IODP
INTEGRATED OCEAN DRILLING PROGRAM

UK newsletter 30

NATURAL ENVIRONMENT RESEARCH COUNCIL

ODP Highlights

Leg 301: Juan de Fuca

- Two new seafloor observatories (CORKS) established replacing a previously deployed observatory within 3.5 Ma crust.

Leg 302: Arctic Coring Expedition (ACEX)

- First Mission Specific Platform operation by the ECORD Science Operator.
- Three sites were successfully drilling reaching a depth of 429 metres below sea bed recovering a total of 330 metres of core.

Leg 303: North Atlantic Climate 1

- A total of 4656 metres of high quality core were recovered to sample and study the climate records that record North Atlantic Pliocene-Quaternary climate.

Legs 304 and 305: Oceanic Core Complex 1 and 2

- Sample oceanic core complexes to characterise magmatic, tectonic and metamorphic history of core complex emplacement and to also characterise the nature of the alteration front within oceanic peridotite.

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Front Cover: Coring and ice-breaking operations in 9/10 ice cover during IODP Expedition 302 (ACEX). Drillship *Vidar Viking* (foreground) was protected by ice breakers *Oden* and *Sovetskiy Soyuz* (middle and background).

Foreword

Sir Geoffrey Allen, Chair UK-IODP

Welcome to this newsletter reviewing the first year of the UK's membership of the Integrated Ocean Drilling Program.

As chairman of UK-IODP, let me introduce myself. I am a chemical physicist and cannot pretend to be more than an enthusiastic layman parachuted by NERC into your community. UK-IODP is however part of an international venture. At least I am experienced in international collaboration, having been chairman and chief executive of a research council, member of CERN council, research director of a multinational company and survivor of several EU committees. Also I have led a NERC thematic programme on urban regeneration (URGENT).

Ocean drilling began in 1968 with the Deep Sea Drilling Project which ran for 15 years. It validated the theory of tectonic plates, initiated the science of palaeoceanography and gave insight into the lavas and sheeted dykes of the upper ocean crust. Built on this success, the Ocean Drilling Program (1983-2003) extended our knowledge of the ocean crust and upper mantle and revealed the incredible variability of past climate change and ocean circulation over a wide range of timescales.

Thus began our understanding of the complex interactions between different parts of the Earth System. The development of this integrated view is basic to IODP which began officially in October 2003.

Funded by 3 major partners: the European Consortium for Ocean Research Drilling, Japan, and the US, it represents cooperation in science on a scale hitherto achieved only by the nuclear physicists at CERN. The Japanese will contribute a state-of the-art riser-equipped drilling vessel, the US is committed to a successor to, or a major revamp of, the *JOIDES Resolution* non-riser drill-ship - the workhorse of ODP. The ECORD will contribute Mission Specific Platforms.

The transition from ODP to IODP has been a smooth one; 4 drilling legs were completed in 2004. Nine more are planned for 2005 and the new Japanese ship '*Chikyu*', capable of drilling in over-pressured subduction zone environments, will commence operations in 2006. The outcome of the Arctic Coring Expedition (2004), in which the ECORD Science Operator carried out the drilling operation, is awaited with interest. By drilling into the Lomonosov Ridge, a good haul of cores have, for the first time, been recovered. Information about the climate history of the Arctic Ocean is expected at a time when the role of the Arctic in forcing rapid changes in ocean circulation and climate change is of particular interest.

NERC has signed up to membership of ECORD for 10 years with 5 years funding confirmed for the UK programme. The UK-IODP is charged with directing and managing a national thematic programme of relevance to our science-base. We are, and will continue to be, an active and influential partner within ECORD and hence in IODP by fashioning this programme primarily from proposals generated from the earth sciences community which has formed around ODP.

Ten members of the committee already represent UK interests in a bewildering array of ECORD and IODP committees that determine or coordinate the projects. Of special importance are the European Science Support and Advisory Committee and the Science Planning and Policy Oversight Committee of IODP, where we are represented by Chris MacLeod and Julian Pearce (Cardiff), Paul Wilson (Southampton) and Mike Bickle (Cambridge).

At this stage IODP has identified 3 major science themes to be informed by the drilling programme:

- Environmental Change, Processes and Effects.
- The Deep Biosphere and Subseafloor Ocean.
- Solid Earth Cycles and Geodynamics.

The UK committee seeks proposals for:-

- the survey of new drilling sites;
- research projects associated with new or established wells to create further understanding;
- the development of new techniques or technology.

The UK and ECORD committee members are keen to offer advice and assistance to those developing proposals for drilling, related research or the development of technology.

Equally important is to have a strong cohort of postgraduates, postdoctoral fellows and staff at all levels who can be nominated for places on forthcoming expeditions relevant to our programme as they are commissioned. Heather Stewart, the Science Coordinator, is pleased to talk with volunteers.

A list of all the schemes is appended elsewhere in this newsletter.

The committee has asked Richard Davies (vide infra) to convene an Industrial Liaison Panel to recognise the interests of oil companies, mining companies and companies specialising in drilling technology and to nurture collaboration with academe of mutual benefit. To ensure coherence with overall planning, the chairman of the IODP-ILP has accepted a place on UK-ILP and by reciprocal arrangement a member of our panel will sit on IODP-ILP. At this time we are the only member country to have a national panel.

There are also a number initiatives designed to strengthen our UK community. The Science Coordinator and I plan to visit in 2005-6 the universities with research groups in the field. The primary objective will be to discuss the opportunities available through UK-IODP and methods of realising them. At the same time we hope to capture the interest of groups in neighbouring fields, especially the biological and climate modelling sciences, and so expand our capacity for research. In addition, we aim to organise annual visits of distinguished research scientists from overseas to give us of their perspective of the progress of the IODP.

Many of you attended the 2004 meeting at the Royal Society, in London, to launch the programme. This was followed in December with a workshop on 'Borehole Logging', organised by Mike Lovell and Tim Brewer at the University of Leicester. There will be an annual workshop or conference each year on a 'hot topic'. The Science Coordinator welcomes suggestions. In June this year it will take the form of a 2-day conference at The Geological Society of London to present and review the results of the pioneering Arctic Coring Expedition in the context of rapid climate change in the North Atlantic.

We need to engage your interest and enthusiasm to help us put the UK in the forefront of the Integrated Ocean Drilling Program.

Upcoming expeditions

307 Porcupine Basin Carbonate Mounds

The IODP expedition Porcupine Basin Carbonate Mounds will drill a downslope suite of three sites on the eastern slope of Porcupine Seabight, west of Ireland. The sites are centred on 'Challenger mound' (site PORC-03A), a 170m high, partly buried carbonate mound in the 'Belgica mound province', topped by dead cold-water coral rubble.

The Belgica mound province belongs to the best-documented carbonate mound provinces worldwide. High resolution seismic profiling, multibeam bathymetry and sidescan sonar imaging have shed light on the stratigraphic, structural and morphological setting. The mounds are rooting on a strongly erosive unconformity and are seated partly on an enigmatic sequence of sigmoidal units, partly on a semi-transparent layer. Sites have been chosen to identify the semi-transparent basement layer, the nature of the sigmoidal units, constrain the age of the unconformity and the importance of the hiatus. An 'on-mound site' will unveil the environmental record locked in a carbonate mound and shed light on the processes which may have controlled the genesis of the mound, in particular to test the hypothesis of the possible role of fluid venting as a trigger for mound growth and to assess the importance of environmental forcing factors. Particular attention will be paid to microbiological and biogeochemical processes in mound genesis and development.

308 Gulf of Mexico Overpressures

The Gulf of Mexico Overpressures expedition aims to develop a macro-scale (km scale) model that describes how sedimentation drives compaction and fluid flow in geologic settings where low permeability mudstones load high permeability aquifers. This model will be tested by characterising the spatial variation in pressure, stress, and rock and fluid properties along a known flow focusing structure (Ursa Basin). The micro-scale material behaviour of the shallow sediments will be established through analysis of two reference sites where pore pressures are normal, yet in-situ effective stresses are different (the Brazos Trinity Basin). A core component of the study will be laboratory based geotechnical analysis of sediment properties to further constrain material behaviour. Achievement of the scientific objectives will illuminate controls on slope stability, seeps, and large-scale crustal fluid flow.

309 Superfast Spreading 1

This expedition forms the first part of a two-stage drilling operation and follows on from successful operations during Leg 206 at Site 1256 that for the first time in scientific ocean drilling successfully constructed the bore-hole infrastructure required for deep drilling into the ocean basement. A large re-entry cone with 16-inch casing cemented into basement was installed in Hole 1256D before this hole was deepened to more than 500 meters sub-basement. Deepening Hole 1256D to the gabbros would be the first sampling of a complete section of ocean crust from extrusive rocks, dykes and into the gabbros, and would confirm the nature of high level axial magma chambers and define the relationship between magma chambers and their overlying lavas and the interactions between magmatic, hydrothermal, and tectonic processes. These cores will provide further evidence for the geological nature of the seismic stratigraphy of the ocean crust as well as quantify the relative influence of different layers as sources of marine magnetic anomalies.

The results from this expedition will be the first sampling of a complete section of ocean crust from extrusive rocks, dykes and into the gabbros, and will confirm the lithology of the seismic Layer 2–Layer 3 transition, the nature of high level axial magma chambers, define the relationship between magma chambers and their overlying lavas and dykes, and the interactions between magmatic, hydrothermal, and tectonic processes throughout the upper and middle oceanic crust. This site represents one end-member in the continuum of seafloor spreading, and this end-member presents the best opportunity for achieving the scientific goals.

310 Tahiti Sea Level

This expedition, the second Mission Specific Platform of IODP, aims to drill to a series of boreholes along a number of transects. Data from these holes will be used to reconstruct the deglaciation curve for the period 20,000 to 10,000 yrs BP in order to establish the minimum sea-level during the Last Glacial Maximum (LGM), to test predictions based on different ice and rheological models, and to assess the validity, the timing and amplitude of meltwater pulses which are thought to have disturbed the general thermohaline oceanic circulation and, hence, global climate, identify and to establish patterns of short-term palaeoclimatic changes that are thought to have punctuated the transitional period between present-day climatic conditions following the LGM.

It is proposed to quantify the variations of sea surface temperatures based on high-resolution isotopic and trace element analyses on massive coral colonies. When possible, specific climatic phenomena such as El Nino-Southern Oscillation in the time frame prior to 10,000 yrs BP will be identified and a better knowledge of the global variation and relative timing of post-glacial climate change in the southern and northern hemisphere will be gained.

Analysis of the impact of sea-level changes on reef growth, geometry and biological makeup, especially during reef drowning events; this approach will help improving the modeling of reef development and the morphological and sedimentological evolution of the foreslopes (highstand vs lowstand processes) will also be undertaken.

311 Cascadia Gas Hydrates

The expedition will build on the previous Cascadia hydrate drilling of Leg 146 in the area and on more recent Leg 204 off Oregon. This expedition will make use of the now well-developed CORK downhole monitoring, Log-While-Drilling (LWD), Distributed Temperature Sensors (DTS), and Pressure Core Barrel sampler for hydrate, free gas, and fluid recovery in situ.

The aims of this expedition are to constrain models for the formation of marine gas hydrate in subduction zone accretionary prisms. The objectives include the deep origin of the methane, its upward transport, its incorporation in gas hydrate, and its subsequent loss to the seafloor. The main attention is on the widespread seafloor-parallel layer of dispersed hydrate located just above the base of the stability field. Such layers may make up the largest volume of hydrate globally. These objectives require high quality data on the vertical concentration distributions of gas hydrate and free gas, and variation landward in the accretionary prism, and estimates of the vertical fluid and methane fluxes through the sediment section, as a function of landward distance from the deformation front.

312 Monterey Bay Engineering

This expedition proposes to install three ~300-m cased reentry boreholes in Monterey Bay, California, to establish a borehole instrument test facility and to develop borehole-to-submarine-cable technologies. Two closely spaced holes (50 m apart) will have basic completion assemblies. These sites will first be used to conduct borehole hydrologic and geochemical measurements to establish what equilibrium conditions are in a low flow environment. Subsequently these sites will be used to conduct perturbation experiments (by pumping) that will be fundamental to understanding how porosity and permeability measurements scale in time and space. After these tests, the side-by-side boreholes will be available for other down-hole experiments and tests. The third hole will be configured for a borehole seismometer with a casing strategy to minimize fluid flow into or out of the formation, which is a source of seismic noise. The seismic hole will be placed approximately 2 km from the other holes to isolate it from noise associated with the other facilities. This site will be the first cable-connected borehole seismic observatory along the North American Margin that is entirely on the Pacific Plate.

