uk and www.nerc.ac.uk/research/programmes/ukiodp/

ECORD Sites
European Consortium for Ocean Research Drilling (ECORD) – www.ecord.org
ECORD Science Support Advisory Committee – www.essac.ecord.org

IODP Central Sites
IODP Management International Inc. – www.iodp.org
Initial Science Plan for IODP – www.iodp.org/isp
JAMSTEC – www.jamstec.go.jp/chikyu/eng/index.html
IODP Science Advisory Structure – www.iodp.org/sas

IODP Implementing Organisations
Centre for Deep Earth Exploration (CDEX) – www.jamstec.go.jp/chikyu/eng/index.html
ECORD Science Operator – www.eso.ecord.org
JOI-Alliance US Implementing Organisation – www.iodp-usio.org

IODP National Offices
Finland – http://iodpfinland.oulu.fi/
France – www.iodp-france.org/
Germany – www.iodp.de/
Italy – www2.ogs.trieste.it/iodp/
Netherlands – www.iodp.nl/
Portugal – http://e-geo.ineti.pt/ecord/
Spain – http://carpe.usal.es/~iodp/
Switzerland – www.swissiodp.ethz.ch

IODP China – www.iodp-china.org/chs/
IODP Korea – www.kodp.re.kr
ODP Australia – www.odp.usyd.edu.au

IODP Related Sites
European Science Foundation (ESF) – www.esf.org
Japan Drilling Earth Consortium (J-DESC) – www.j-desc.org/
International Continental Scientific Drilling Program (ICDP) – www.icdp-online.org/contenido/icdp/front_content.php
Lamont Doherty Earth Observatory – www.ldeo.columbia.edu
MEXT Ministry of Education, Culture, Sports, Science and Technology – www.mext.go.jp/english/
National Science Foundation – www.nsf.gov
Natural Environment Research Council – www.nerc.ac.uk
USSSP U.S. Science Support Program – www.usssp-iodp.org

ODP Legacy Sites
Joint Oceanographic Institutions for Deep Earth Sampling – www.ifm-geomar.de
Consortium for Ocean Leadershio – www.oceanleadership.org/
ODP Wireline Logging Services – www.ldeo.columbia.edu/BRG/ODP/
Science Operator Texas A&M University (TAMU) – www-odp.tamu.edu/index.html

Mid-Ocean Ridge Links
InterRidge Office – www.interridge.org
NOAA Vents Programme – www.pmel.noaa.gov/vents
DeRIDGE – www.deridge.de

Margins Links
HERMES (hotspot ecosystem research on the margins of European seas) – www.eu-hermes.net/
US Margins Programme – www.nsf-margins.org/

NERC Marine Programmes
Joint Climate Research Programme – www.nerc.ac.uk/research/programmes/jointclimate/
Oceans 2025 – www.nerc.ac.uk/research/programmes/oceans2025/
RAPID – www.nerc.ac.uk/research/programmes/rapid/
Technology Proof of Concept – www.nerc.ac.uk/research/programmes/technologypoc/

Completed NERC Marine Programmes
Autosub Under Ice (AUI) Programme – www.nerc.ac.uk/research/programmes/autosubunderice/
COAPEC (Coupled Ocean-Atmosphere Processes and European Climate) – www.nerc.ac.uk/research/programmes/coapec/
Ocean Margins LINK Programme – www.nerc.ac.uk/research/programmes/oceanmargins/
Surface-Ocean/Lower-Atmosphere Study (SOLAS) – www.nerc.ac.uk/research/programmes/solas/

Acronyms

www.iodp.org/acronyms/

ACEX	Arctic Coring Expedition
BCR	Bremen Core Repository
BoG	Board of Governors
CDEX	Center for Deep Earth Exploration
CDP	Complex Drilling Projects
DSDP	Deep Sea Drilling Project
ECORD	European Consortium for Ocean Drilling Research
EDP	Engineering Development Panel
EMA	ECORD Management Agency
EPC	European Petrophysical Consortium
EPSP	Environmental Protection and Safety Panel
ESO	ECORD Science Operator
ESSAC	ECORD Science Support and Advisory Committee
ETF	Engineering Task Force
GCR	Gulf Coast Repository
ICDP	International Continental Scientific Drilling Program
IIS-PPG	Industry-IODP Science Program Planning Group
ILP	Industry Liaison Panel
IO(s)	Implementing Organization(s)
IODP	Integrated Ocean Drilling Program
IODP-MI	Integrated Ocean Drilling Program – Management International
ISP	Initial Science Plan
J-DESC	Japan Drilling Earth Science Consortium
JOI	Joint Oceanographic Institutions, Inc.
KCC	Kochi Core Center Repository
LUBR	Leicester University Borehole Group
MEXT	Ministry of Education, Culture, Sports, Science, and Technology (Japan)
MOST	Ministry of Science and Technology (People's Rep. of China)
MSP	Mission Specific Platform
NanTroSEIZE	Nankai Trough Seismogenic Zone Experiment
NERC	Natural Environment Research Council (UK)
NSF	National Science Foundation (USA)
ODP	Ocean Drilling Program
OTF	Operations Task Force
PI	Primary Investigator
POC	Platform Operations Costs
SAS	Science Advisory Structure
SASEC	Science Advisory Executive Committee
SOC	Science Operating Costs
SPC	Science Planning Committee
SSEP	Science Steering and Evaluation Panel
SSP	Site Survey Panel
STP	Scientific Technology Panel
TAP	Technology Advice Panel
USAC	United States Advisory Committee for Scientific Ocean Drilling
USIO	United States Implementing Organization
USSAC	United States Science Advisory Committee
USSSP	United States Science Support Program

Back Cover: The liftboat *Kayd* (Montco Offshore, Inc.), the mission-specific platform that the ECORD Science Operator will use during the New Jersey Shallow Shelf Expedition. *Photo A. Skinner © IODP and ECORD*

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