The objective is to stimulate the development of the next generation of seafloor borehole experiments. IODP promises to expand on the progress made in ODP to conduct experiments in boreholes under the ocean floor. However, the experience with conducting borehole experiments shows that these are inherently complicated systems to develop and deploy. Thus, an accessible facility in which new systems can be tested and refined will be critical to stimulating this new style of science within the IODP community.

313 Superfast Spreading 2

Superfast Spreading 2 is the second part of a two stage drilling strategy to sample, at ODP Site 1256, a complete section of the upper oceanic crust formed at a superfast (>200 mm/yr) spreading rate. The observed relationship between ocean ridge spreading rate and the depth to axial low velocity zones, interpreted to be melt lenses, predicts that the dyke-gabbro transition should be at its shallowest in crust formed at superfast spreading rates, and gabbros are predicted to occur at the depth range 900 to 1300 meters sub-basement (msb). These cores will provide further evidence for the geological nature of the seismic stratigraphy of the ocean crust as well as quantify the relative influence of different layers as sources of marine magnetic anomalies.

Results of the expedition will be the first sampling of a complete section of ocean crust from extrusive rocks, dykes and into the gabbros, and will confirm the lithology of the seismic Layer 2–Layer 3 transition, the nature of high level axial magma chambers, define the relationship between magma chambers and their overlying lavas and dykes, and the interactions between magmatic, hydrothermal, and tectonic processes throughout the upper and middle oceanic crust. This site represents one end-member in the continuum of seafloor spreading, and this end-member presents the best opportunity for achieving the scientific goals.

Reports on recent IODP Legs

Expedition 301: The hydrogeologic architecture of basaltic oceanic crust on the eastern flank of Juan de Fuca Ridge

Rosalind Coggon (SOC) and Leg 301 Shipboard Scientific Party

In the true spirit of the Integrated Ocean Drilling Program (IODP) the first expedition, Exp 301, was part of a multidisciplinary program designed to resolve the fundamental nature of fluid pathways in the crust and the dynamic influences of fluid circulation on Earth evolution.

The hydrothermal circulation of seawater through the oceanic crust significantly affects the physical, chemical and biological evolution of both the lithosphere and oceans. For example, it provides a control on the thermal state of the ocean plates and the distribution of magmatic and seismic activity along the mid-ocean ridge and subduction zone plate boundaries; fluid-rock interactions contribute to global geochemical cycles effecting the compositions of the oceans, the lithosphere and subsequently the mantle through subduction; and it supports vast sub-seafloor microbial ecosystems.

Heat flow studies indicate that approximately two thirds of this convective heat loss occurs at crustal ages greater than 1 Ma (Stein and Stein, 1994) at significantly lower temperatures than axial black smoker venting that has been the focus of most research over the last 30 years. The fluid flux required to dissipate this heat at lower temperatures is at least ten times axial emissions (Elderfield and Schultz, 1996) and is comparable to the annual riverine flux to the oceans. As a result the upper oceanic crust comprises the largest aquifer on Earth. However, little is known about the distribution of hydrologic properties within this system. IODP Exp 301 was the first of a two-expedition experiment to investigate the formation-scale hydrogeologic properties within oceanic crust on the eastern flank of the Juan de Fuca Ridge (JdFR) in the northeast Pacific Ocean, and to quantify relationships between thermal, fluid, solute and biological processes. Exp 301 established two new subseafloor observatories (CORKS), and replaced a previously deployed observatory, within 3.5 Ma crust. Additional work will occur during a follow-up drilling expedition (to be scheduled) and several years of seafloor experiments.

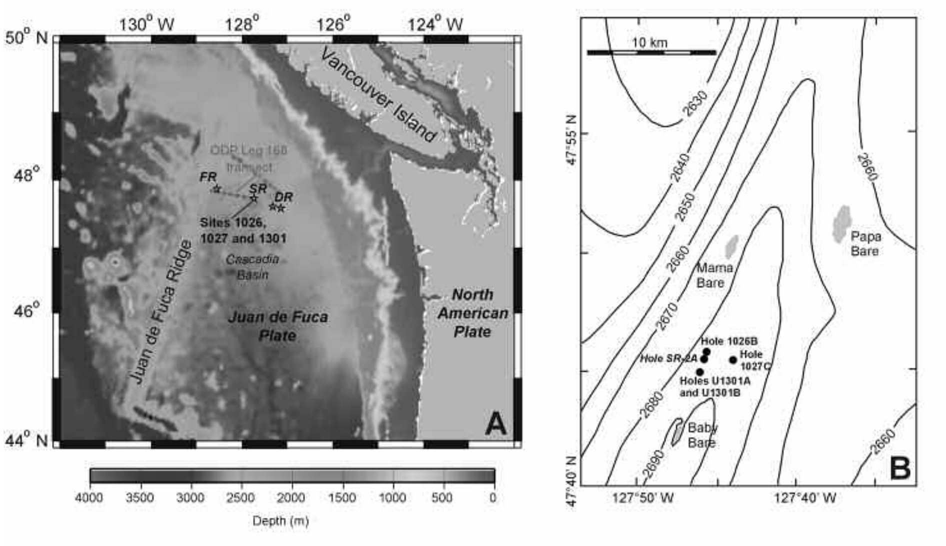

Figure 1. A (left). Regional bathymetric map showing major tectonic features and the locations of IODP Exp 301 drill sites and the ODP Leg 168 drilling transect. FR = First Ridge, SR = Second Ridge, DR = Deep Ridge. B (right). Map of the Second Ridge area showing the relative locations of Holes 1026B, 1027C, U1301A, U1301B and the planned SR-2 Hole and basement outcrops Mama, Papa and Baby Bare. Depth contours in meters. (After Shipboard Scientific Party, 2004).

The Juan de Fuca Ridge

Ocean crust is produced at ~3 cm/y along the Endeavour segment of the JdFR, and is rapidly buried by abundant Pleistocene glacial turbidite sediments eroded from the North American continental margin into the Cascadian Basin (Figure 1). Variable sedimentary thickness across the ridge flank results from basement topography, which is dominated by ridge-parallel valleys and ridges (Kappel and Ryan, 1986). The thick sediments hydrologically and thermally isolate the crust within 1 Ma of its formation, producing strong thermal, chemical and alteration gradients within the basement, making this an ideal area to investigate ridge-flank hydrothermal processes.

ODP Leg 168 investigated the hydrothermal flow within the uppermost oceanic crust and the overlying sediments across the eastern flank of the JdFR (Davis *et al.*, 1997), focussing on physical and chemical processes occurring within sediments and the upper tens of meters of basement. During Leg 168 ten sites were drilled at different crustal ages, sediment thicknesses and thermal and chemical basement conditions along an 80 km transect perpendicular to the ridge crest. Borehole packer experiments and open-hole thermal data were used to determine local hydrogeologic properties and revealed a decrease in the uppermost basement permeability with increasing crustal age (Becker and Davis, 2003; Becker and Fisher, 2000). Borehole (CORK) observatories were installed at four sites, and were instrumented to monitor borehole fluid pressure and temperature and to collect long-term fluid samples. Additionally, a 'BioColumn' experiment attached to the Hole 1026B CORK provided the first direct microbiological sampling from ridge flank fluids (Cowen *et al.*, 2003).

The extent of alteration of upper basement cores and pore fluids generally increased from west to east, along with crustal age and basement temperature, suggesting this is the dominant direction of fluid flow within the crust (Wheat *et al.*, 2000). However, ^{14}C dating and compositions of pore fluids provide geochemical evidence for along-strike (south to north) flow, and thermal data combined with calculations based on the local hydrogeologic properties show that basement outcrops influence local flow patterns, (Fisher *et al.*, 2003). Hydrothermal flow through the ridge flanks is clearly complicated. We still do not know how deep fluid circulates, the magnitude of permeability anisotropy, or the significance of hydrogeologic barriers in the crust.

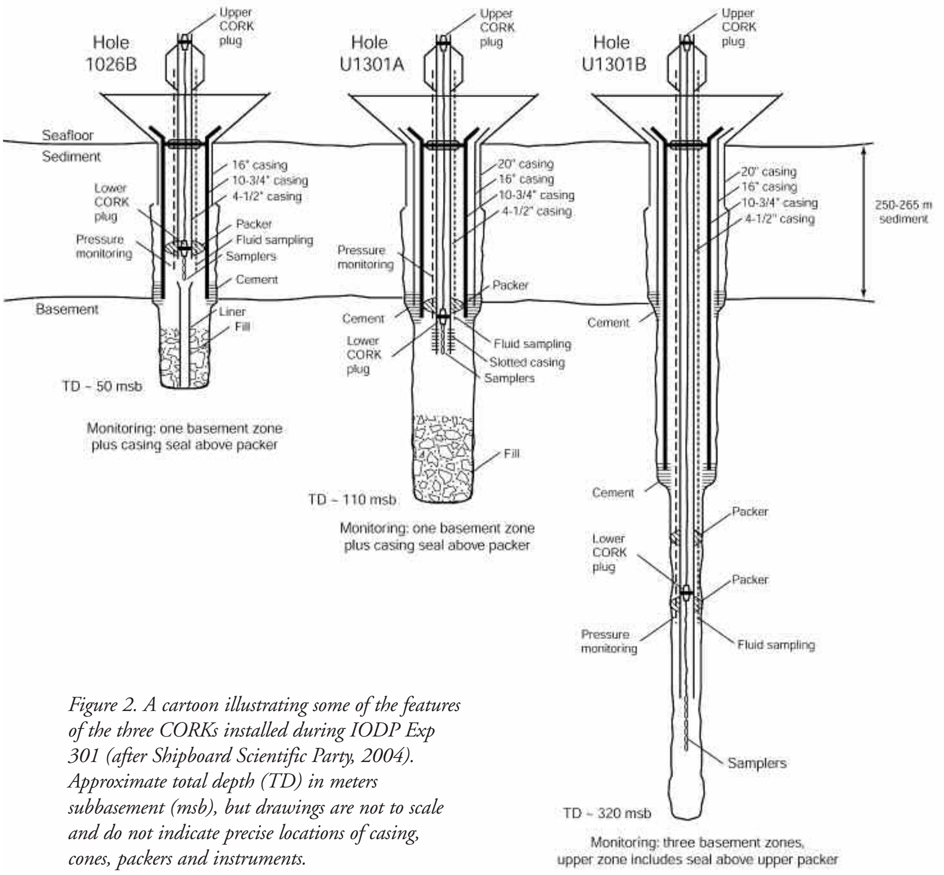

Figure 2. A cartoon illustrating some of the features of the three CORKs installed during IODP Exp 301 (after Shipboard Scientific Party, 2004). Approximate total depth (TD) in meters subbasement (msb), but drawings are not to scale and do not indicate precise locations of casing, cones, packers and instruments.

IODP Expedition 301

A two expedition-drilling program was designed to answer some of these questions and extend the results of ODP Leg 168 in three primary ways:

- Through deeper drilling, coring, and downhole measurements within basement.
- By expanding the multidisciplinary mixture of ridge-flank research in a single area, including microbiological and biogeochemical analyses of sediments and basement rocks.
- By establishing a three-dimensional network of borehole observatories, to be used in long-term, crustal-scale experiments.

During Exp 301 the existing borehole observatory in Hole 1026B was replaced and two new observatories at Site U1301 were installed. Basaltic upper crust and overlying sediments were also cored and sampled at Site U1301 to assess physical, geochemical and microbiological conditions and completed a series of downhole experiments to determine the hydrogeologic properties near the new boreholes.

Site U1301

Sites 1026 and U1301are separated by ~1 km and located above a buried basement ridge, where sediment thins to 250-265 m (Figure 1). Four holes were drilled at Site U1301. Hole U1301A penetrates 262 m of sediment and the upper 108 m of basement, a CORK borehole observatory (Figures 2 and 3) was installed after short-term hydrogeologic testing. Hole U1301B penetrates 265 m of sediment and 318 m of basement, of which the lowermost 232 m was RCB cored, logged and subjected to hydrogeologic testing at several depths. A multilevel CORK (Figure 2) was installed. Hole U1301C was discontinuously APC cored to 265 mbsf, and in-situ temperatures were determined to evaluate the thermal state of the uppermost basement. Following the replacement of the 1026B observatory the remaining time was used to APC spot core Hole U1301D to recover sediment from an interval that was not cored in Hole U1301C.

The sediments at Site U1301 comprise an upward-fining turbidite sequence with gravel interbeds (Unit I) overlying a hemipelagic clay sequence (Unit II). The lithologies are virtually the same as at Site 1026 (cored during ODP Leg 168). APC coring had not previously penetrated below 100 mbsf in this area, and was conducted to achieve good recovery and high-quality sampling for geochemical and microbiological analyses. In-situ temperature measurements indicate that heat flow through the sediments is 280 mW/m^2 and the upper basement temperature is ~ 62°C. Two biogeochemical zones were identified on the basis of geochemical gradients at the seawater/sediment and sediment/basement interfaces, as observed at numerous DSDP and ODP holes drilled to basaltic basement. Sulfate reduction occurs at ~50 and 125 mbsf with diffusive sources from bottom seawater and basaltic formation fluid, and methane concentrations vary inversely with sulfate, consistent with microbiological production. Total cell counts decreased slightly with depth, following a similar trend to that established for ODP sites. An increase in cell numbers was observed near the sediment/basement interface, which may relate to an upward flux of electron acceptors from hydrothermal fluids in the underlying basement. Incubation experiments began at sea and are continuing on shore.

Basement coring was restricted to Hole 1301B, where the uppermost 85 m of basement were cased to stabilize the hole. Basement was cored in Hole U1301B from 86 to 317.6 m subbasement with 30% recovery. The basement is predominantly comprised of aphyric to highly phyric pillow basalt, with massive basalt and some basalt-hyaloclastite breccia. The lavas have normal mid-ocean ridge (N-MORB) chemistries and the physical property parameters of density, porosity, velocity, natural gamma ray, magnetic susceptibility and thermal conductivity correspond to the igneous lithologies. All the basement rocks are affected by low temperature alteration, typical of upper ocean crust, with secondary minerals filling vesicles and veins or fractures, and replacing phenocrysts, interstitial mesostasis and glass. The principal secondary minerals are saponite, celadonite and iron-oxyhydroxide, with minor carbonate, pyrite and zeolite.

Of the 69.1 m of recovered basement core, an impressive 9% was taken as whole-round samples on the catwalk and dedicated to microbiological analyses. Shipboard incubation experiments on basalt generated cell growth in <10% of cultures, including those at near in-situ temperatures, possibly including indigenous microbes from the warm, shallow basalt aquifer. On shore work includes further physiological and phylogenetic characterizations of the retrieved microbes.

After drilling was concluded a suite of geophysical wire-line tools were deployed. Integration of core data and geophysical logs will help to refine the igneous stratigraphy and structure, as the more altered and deformed rocks are likely to be lost during drilling, leading to bias in the core logging. Constant-rate injection packer experiments completed in Holes U1301A and U1301B show that the upper crust is highly permeable, although preliminary analysis suggests that there may be a decrease in bulk permeability with depth.

Fitting the CORK in Hole U1301B was not easy. During cementing the lowermost 100 m of the 10¾ inch casing string came unscrewed and dropped ~6 m into the hole. Non-alignment of the two sections made it difficult to lower drill pipe, and subsequently the packer and CORK assemblies, into the hole. Some creative engineering and cement operations were conducted to try and patch this gap. However the first attempt to fit the CORK was unsuccessful, the 4½ inch casing at the base of the CORK failed and most of the CORK assembly was run out onto the seafloor. Fortunately, with some further creative engineering we were able to retrieve the CORK head, clear the crumpled casing from the area and assemble and successfully install a second CORK using available parts. This CORK monitors three intervals within the hole separated by inflated packers ~120 and ~162 m from the base of the hole.

Figure 3. Assembling the U1301B CORK-head on the rig-floor.

Future experiments

The CORKs deployed during Exp 301 are instrumented with autonomous temperature loggers, osmotic fluid samplers, and microbiological growth substrate. Submersible/ROV platforms allow the future collection/deployment of instruments to the CORKs. Future experiments will include hydrogeologic tests to determine fluid transmission and storage properties, at cross-hole distances of 35 to 2200 m. The osmotic fluid samplers will be used to detect tracers pumped into the crust at another site, thus allowing quantification of the rates and modes of solute transport. The relationship between velocity and hydrogeologic anisotropy will be investigated using seismic experiments. Exp 301 successfully completed the first stage of this complicated and ambitious project. The next IODP expedition to this area will drill new basement holes, complete the three-dimensional observatory network, and initiate crustal-scale, subseafloor experiments.

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ACEX, the first ECORD operation for IODP

Andy Kingdon and Dan Evans (ESO)

Looking back to early 2004 it is astonishing how much progress has been made in making the Integrated Ocean Drilling Program (IODP) a real scientific program. At that time IODP still only consisted of two nations and no scientific operations had taken place.

Now everything has changed. Both ECORD (European Consortium for Ocean Research Drilling), now including 17 nations, and China are formally part of IODP, and other nations appear likely to join. But most progress has been on the operational side for IODP is now a fully operational scientific program. As well as a full program of US-led non-riser drilling operation using the JOIDES Resolution, ECORD has delivered a genuine first for IODP: a mission specific platform (MSP) operation, the Arctic Coring Expedition (ACEX),

The operation was undertaken by the ECORD Science Operator (ESO) during August and September 2004 for ECORD who funded it as their contribution to IODP for 2004. ESO is a consortium co-ordinated by the British Geological Survey (BGS) and includes the University of Bremen and the European Petrophysics Consortium (the Universities of Leicester, Montpelier, Aachen and Amsterdam). For this operation the Swedish Polar Research Secretariat (SPRS) joined ESO to give us specialist advice on polar operations.

MSP operations differ from conventional scientific drilling as they may make use of vessels that are not primarily drillships. In the case of ACEX this operation involved 3 icebreakers: the Swedish registered *Vidar Viking* as the coring platform and two protecting vessels, the *Oden* and the *Sovetskiy Soyuz*

The *Vidar Viking* came on contract at Aberdeen as a bare-decked supply-type anchor-handling vessel and was transformed in 6 days into a drilling platform, complete with the 34-metre high R100 rig installed by Seacore, the drilling contractors. A 100-ton stern notch (essential when in ice) and a helideck were added in Sweden before proceeding to Tromsø in Northern Norway. Already inside the Arctic Circle, here she rendezvoused with the Swedish Icebreaker *Oden* before departing north on August 8. They were joined two days later at the ice margin by the *Sovetskiy Soyuz*, on a date planned nearly a year before when none of the ships were even under contract!

The powerful *Sovetskiy Soyuz* was an essential component in the success of the expedition. During transits, she led the convoy through the ice, finding the best paths so that the *Oden* and the *Vidar Viking* could follow at a good pace. The ACEX drillsites were in the zone of sea-ice cover within 240 kilometres of the North Pole, the most northerly deep drilling ever attempted. The drilling was into the crest of the Lomonosov Ridge, a subsea mountain chain which crosses the Arctic Ocean between Greenland and Siberia.

Ice cover is measured in parts of 10. Before the operation, the ice management experts had told us they thought that drilling would be impossible in ice cover greater than 9/10, condition where there are still noticeable open-water leads between the ice floes. In fact the drilling took place successfully despite sea ice cover greater than 9/10, that is almost complete ice cover at all times. This was only possible because a key aspect of the success of ACEX was the ice-management programme.

During drilling, the *Sovetskiy Soyuz*, acted as 'destroyer' scouting 'upstream' from the *Oden* and *Viking*, breaking larger floes and ice ridges into smaller pieces that could then be broken further by the *Oden* (the 'protector'), allowing the *Vidar Viking* to hold station.

Oden, operated by the Swedish Polar Research Secretariat, acted as the expedition command centre for the ice and fleet management. The co-ordination of the fleet by the experienced Fleet Master, Captain Anders Backman, was exemplary. *Oden* and *Sovetskiy Soyuz* broke all but the strongest multi-year ice (which has part thawed and refrozen several times so is very hard) which allowed *Vidar Viking* to drill for extended periods. Arno Keinonen, the leader of the ice-management team observed that 'this work is much more difficult than normal ice breaking, for icebreakers usually avoid the most difficult ice in order to make passage, but in protecting the *Vidar Viking* they have to deliberately break the heavy ice. Taking an icebreaker to the North Pole is easy compared with the task that has been accomplished with ACEX.'

Oden was also the base for the twelve scientists that could be accommodated on the offshore part of the expedition. Three scientists were flown by helicopter to the *Vidar Viking* for each shift, but the micropalaeontologists that formed the bulk of the scientists had their laboratory on the *Oden* and received regular core-catcher samples.

ACEX achieved all of its principal scientific objectives although with less recovery than ideal. Holes at three sites were successfully spudded and ultimately the drilling reached a maximum depth of 429 metres below sea bed, penetrating the entire Neogene and Palaeogene successions and through the pre-Tertiary unconformity into Campanian sandstones. In the process, a total of 330 metres of core, or 68% recovery was collected, from an ocean where the previous longest core recovered was about 16 metres in length!

In the process MSP drilling was firmly established as a tool in IODP's arsenal to compliment the *JOIDES Resolution* and soon the *Chikyu*. BGS's contribution was at the fulcrum of all ACEX activities, including overseeing the drilling operations undertaken by Seacore on the *Vidar Viking*. Also on the drillship were ESO colleagues who were curating and handling the core, while the University of Leicester (for EPC) were responsible for petrophysics including the borehole logging operation that was conducted by Schlumberger. Meanwhile both at sea and on land, a high-profile media campaign undertaken by BGS, the University of Bremen and the Swedish Polar Research Secretariat achieved unprecedented media coverage in some 21 languages and 31 countries.

Another unique feature of this operation was that the majority of the science was not undertaken during drilling but later at the University of Bremen IODP Core Repository during November. A larger group of scientists than could be accommodated on the ships were able to undertake detailed examination of the core at this stage. The Tertiary sediments have already yielded hugely significant results showing that the sea temperatures of the Arctic Ocean were almost subtropical at the end of the Palaeocene. Further information can be found in the ACEX Preliminary Report on www.iodp.org.

Since the end of the offshore phase, ACEX has been extensively reviewed and a number of lessons learned. These are already being incorporated into the planning for future IODP operations. It must be appreciate that taking part in an MSP operations is necessarily a very different experience from an operation on the JR. The JR has been modified over many years into a specialist scientific drilling vessel with all the facilities immediately to hand and laid out in a logical manner. MSP operations will never be as straight forward as everything has to be mobilised onto the drilling platform immediately prior to the operation, and must be demobilised straight afterwards. In the case of Vidar Viking this was exacerbated by the fact that the vessel had never been used as a drilling vessel before.

However MSP operations have just received a huge boost with the opening in February 2005 of the new Bremen Core Repository and laboratories which will make the logistics of the shorebased science party much easier for both science party and ESO staff.

ACEX has been a very real adventure that has broken new technical and scientific barriers in both Arctic exploration and international ocean drilling and will spawn a large number of significant scientific publications. Furthermore, having demonstrated the ability of a well-chosen fleet with experienced personnel to enable drilling to take place in the Arctic ice, it is to be hoped that further drilling campaigns will follow in the region.

Three icebreakers, a drilling rig, logging tools, a container and some warm clothes: ACEX at 88°N on the Lomonosov Ridge

Brice Rea, Department of Geography and Environment, University of Aberdeen

During the period October 2003 until the end of September 2004 I was fortunate enough to be involved in the planning and execution of the Arctic Coring Expedition (ACEX) the first Mission Specific Platform (MSP) expedition within the newly inaugurated Integrated Ocean Drilling Program (IODP). I was employed in the Geology Department at University of Leicester as Petrophysics Staff Scientist working for the EPC (European Petrophysics Consortium), which is responsible for the planning and oversight of all downhole logging and petrophysics operations undertaken by ESO for IODP.

My role within ACEX was to develop the petrophysics measurement plan, which involved the downhole logging operations and the core logging operations. It should be noted that this work built on outline plans already developed by the Detailed Planning Group report commissioned and funded during ODP. It quickly became clear however that there was still a very significant quantity of work to be done with regards to the petrophysics operations that would be undertaken both offshore and onshore, and as with the whole expedition not a lot of time in which to get it done.

Challenges

The main challenges with regards to the petrophysics programme for ACEX were focused on the offshore phase of the operation. Continuous drilling and wireline logging had never been attempted in moving pack ice before and unlike other operations with ODP and IODP the drilling platform is not dedicated to the program. Thus the drilling vessel, the *Vidar Viking* had very limited space to put both the downhole logging equipment and the core petrophysics equipment. It was a particularly difficult task given that everything had to be designed and developed before being taken on-site requiring detailed planning to clearly identify both the downhole and core logging requirements. Once this was done the best solution for their measurement had to be found given the environmental and space limitations. This was ultimately achieved: first, through a series of iterations between the co-chief scientists, members of the science party, the IODP Scientific Measurements Panel and the EPC in order to identify core and downhole logging off-shore requirements and second, through consultation and iteration

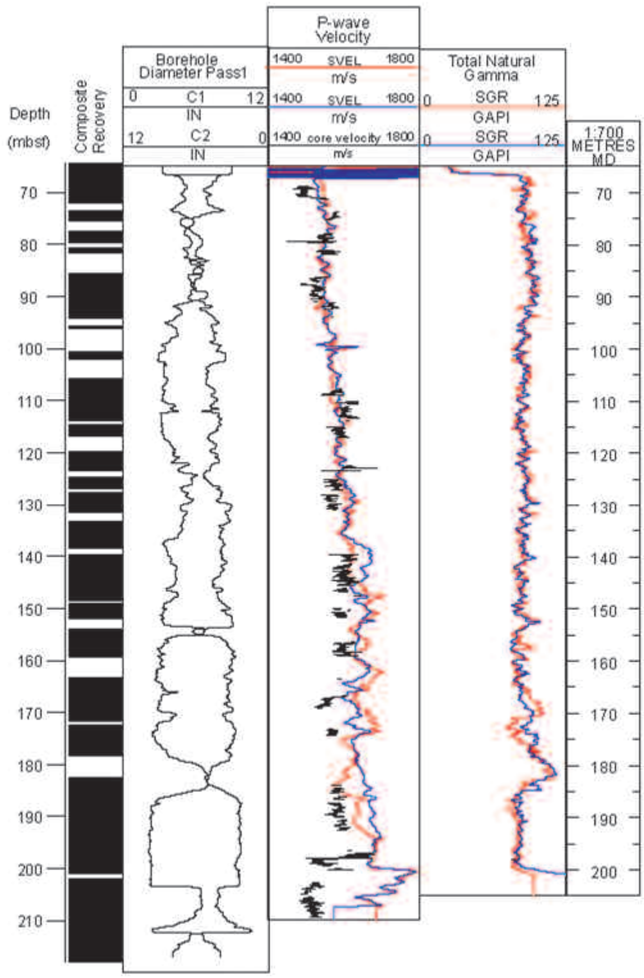


Figure 1. Caliper, p-wave velocity and natural gamma downhole logging data obtained on ACEX.

with Schlumberger (downhole logging) and Geotek (core logging) who provided the equipment necessary to obtain the data.

Downhole logging

There were many new challenges to be faced undertaking a logging operation in the arctic pack ice the main one being the unknown of, how long we could stay on-site with the pipe in the hole, this being critical for downhole logging as the pipe must remain in the hole throughout the operation. This said, a wireline operation similar to that undertaken many times on the *JOIDES Resolution* (JR) during ODP was planned. Schlumberger were providing the logging services (tools and a logging engineer) on ACEX and a suite of tools familiar to those who have sailed on the JR were available. Procedures for the wireline operation were similar to those employed on the JR.

The first attempt to obtain wireline data was made in Hole 4A, which was the deepest hole penetrated during ACEX and extended to almost 430 mbsf. Once coring operations were terminated the pipe was pulled to approximately 70 mbsf and the logging operation began. Everything went very smoothly with the operation despite this being the first time that the wireline and toolstring had been rigged up on the deck of *Vidar Viking*. However, as has happened numerous times before, the logging operation was thwarted by a blockage and so logging in this hole was abandoned without any data being collected. Fortunately a second opportunity came to collect downhole data in the Hole 4B, and although not being as deep as the previous hole still provided the opportunity to log 150 m of open hole. Again the rigging up of the wireline and toolstring went very smoothly and the open hole was logged using a single toolstring that recorded, sonic velocity, total and spectral natural gamma ray and high-resolution resistivity images of the borehole wall (Figure 1). The operation went incredibly smoothly and rapidly being completed in less than 7 hours. This was all due to the skill and excellent teamwork developed between the SeaCore drilling crew, the ESO personnel and the Schlumberger Engineer (Alain Kayo), and a big thanks to them all.

Core petrophysics

To those readers familiar with things on the JR, as was I, having sailed twice as a Logging Staff Scientist, this is where things get a bit different. The labs for core petrophysics and geochemistry measurements and core curation on the *Vidar Viking* had to be planned and designed prior to installation on the ship. For the core petrophysics measurements a GeoTek multi-sensor core logger (MSCL) was installed in a converted standard 20ft container, which also provided the working space for the on-shift stratigraphic correlator (also running the MSCL) and co-chief scientist. Space in the container was thus limited (Figure 2).

The interesting twist for me was that when I joined the *Vidar Viking* in Tromsø, the petrophysics container had to be made operational. This included installing instruments on the MSCL, re-configuring the layout of the container (un-screwing and re-locating benches and heaters in the container) and with assistance from other ESO, SeaCore and *Vidar Viking* crew getting power, water and network cables into the container. The first few days of the transit were cold and miserable due to working in a steel container without heat, light or even music! Ultimately all was made operational in time for arrival at the first site. The location of the core curation and petrophysics containers at the stern of the ship placed them directly above the propellers, which was fine in the open sea, however, once in the pack, periodically ice blocks would get caught in the propellers, which caused the stern and thus, containers to vibrate violently. This led directly to the death of at least one laptop and more than one cup of tea! The configuration and equipping of the container all went well and proved a complete success with all but one of the cores recovered being successfully logged at sea.

Figure 2. Top showing outside view of the petrophysics container (left) and core-curation geochemistry container (right), and an inside view of the petrophysics container (bottom).

Overall

From the petrophysics side of the operation ACEX went very well with a successful programme of both core and downhole logging completed. The petrophysics container proved an excellent facility and will now undergo some minor modifications before its second outing on the next MSP expedition; Tahiti Sea Level. For anyone whishing to participate on an MSP, remember it will most likely be significantly different from anything previously experienced on the JR. For me personally, the opportunity to go to the amazing environment of the Arctic pack ice was one that I will always remember. As for the science, the cores recovered have already and will further expand our knowledge and understanding of this once inaccessible, but very important region of the planet. A special note of thanks to all that I sailed with on the *Vidar Viking*, the ship's crew, the SeaCore drillers, Schlumberger Engineer and ESO personnel, who made the trip a lot of fun and a real pleasure.

Onshore

Another new and different experience when participating on an MSP expedition is the on-shore phase. This was conduced at the University of Bremen, during November 2004, when the full science party assembled. The organisation of the onshore petrophysics measurements was significantly more straightforward as most of the equipment needed was sourced and moved onsite by the Bremen core repository staff. The only additional equipment needed was for core gamma ray measurements and a semi-automated system was leased from Geotek for the duration of the onshore work. This system allowed 6 cores to be loaded onto a frame and the system then logged them automatically. A special note of thanks is extended to Marc Reichow, who fed the logger (which was set up in the reefer) for a few weeks before the arrival of the science party. The extra time this allowed, compared with normal offshore logging on the JR for example facilitated the collection of gamma ray using long count times, thus improving the quality of the data. Thanks to the entire Bremen core repository staff that organised and maintained the equipment needed for the petrophysics measurements, and provided some happy smiling faces every day.

Expedition 303: North Atlantic Climate 1

Sasha Leigh, University of St Andrews

Expedition 303 was designed to sample and study the climate records at strategic sites that record North Atlantic Pliocene-Quaternary climate in terms of the composition and structure of surface or bottom waters, and detrital layer stratigraphy indicative of ice sheet instability. The overall objective the Expedition was '*To establish late Neogene-Quaternary inter-calibration of geomagnetic paleointensity, isotope stratigraphies and regional environmental stratigraphies, and in so-doing develop a millennial-scale stratigraphic template. Such a template is required for understanding the relative phasing of atmospheric, cryospheric and oceanic changes that are central to our understanding of the mechanisms of global climate change on orbital to millennial timescales*'. This 'template' takes the form of a palaeointensity-assisted chronology (PAC) based on both oxygen isotope and geomagnetic palaeointensity stratigraphies. The sites are distributed from the mouth of the Labrador Sea (Eirik Drift and Orphan Knoll) to the central Atlantic in the region of the Charlie Gibbs Fracture Zone (Figure 1). The sites were chosen on the basis of the importance of the climate or paleoceanographic record, adequate sedimentation rates in the 5-20 cm/k.y. range, and the potential for complete and undisturbed recovery of the stratigraphic sequence.

The eight primary drilling locations were known, either from previous Ocean Drilling Program (ODP)/Deep Sea Drilling Project (DSDP) drilling or from conventional piston cores, to have the following attributes:

- They contain distinct records of millennial-scale environmental variability (in terms of ice sheet–ocean interactions, deep circulation changes, or sea-surface conditions)
- They provide the requirements for developing a millennial-scale stratigraphy (through geomagnetic palaeointensity, oxygen isotopes, microfossils, and regional environmental patterns)
- They document the details of geomagnetic field behavior.

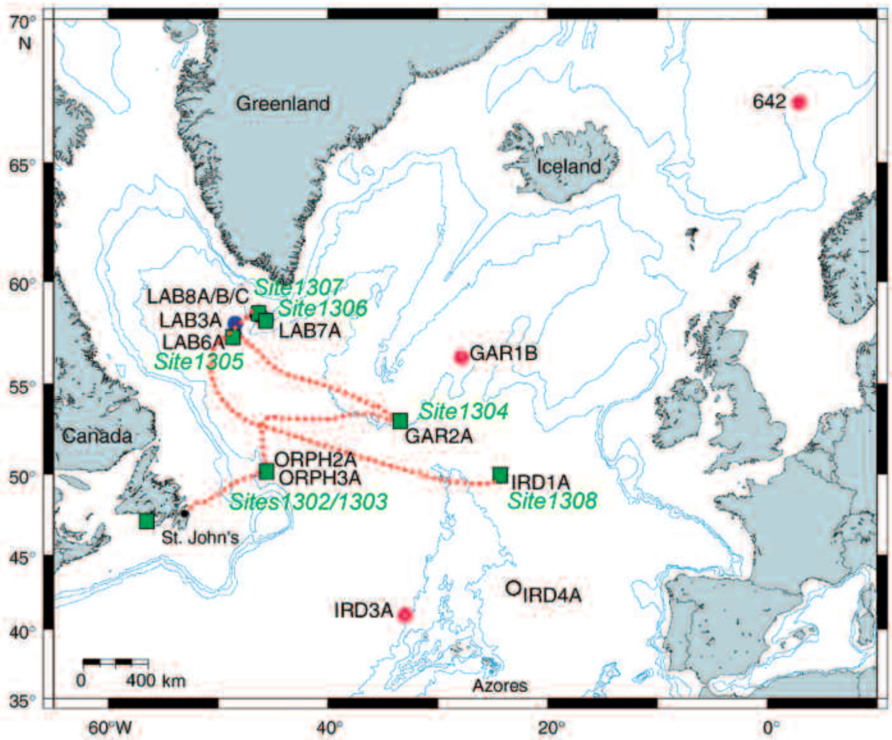
The ultimate objective is to generate a chronostratigraphic template for North Atlantic climate proxies, to allow their correlation at a sub-Milankovitch scale, and their export to other parts of the globe.

Scientific objectives

Understanding the mechanisms and causes of abrupt climate change is one of the major challenges in global climate change research today and constitutes a vital initiative of the Initial Science Plan of IODP. Ideally, the best approach to this problem would be to collect records of climate variability from a dense geographic network of sites, but this is impractical in palaeoceanographic research. In the absence of dense coverage, the most viable approach is to obtain long, continuous time series from key regions and compare the response and timing of climate change among sensitive regions. Here, we intend to develop PACs to establish the phase relationships among globally distributed millennial-scale records. Building global correlations on millennial timescales is an essential step to understanding the changes in the ice sheet-ocean-atmosphere system and the underlying mechanisms of abrupt climate change.

The North Atlantic Ocean is undoubtedly one of the most climatically sensitive regions on Earth because the ocean-atmosphere-cryosphere system is prone to mode jumps that are triggered by changes in freshwater delivery to source areas of deepwater formation. Given the paramount importance of the North Atlantic as a driver of global climate change, Exp 303 aimed to drill at key locations to extend the study of millennial-scale climate variability over the last few million years. Determining the long-term evolution of millennial-scale variability in surface temperature, ice sheet dynamics, and thermohaline circulation can provide clues to the mechanisms responsible for abrupt climate change.

One such example of millennial-scale climate change is the persistent ~1500 y cycle which has been observed for the past 80 k.y. and is apparently independent of glacial or interglacial climate state and may have been a dominant feature of the Earth's ocean-atmosphere climate over a very long time. The best evidence for the 1500 y cycle during interglacials seems to be coming from IRD proxies that monitor changes in the subpolar gyre in the North Atlantic. The 303 drilling sites are positioned to monitor such changes right back beyond the Pleistocene. In contrast to ODP Site 980 (Rockall Plateau), these sites are located well within the main present-day routes of iceberg transport into the North Atlantic and therefore are well-suited to capturing faint interglacial signals in shifting ocean surface circulation. Through connecting the 1500 y cycle to palaeointensity records, we will have a means of directly comparing both



signals with climate records from well outside the North Atlantic.

Geomagnetic palaeointensity records from marine sediment cores have been shown to contain a global signal suitable for the precise, long-distance, fine-scale correlations of marine cores and ice cores at least for the last glacial cycle. Beyond the range of AMS ^{14}C dating, geomagnetic palaeointensity data may provide the only viable means of sub-Milankovitch-scale long-distance correlation. Palaeointensity records have been applied to stratigraphic correlation in the Labrador Sea for the last 200 k.y. (Stoner *et al.*, 1998), throughout the North Atlantic for the last 75 k.y. (Laj *et al.*, 2000), and for the Atlantic realm for the last 110 k.y. (Stoner *et al.*, 2000). As variations in geomagnetic palaeointensity control atmospheric production of ^{10}Be and ^{36}Cl isotopes, and the flux of these isotopes is readily measurable in ice cores, palaeointensity records in marine cores provide an independent link between marine sediment and ice core records.

In addition to the practical use of magnetic field records for correlation of climate records, further drilling of high-sedimentation-rate drift sites will impact the 'Solid Earth' theme of IODP by documenting the spatial and temporal behavior of the geo-magnetic field at unprecedented resolution. Such data are required to elucidate processes in the geodynamo controlling secular variation and polarity reversal of the geomagnetic field.

Drilling operations

The drilling and core recovery phase of the expedition was a success due to the quality and nature of the cores recovered, and the potential of the cores to meet the scientific objectives of the expedition. The common overall objective of Expeditions 303 and 306 (scheduled for March-April, 2005) provided more flexibility to occupy sites as weather conditions allowed than is usual for an individual expedition. The October–November window in the North Atlantic ensured that this flexibility would be utilized. It was decided in the early planning stages that the expedition would utilize the Advanced Piston Corer (APC) only. Cores acquired using the extended core barrel (XCB), particularly in the interval immediately below the limit of APC drilling, are usually disturbed by the drilling process, and do not meet the standards of core quality required for high-resolution stratigraphic studies. Emphasis was placed on the recovery of complete, undisturbed composite sections utilizing multiple APC holes, with 'drill-over' to increase the depth of APC recovery.

Site summaries

Sites 1302/1303

The overall objective at Sites 1302 and 1303 was to explore the record of Laurentide Ice Sheet (LIS) instability at this location, close to Orphan Knoll. Piston cores collected previously at or near Sites 1302 and 1303 (HU91-045-094P, MD99-2237, MD95-2024, MD95-2025) show the presence of numerous detrital layers, some of which are rich in detrital carbonate. Isotopic data from planktonic foraminifers indicate that these detrital layers are associated with low-productivity meltwater pulses. The objective at Sites 1302 and 1303 was to document this manifestation of LIS instability further back in time, to the base of the recovered section (approximately MIS 17). The mean sedimentation rates at Site 1302 and 1303 are ~13 cm/k.y., ensuring a high-resolution record.

At Site 1302, the first site to be drilled off Orphan Knoll, a debris flow was encountered at ~105 mcd that was not recognized in previous seismic data (Toews and Piper, 2002). The top of the debris flow appears to be within the Brunhes Chronozone at about 700 ka, and the base of the section is estimated, from nannofosssil stratigraphy, to be at about 950 ka. In an attempt to avoid the debris flow, we traversed to Site 1303, located 5.68 km NW of Site 1302. The debris flow was again encountered at Site 1303 at approximately the same depth, drilling was again discontinued. Sites 1302 and 1303 can be easily correlated using a range of MST data, and it is clear that essentially the same section was recovered at the two sites. We generated a complete and continuous composite section by combining the 5 holes from Site 1302 and the 2 holes from Site 1303. A short segment of one core from Site 1303 and the composite record from Site 1302 provide a continuous stratigraphic sequence to ~107 mcd. Sites 1302 and 1303 have therefore provided a detailed record of the instability of the Laurentide Ice Sheet since 700 ka.

Site 1304

While en route to prospective sites on the Eirik Drift (Sites 1305-1307), the unfavorable weather forecast for this area forced the ship to be diverted to Site 1304 at the southern edge of the Gardar Drift. The sediments at Site 1304 comprise interbedded diatom and nannofossil oozes with clay and silty clay. Diatom assemblages are dominated by needle shaped species of the *Thalassiothrix/Lioloma*-complex. The site is located within the central Atlantic IRD belt and therefore provides a distal record (relative to that at Sites 1302/1303) of the ice-sheet instability. Site 1304 provides a high sedimentation rate (high-resolution) record at a water depth (3065 m) sufficient to determine the stable isotopic composition of North Atlantic Deep Water (NADW). The diatom-rich sedimentary section extends back into the uppermost Pliocene at 258 mcd. Mean sedimentation rates of 17.8 cm/k.y. are estimated for the last 0.78 Ma, and 12.2 cm/k.y. for the interval from 0.78 to 1.77 Ma. The diatom-rich stratigraphy implies that the site has been located at the sub-arctic convergence between the surface Labrador Current and the North Atlantic Current. The good preservation of benthic and planktonic foraminifers, the pristine magnetic properties, and the construction of a complete composite section from four holes, indicate that the environmental record can be placed into a reliable and precise age model. Site 1304 therefore provides a high-resolution record of NADW and detrital layer stratigraphy of the central Atlantic IRD belt since latest Pliocene time.

Sites 1305, 1306, 1307

Three sites (Sites 1305, 1306 and 1307) were drilled on the Eirik Drift. The first of these was the designated the 'deep-water' site (Site 1305) in 3459 m water depth at the western extremity of the Eirik Drift. The primary 'shallow-water' site (Site 1306) in 2273 m water depth is located 191 km NE of Site 1305. The two sites were chosen by maximizing the thickness of the Quaternary sedimentary section in the multichannel seismic network obtained over the Eirik Drift during Cruise KN-166 (R/V Knorr, PI: Greg Mountain) in summer 2002.

Conventional piston cores have shown that the sedimentation history on the Eirik Drift during the last glacial cycle is strongly affected by the Western Boundary Under Current (WBUC) that sweeps along east Greenland and into the Labrador Sea. Based on two conventional piston cores (HU90-013-013P and HU90-013-012) from the Eirik Drift at similar water depths, the 'deep-water' site (Site 1305) was expected to display relatively expanded interglacials and relatively condensed glacial intervals, and the converse is true for the 'shallow-water' site (Site 1306). The base of the section at both sites lies within the Olduvai Subchronozone at ~300 mcd, and the mean sedimentation rates are 17-18 cm/k.y. However the patterns of sedimentation at the two sites are likely to be different due to the contrasting water depths of the sites and the influence of the WBUC. Sites 1305 and 1306 not only record the history of activity of the WBUC, and hence this component of NADW, but also monitor the detrital layer stratigraphy associated with instability of surrounding ice sheets, particularly the Greenland Ice Sheet. In addition the sites provide the attributes for well-constrained age models using stable isotopes, biostratigraphy and geomagnetic palaeointensity.

Site 1307 was not in the initial plan for Exp 303, but was occupied when a storm moving northeastward across the North Atlantic blocked our passage to our intended next site (Site 1308). Site 1307 was placed at a location on the Eirik Drift where the Quaternary sedimentary section appears to be thinned relative to its thickness at Site 1306, providing APC access to the underlying Pliocene section. Two holes were drilled at Site 1307 reaching a maximum depth of 162 mcd in the uppermost Gilbert Chronozone (~3.6 Ma). The mean sedimentation rate for the recovered section was 4.9 cm/k.y., however, interval sedimentation rates between polarity reversals ranged from 2.7 to 7.6 cm/k.y. Poor weather and excessive ship-heave curtailed drilling at this site, and the two holes were insufficient to generate a complete composite section. The site did, however, establish the feasibility of recovering the Pliocene sedimentary section on the Eirik Drift using the APC. The site extends the environmental record back to ~3.6 Ma, and will provide invaluable age control throughout the multichannel seismic (MCS) network established on the Eirik Drift by the KN-166 cruise in 2002.

Site 1308

The final site of Exp 303 was Site 1308, a re-occupation of DSDP Site 609. Shipboard and shore-based analytical techniques have changed considerably in the 21 years since this site was originally drilled in 1983. For example, the shipboard facilities for the construction of composite section were introduced eight years later in 1991.

DSDP Site 609 has been the focus of some of the most important developments in palaeoclimate research in the last 15 years. Layers of ice rafted debris containing detrital carbonate (Heinrich events) were recognized at this site in the early stages of their correlation to the Greenland ice core record (eg, Bond *et al.*, 1993). The 1500-y cycle in petrologic characteristics such as hematite stained grains and Icelandic glass has also been recognized at this site (Bond *et al.*, 1999). Most of the recent work on DSDP Site 609 sediments has been carried out on the last glacial cycle due in part to uncertainties in the continuity of the section at greater depth. The objective of the re-occupation of DSDP Site 609 was to recover a demonstrably complete sedimentary section that could be used to establish the isotopic characteristics of NADW, monitor the detrital layer stratigraphy of the central Atlantic IRD belt, and place this record into a well-constrained chronostratigraphy. The maximum penetration at Site 1308 was 341 mbsf, to the Upper Miocene at about 6 Ma. There was almost continuous recovery back to about 3.5Ma, however, the complete composite section is limited to the top 190 mbsf, extending down to the Gauss Chronozone at ~2.6 Ma, the mean sedimentation rate since that time being ~7 cm/k.y.

The drilling and recovery phase of Expediton 303 has been an unqualified success due to the dedication of IODP staff, the Transocean employees, and members of the science party. The weather also played an important role in permitting the recovery of high quality cores at all sites. A total of 4656 m of high quality core were recovered from sites with mean sedimentation rates in the 5-18 cm/k.y. range.

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Scientific results from past legs

Link between rapid stepwise Antarctic glaciation and ocean chemistry

Helen K. Coxall[*1], Paul A. Wilson[*], Heiko Pälike[†2], Caroline H. Lear[¶3], Jan Backman[†]

The pattern of post-Eocene climate change, revealed by the δ^{18}O analysis of microscopic fossil carbonate shells of bottom-living foraminifera, is one of abrupt (<1 million year, Myr) δ^{18}O increases, superimposed on longer-term increases reflecting a combination of global cooling and ice growth (Kennett and Shackleton, 1976; Miller *et al.*, 1991; Zachos *et al.*, 1996; Lear *et al.*, 2000). Most prominent of the abrupt increases is 'Oi-1' near the Eocene/Oligocene boundary, about 34 Ma (Miller *et al.*, 1991; Zachos *et al.*, 1996). Oi-1 is thought to mark the initiation of major permanent Cenozoic ice-sheets on Antarctica but its cause is widely debated. One hypothesis is that Oi-1 was triggered by the opening of Southern Ocean gateways (Kennett and Shackleton, 1976); another is that it was caused by a threshold response to long-term Cenozoic decline in atmospheric carbon dioxide levels (DeConto and Pollard, 2003).

The Eocene/Oligocene transition also shows a marked deepening in the calcite compensation depth (CCD) (Van Andel, 1975). This is the depth in the ocean where calcium carbonate dissolves at the same rate as it is deposited. Because the CCD is linked to ocean acidity, which is in turn linked to atmospheric carbon dioxide concentrations and, hence, to global climate, it is important to understand the impact of possible changes in its depth. Earlier surveys of deep-sea sequences suggest that the CCD deepened by ~1km close to the Eocene/Oligocene boundary. However, the precise timing and duration of this deepening, the amplitude and implied ice budget of Oi-1 and the relationship between these two events have long been poorly understood.

In 2001 Ocean Drilling Program (ODP) Leg 199 recovered an exceptionally complete series of Eocene/Oligocene boundary sediment cores from the equatorial Pacific Ocean with unprecedented magneto- and

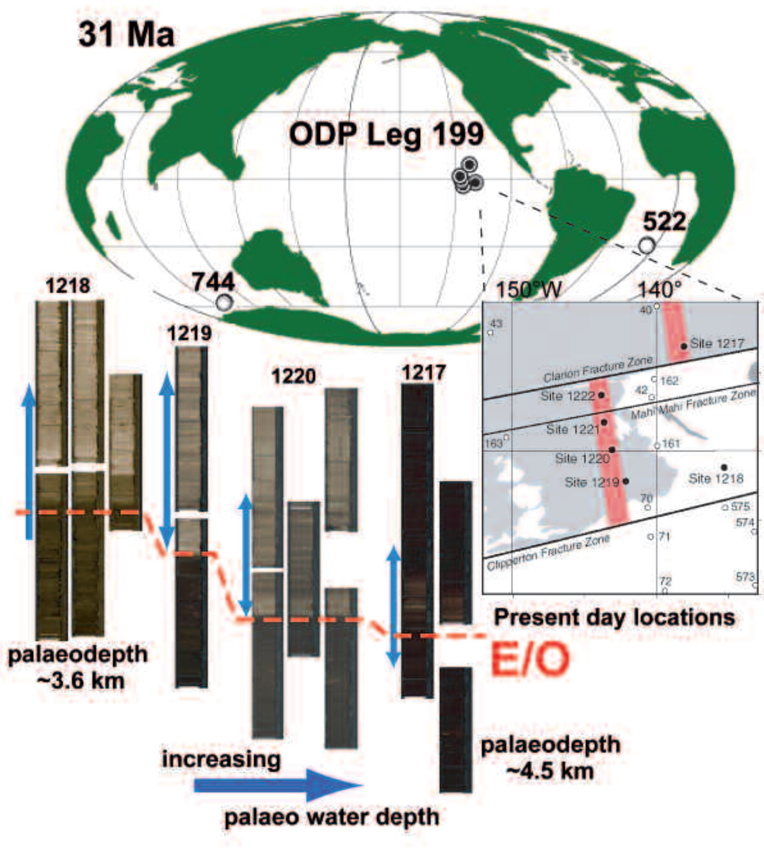

Figure 1. ODP Leg 199 Eocene/Oligocene (E/O) drill-sites. Palaeogeographic reconstruction showing the location of Leg 199 sites ~31 million years ago. Before Leg 199 the best E/O records were from South Atlantic Site 522 and Southern Ocean Site 744. Bottom left, Leg 199 E/O depth transect; sediments cores show pronounced colour change near the E/O boundary (dashed line) as the result of increased $CaCO_3$ content (deepening CCD) in the earliest Oligocene. Bottom right = Leg 199 latitudinal transect in relation to magnetic anomaly C25n (~58 Ma crust).

cyclostratigraphic age control (Figure 1; Shipboard Scientific Party, 2002). Subsequently, a team of scientists from the Southampton Oceanography Centre, Cardiff University, Rutgers University (USA) and the University of Stockholm (Sweden), who participated on Leg 199, conducted research that has shed new light on the nature and speed of Eocene/Oligocene glaciation and the link between CCD deepening in the Pacific Ocean. These results were published in the 6th January issue of Nature (Coxall *et al.*, 2005) and are summarized below.

The Eocene/Oligocene CCD shift is instantly recognizable in Leg 199 cores by up-section shifts from opal-rich (dark coloured) to carbonate-rich (light coloured) sediments (Figure 1). To reconstruct CCD changes, bulk weight per cent $CaCO_3$ and mass accumulation rates (MAR) were determined. The results showed that $CaCO_3$ MAR dominates bulk sediment MAR and the records show strong variations on orbital timescales. The sharp increase in $CaCO_3$ around 34 Ma and the correlative appearance of $CaCO_3$ in deeper water sites (Figure 1; Shipboard Scientific Party, 2002), suggest that the classic CCD records accurately capture the magnitude of the Eocene/Oligocene CCD deepening in the Pacific Ocean. But the new data show that the deepening took place an order of magnitude faster than was previously thought and not as a single event but in two steps (~40 kyr each) separated by an intermediate plateau (~200 kyr).

To investigate the cause of Eocene/Oligocene CCD deepening and its relation to changes in global climate and carbon cycling, $\delta^{18}O$ and $\delta^{13}C$ were analysed in benthic foraminifera. The isotope records show that increases in $\delta^{18}O$ and $\delta^{13}C$ documented in mid- and high-latitude South Atlantic (Zachos *et al.*, 1996) and Southern Ocean (Salamy and Zachos, 1999) sites also occur in the Pacific, confirming that these are truly global signals with stratigraphic utility. They are of the highest resolution (about 2 thousand years between samples) yet achieved for this interval and shed new light on this important event. Most significantly, they show that the pronounced increase in $\delta^{18}O$ is synchronous with the %$CaCO_3$ and MAR series, and hence CCD deepening, demonstrating that the transition from a relatively deglaciated climate state in the latest Eocene to a climate state with well-developed ice sheets on Antarctica in earliest Oligocene time was completed within 300 kyr and coincided with a decrease in ocean acidity.

Comparison of these records with astronomically calculated solutions for orbital oscillations in the past show that the glaciation began during an interval of low eccentricity and low amplitude change in obliquity, conditions favouring dampened seasonality. This observation is consistent with the view that it was the prolonged absence of warm summers, inhibiting summer snow melt, not the occurrence of cool winters favouring accumulation, that was important for establishing the first major ice sheets on Antarctica (DeConto and Pollard, 2003). The data indicate that Earth's orbital configuration was the ultimate trigger for Oi-1 and the pacemaker for ice sheet growth. Yet, some other conditioning factor must have been important because there is no evidence to suggest that the low eccentricity obliquity 'node' conditions at 34 Ma are more extreme than those occurring every 2.4 and 1.2 Myr, respectively during the past 40 Myr, and possibly back to 50 Ma (Pälike *et al.*, 2004; Laskar *et al.*, 2004). Results of a recent GCM experiment (DeConto and Pollard, 2003) suggest that this conditioning factor was long-term decline in Cenozoic atmospheric CO_2 levels (E/O ice sheet threshold ~2.8 to 3 pre-anthropogenic).

Eocene/Oligocene records of Mg/Ca in deep sea foraminifera indicate there was no cooling associated with Oi-1 $\delta^{18}O$ increase (Lear *et al.*, 2000; 2004; Billups and Shrag, 2003), suggesting, controversially, that all of the $\delta^{18}O$ increase is attributable to ice growth. However, the magnitude of $\delta^{18}O$ shift (~1.5‰) is significantly larger than would be expected for Antarctic ice-growth alone. These observations raise the possibility of contemporaneous Northern Hemisphere glaciation, consistent with evidence (Davies *et al.*, 2001) for early onset of North Atlantic deep-water formation. Regardless, ice volumes estimated for a 1.5‰ $\delta^{18}O$ increase are so large that we conclude that Oi-1 must have included a cooling component. This would imply that something acts to mask the cooling signal in the Mg/Ca records, possibly the effect of increasing sea-water pH and/or [CO_3^{2-}] associated with CCD deepening on Mg partitioning into foraminiferal calcite (Lear *et al.*, 2004).

The data show that the E/O CCD shift was synchronous with the development of major permanent Cenozoic Antarctic ice-sheets. Consideration of the possible causes of CCD shift suggest that the deepening itself is unlikely to have triggered Antarctic glaciation and that more probably glaciation triggered the CCD shift. The most likely mechanism to explain the apparent link between the event in the tropical Pacific and Antarctic glaciation is a shift of global $CaCO_3$ sedimentation from the continental shelf to deep ocean basins (Berger and Winterer, 1974; Opdyke and Wilkinson, 1989; Kump and Arthur, 1997). In this scenario glacioeustatic sea-level fall associated with the growth of large Antarctic ice sheets would have reduced the size of the shelf carbonate reservoir, promoting higher deep-ocean carbonate ion concentration, decreased ocean acidity and a deeper CCD. Research is now underway at Southampton to further understand the links between Antarctic glaciation and ocean acidity and to provide additional high-resolution studies of the climate system over more extended periods of time.

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UK ODP Rapid Response Award: Oligocene paleoceanography, glaciation events and sea-level changes

Bridget Wade[1] and Heiko Pälike[2]

Introduction

The Oligocene marks the development of the 'icehouse' world and the establishment of a permanent ice sheet on Antarctica. Previous studies have suggested the Antarctic ice sheet oscillated throughout the Oligocene (eg, Miller *et al.*, 1991) and resulted in substantial sea-level fluctuations. However, until now, little was known about climatic dynamics during this interval and previous records have lacked the resolution to resolve the timing of fluctuations in Southern Hemisphere ice volume and their influence on the ocean-atmosphere system.

Site 1218 (8°53.38´N, 135°22.00´W, ODP Leg 199) is located in the eastern equatorial Pacific Ocean (Shipboard Scientific Party, 2002). At this site an entire Oligocene sequence was recovered with high sedimentation rates (15 m/myr), clear magneto- and bio-stratigraphy, and abundant foraminifer through most of the Oligocene. Magnetic susceptibility measurements and sediment colour record cyclic oscillations which reflect orbital variations of solar insolation (Shipboard Scientific Party, 2002).

To document climatic and paleoceanographic evolution, we generated a high-resolution planktonic and benthic foraminiferal stable isotope stratigraphy of the Oligocene equatorial Pacific at 6 kyr resolution between magnetochrons C9n and C11n.2n (~26.4–30 Ma on a newly developed astronomically calibrated timescale) at Site 1218. Our data provide a detailed, continuous, 3.6 Myr record of climate and paleoceanographic change in the equatorial Pacific during the Oligocene and allow a detailed examination of early cryosphere evolution and the influence of orbital forcing on glacioeustatic sea level variations.

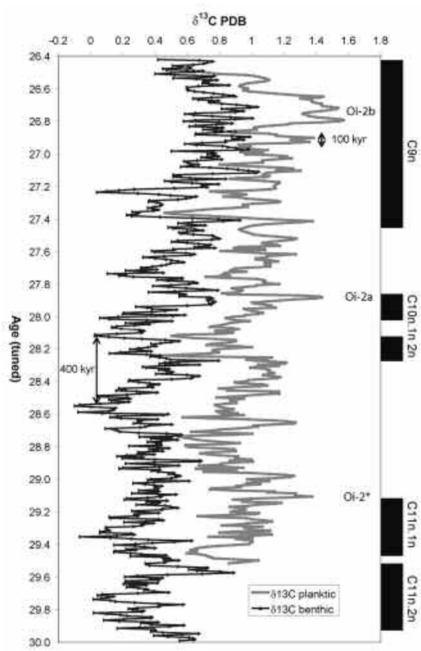

Figure 1. Planktonic and benthic foraminifera carbon isotope data from Site 1218 plotted against astronomical age. Magnetochrons determined for Site 1218 shown on the right (Shipboard Scientific Party, 2002). Data after Wade and Pälike (2004, in press).

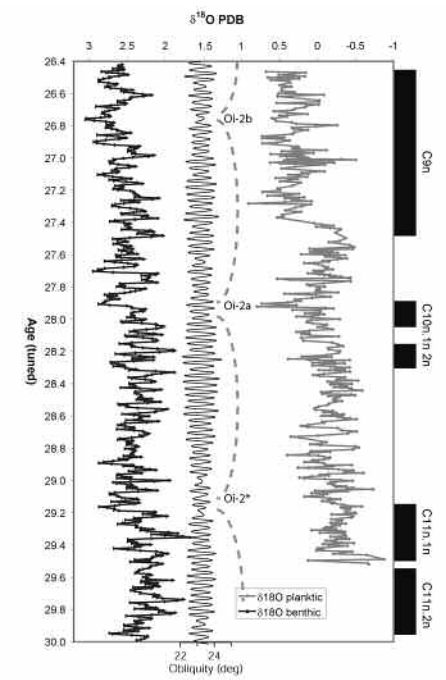

Figure 2. Planktonic and benthic foraminifera oxygen isotope data from Site 1218 plotted against astronomical age. Benthic foraminifera oxygen isotope values were adjusted by +0.64‰ as per Shackleton and Opdyke (1973). Magnetochrons determined for Site 1218 shown on the right (Shipboard Scientific Party, 2002). Data after Wade and Pälike (2004, in press).

Methods and procedures

Stable isotopic data was generated for planktonic (*Globoquadrina venezuelana*) and benthic (*Cibicidoides grimsdalei* and *Cibicidoides havanensis*) foraminifera from Site 1218. We sampled a composite of holes A, B and C (122 to 172 meters below seafloor; 137 to 192 revised meters composite depth), at 10 cm resolution, corresponding to an age of 26.4 to 30.0 Ma and temporal resolution of ~6 kyr. This is the highest resolution ever applied over this interval and thus provides unprecedented insights into temperature variability, the carbon cycle, major ice volume changes, and their relationship to astronomical cycles during the transient climates of the Oligocene. Further details of methodology and description of results are provided in Wade and Pälike (2004, in press).

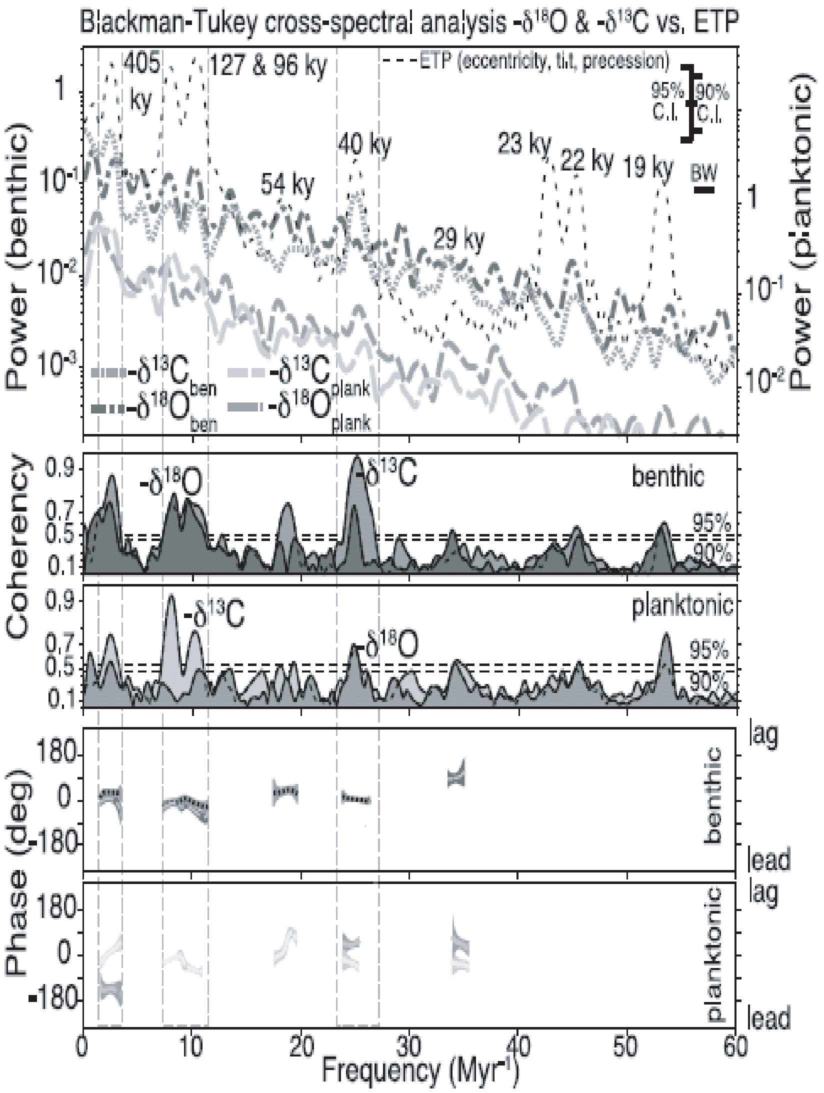

Figure 3. Blackman-Tukey cross-spectral analysis of benthic and planktonic stable isotopes, against astronomical tuning target ETP. Both astronomical and stable isotope series were re-sampled at equal intervals corresponding to the median time step of 6 kyr. Cross-spectra, confidence intervals (C.I.), and bandwidths (BW) were calculated with 140 lags after linear detrending. Phase estimates are plotted only where coherency values are significant and spectral power is present. The eccentricity and obliquity frequency bands are marked by bars. Stable isotope values were flipped prior to analysis. Spectra were calculated with AnalySeries (Paillard et al., 1996). Reillustrated from Wade and Pälike (2004 – Figure 5).

Results and discussion

Pronounced variations are recorded in both planktonic and benthic foraminiferal $\delta^{13}C$ between +0.32 and +1.67 ‰ and -0.18 and +1.09‰ respectively (Figure 1). Planktonic and benthic foraminifera oxygen isotope values fluctuate between -0.88 to +0.91‰ and +1.51 to +3.10‰ respectively (Figure 2). Coeval increases in planktonic and benthic foraminiferal $\delta^{18}O$ and planktonic $\delta^{13}C$ are recorded on 1.2 Myr timescales at 29.16, 27.91 and 26.76 Ma.

Orbital forcing of oligocene climate

High-resolution records from the same site are required to recognise orbital climate variability. The high-resolution isotope records from Site 1218 have enabled us to document the effect of orbital forcing on the Oligocene climate. We performed cross-spectral analyses between the benthic and planktonic $\delta^{13}C$ and $\delta^{18}O$ measurements that are presented in Figures 1 and 2 to evaluate the relative strength of potential astronomical forcing in the stable isotope data of this study, and to estimate phase relationships between the time series (Figure 3).

Power in the orbital bands of eccentricity (406, 130–94 kyr) and obliquity (40 kyr) is indicated by spectral analysis of the isotopic records (Figure 3). The benthic stable isotope time series show a strong and coherent response at the ~100 and ~405 kyr short and long eccentricity periods. This eccentricity imprint is also reflected in the planktonic isotope series, but with a less clear response to short eccentricity in the planktonic $\delta^{18}O$ series. The sensitivity of Oligocene climate to orbital changes in solar insolation is indicated by cross-spectral analysis, which reveals significant coherency between the stable isotope records and orbital forcing. The pronounced ~100 and ~405 kyr periodicity within the isotope records confirms the importance of eccentricity oscillations in pre-Pleistocene climate.

In addition to the ~100 and ~405 kyr short and long eccentricity cycles demonstrated in Oligocene data sets, we also find a strong direct imprint of the ~1.2 Myr obliquity cycle (Figure 2). In astronomical calculations, this cycle is present mainly through its amplitude modulation of the 40 kyr obliquity cycle. In our benthic oxygen isotope data, intervals with particularly heavy isotopes correspond to minima of the 1.2 Myr obliquity amplitude cycle, and generally to minima in the ~405 and ~100 kyr eccentricity cycles. The direct imprint of the 1.2 Myr cycle most likely arises through an enhanced sensitivity of the cryosphere to low variations in seasonality. Zachos *et al.* (2001) suggested that it is the prolonged absence of particularly warm (Southern Hemisphere) summers rather than the occurrence of particularly cool ones that is the significant astronomical factor for inhibiting summer ice melt and thus triggering ice sheet initiation. On the basis of our data, we can support this hypothesis, and postulate that glaciations during the Oligocene are primarily driven by the eccentricity cycles, but with enhanced probability of glaciations during intervals of low obliquity amplitude variations. The 1.2 Myr glacial cycles suggest that ice sheets on Antarctica were dynamic and sensitive to orbital variations of solar insolation.

'Oi' stable isotope events and eustatic sea level change

Previous work has documented a number of enrichments (>0.5‰) in benthic foraminiferal $\delta^{18}O$ records of the Oligocene that correspond to sequence stratigraphic and continental margin sequences (Pekar *et al.*, 2002). These intervals have been interpreted as significant increases in Antarctic ice volume and support the oscillation of ice volume and sea level throughout the Oligocene (e.g., Miller *et al.*, 1991; Pekar and Miller, 1996; Pekar *et al.*, 2001). Accurate definition of the timing and magnitude of glacial (Oi) events has been prevented in previous lower resolution studies. In our records, increases in $\delta^{18}O$ are evident in both the planktonic (0.75 to 1.01‰) and benthic (0.77 to 0.93‰) record at 29.16,

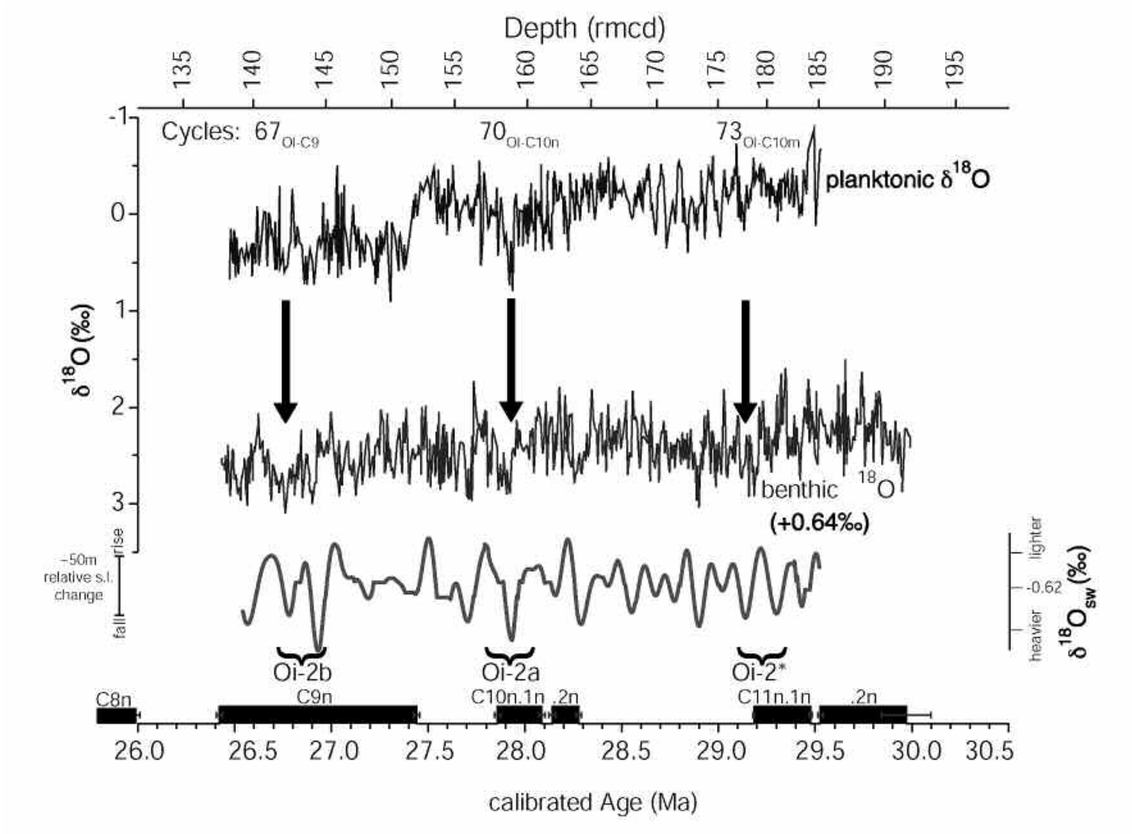

Figure 4. Sea level variation estimates based on covariation of benthic and planktonic oxygen isotope measurements and in relation to sequence stratigraphic estimates of sea level variations. Reillustrated from Wade and Pälike (2004 – Figure 7).

27.91 and 26.76 Ma (Figure 2). We interpret these events to correspond to the Oi-2b, Oi-2a and Oi "unnamed" or Oi-2*, as defined by Miller *et al*. (1991) and Pekar and Miller (1996), but also recognize additional events close in time. The Oi events are typified by covarying enrichment in planktonic and benthic δ^{18}O values (>0.7‰), heavy benthic oxygen isotope values (>2.9‰), and durations from ~70 to 240 kyr.

Eustatic fall at the Oi events can be calculated using the late Pleistocene calibration of 0.11‰ increase in δ^{18}O per 10 m sea level fall (Fairbanks and Matthews, 1978). Using simultaneous changes between benthic and planktonic oxygen isotope values as an indicator of eustatic sea level changes, we calculated a relative sea level curve by multichannel singular spectral analysis with the software SSA Toolkit (Ghil *et al*., 2002). We selected those spectral components that are common to both signals, and reconstructed a combined smoothed time series (Figure 4). Our records indicate that one can match third-order eustatic sea level variations with high resolution oxygen isotope records, and that major glaciation cycles are indeed driven by the confluence of eccentricity cycles and longer-term obliquity amplitude variations. The magnitude of change recorded at Site 1218 suggests there were large variations in the amount of ice on Antarctica during the Oligocene resulting in sea level variations of 50-65 metres.

Oligocene δ^{13}C variations and the carbon cycle

Positive excursions in foraminifera δ^{13}C are associated with enriched δ^{18}O values and eustatic fall during the Oi events. The fluctuations are particularly pronounced (1‰) in the planktonic foraminiferal δ^{13}C data where heavy planktonic foraminifera δ^{13}C values (>1.4‰) and enhanced carbon isotope gradients are recorded at 29.1, 27.9 and 26.8 Ma (Figure 1). These increases in planktonic foraminifera δ^{13}C match cycles within the lithological record and are associated with increased percent carbonate (Wade and Pälike, 2004).

Significant and coherent variations at short and long term eccentricity frequencies are prevalent in δ^{13}C records (Figure 3). The cyclic δ^{13}C in planktonic and benthic foraminifera and $CaCO_3$ content has considerable implications regarding the nature of carbon burial during the Oligocene. Orbital forcing and particularly modulation by the eccentricity cycles affected both carbonate export productivity and carbon burial. The association and cyclic variations of δ^{13}C in planktonic and benthic foraminifera, enhanced δ^{13}C and increased carbonate content during each of the glacial events is significant. This suggests a direct relationship between the carbon cycle and glaciations, and supports the oscillation of the carbon cycle and pCO_2 levels in relation to ice sheet development and expansion. Enhanced productivity and an increased rate of burial of organic carbon during glacial events would account for the high-amplitude δ^{13}C variations.

While the substantial shifts and maxima in the planktonic foraminifer δ^{13}C record and increased δ^{13}C gradient between the surface and the deep ocean are to a large extent attributed to the global carbon reservoir signal, the planktonic carbon record reveal much more pronounced short-term eccentricity variations (110 kyr). The corresponding changes in percent carbonate and increases in planktonic foraminiferal δ^{13}C suggest an enhanced production of biogenic material and mass accumulation rates related to changes in surface water productivity. Indeed, strongly changing productivity patterns and advective flow of eutrophic waters in the area have been suggested by sediment mass accumulation rate studies for the Pacific equatorial region, with a pattern of productivity that was quite different to the single upwelling driven equatorial belt that we see at present (Moore *et al*., 2004). Cyclic shifts in the boundary between the North Equatorial Current and the Equatorial Counter Current, related to orbital modulation of wind patterns may account for changes in surface water productivity.

Summary

The detailed stable isotope stratigraphy covering 3.6 million years is the highest resolution record of this interval. Spectral analysis reveals power and coherency for obliquity (40 kyr period) and eccentricity (~110, 405 kyr) orbital bands, with an additional strong imprint of the eccentricity and 1.2 Myr obliquity amplitude cycle, driving ice sheet oscillations in the Southern Hemisphere. Increases in both planktonic and benthic foraminifera $\delta^{18}O$ are used to constrain the magnitude and timing of major fluctuations in ice volume and global sea level change. Glacial episodes, related to obliquity and eccentricity variations, occurred at 29.16, 27.91, and 26.76 Ma, corresponding to glacioeustatic sea level fluctuations of 50–65 m.

High amplitude cyclic variations are recorded in the carbon isotope signal of planktonic and benthic foraminifera, the water column carbon isotope gradient and estimated percent carbonate. Maxima in $\delta^{13}C$ are associated with each of the glacial events. Alteration of high-latitude temperatures and Antarctic ice volume thus had a significant impact on the global carbon burial and equatorial productivity. During the Oligocene ice volume and temperature variations were driven by the 405 kyr and 1.2 Myr orbital cycles, which exerted a prominent influence on climate, equatorial productivity and global sea level changes.

Together with additional collaborative studies from the earlier and later Oligocene, this data will form part of a Pacific stable isotope reference section. In Wade and Pälike (2004) we also investigate the implications of a close correspondence between oxygen and carbon isotope events and long-term amplitude envelope extremes in astronomical calculations during the Oligocene, and develop a new naming scheme for stable isotope events, on the basis of the 405 kyr eccentricity cycle count.

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News

Industry and academia...we need each other!

Richard Davies, UK ILP Chair

There are many instances where the collaboration between industry and academia has led to significant advances in the earth science discipline. We've got much to share - experience, sub-surface data and varied perspectives. In the hydrocarbon exploration and production industry for instance, economics and risk evaluation are key elements of the geoscientist's job, whereas academics strive to tackle fundamental scientific problems, so the perspectives can be highly complementary.

But if we can make the collaboration work – the prize is high. The industry has a wealth of subsurface data, particularly 2D and 3D seismic reflection datasets invaluable for calibration of the shallower subsurface of most interest to academia that otherwise have to spend valuable time and money acquiring 2D seismic reflection. Can we not find ways to share these datasets? We do to some extent but more can be done. Sharing goes beyond data; there are drilling, coring and logging technologies that can also be transferred in both directions. The hurdles are not insignificant, but to try and optimise the synergies the UK IODP has set up an industrial liaison panel (ILP), composed of industrial geoscientists, with current research interests. The panel aims to bridge these gaps and ensure that both parties can assist, and mutually benefit, from IODP activities. ILP is chaired by Dr Richard Davies, Cardiff University (formerly ExxonMobil) and has the following members: Dr Phil Christie (Schlumberger), Dr Tony Doré (Statoil), Dr Harry Doust (Vrije Universiteit), Dr Peter Jeans (consultant), Prof. David Roberts (BP), Dr Peter Schultheiss (Geotek Ltd.), Dr Nick Stronach (Robertson Research International), Mr Richard Woodhouse (consultant) and Dr Bernie Vining (ExxonMobil). If you require further information please email Richard.Davies@earth.cf.ac.uk or hebe@nerc.ac.uk.

IODP's untapped wealth: multiparameter logging of legacy core

Melanie E. Holland[1], Peter J. Schultheiss[1], Robert M. Carter[2], John A. Roberts[1], and Timothy J.G. Francis[1]

Since 1968, the Deep-Sea Drilling Project (DSDP) and the Ocean Drilling Program (ODP) have recovered and stored approximately 300 km of core, at an estimated average cost of $2,000,000/km. Half of every core has been kept as an archive, normally only available for viewing. These archive half-cores are well-suited for automated non-destructive geophysical measurements ("core logging"), including many parameters that provide essential data for reconstructing Earth's climatic history, such as high-resolution magnetic susceptibility, natural gamma spectroscopy, and UV/VIS/IR spectrophotometry.

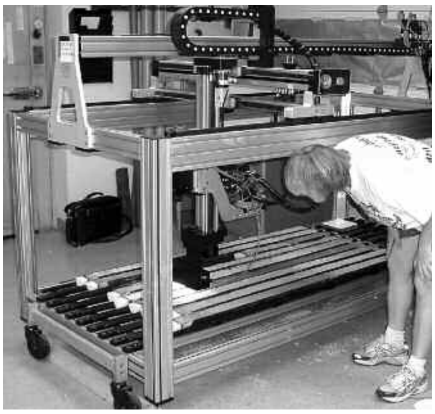

Figure 1. MSCL-XYZ system set up for RGB linescan imaging of archive core.

We recently used a Geotek MSCL-XYZ core logger (Figure 1) at the IODP West Coast Repository to log archive core halves recovered by D/V Glomar Challenger in 1983. The MSCL-XYZ system is specifically designed to allow multiparameter, non-destructive geophysical data to be collected easily at high spatial resolutions on up to nine split-core sections between reloading. This enables the machine to be loaded and run unattended for periods of many hours (including overnight and weekends), making it well-suited for archive core logging in a repository environment. The immediate goal was to obtain a high-resolution paleoclimate record for DSDP Site 594, east of New Zealand, Southwest Pacific, but our underlying intention was to open up the vast reservoir of paleoclimate and other data that awaits extraction from IODP's well-preserved archive half-cores.

New data from old DSDP Site 594

We obtained complete data sets of natural gamma, magnetic susceptibility, spectral color and RGB digital line scan images from the top 150 m of the sediment column at DSDP Site 594 using the MSCL-XYZ (Figure 2). This has provided high resolution climatic data from cores where no core or downhole log data were previously available. The cores show striking alternations of calcareous biopelagic and terrigenous muds that represent, respectively, warm interglacial and cold glacial conditions. Natural gamma was of primary interest and was collected at 5 cm intervals (nominal resolution 300-500 yr). To our knowledge this is the first time that a high-resolution natural gamma data log has been recovered from an archive core half. Magnetic susceptibility data and colour spectrophotometer data were collected at 2 cm intervals (nominal resolution 125 -200 yr). Digital linescan images provided integrated colour reflectance data at 0.1 cm spatial intervals equating to a nominal resolution of 6-10 yr. The excellent quality of the spectral color and RGB image data, despite the ephemeral nature of these properties, is a testament to the core storage techniques employed over 21 years.

The new data collected with the MSCL-XYZ has confirmed the iconic status of the climatic record from Site 594 through Marine Oxygen Isotope Stages 1-5 (Schultheiss *et al.*, AGU 2004; email melanie@geotek.co.uk for poster PDF). Peaks in the magnetic susceptibility record reflect the presence of sand-sized ice-rafted terrigenous detritus (IRD). This record has helped demonstrate the lack of a regionally uniform pattern of occurrence for IRD in the Southern Ocean. The natural gamma ray record for Site 594 shows a strong half-precessional (~10 ky) rhythmicity which is mirrored to a lesser extent in the other data sets. This data set provides an atmospheric climate record that can now be compared with its companion marine benthic oxygen isotope record. The grey-scale and colour reflectance records serve as a detailed proxy for the amount of calcium carbonate present, and hence for pelagic productivity and sea surface temperature at Site 594. Rich detail in these records indicate that abrupt, episodic climate changes characterise the DSDP 594 record down to the millenial scale during both glacial and interglacial intervals. At the high resolution of the RGB scan, the Site 594 climate record is pervaded by short-term fluctuations equivalent to temperature changes of ~0.2 - 1.0°C over periods of decades to centuries. These fluctuations are similar to those recorded in Earth-surface instrumental temperatures for the 19th and 20th centuries.

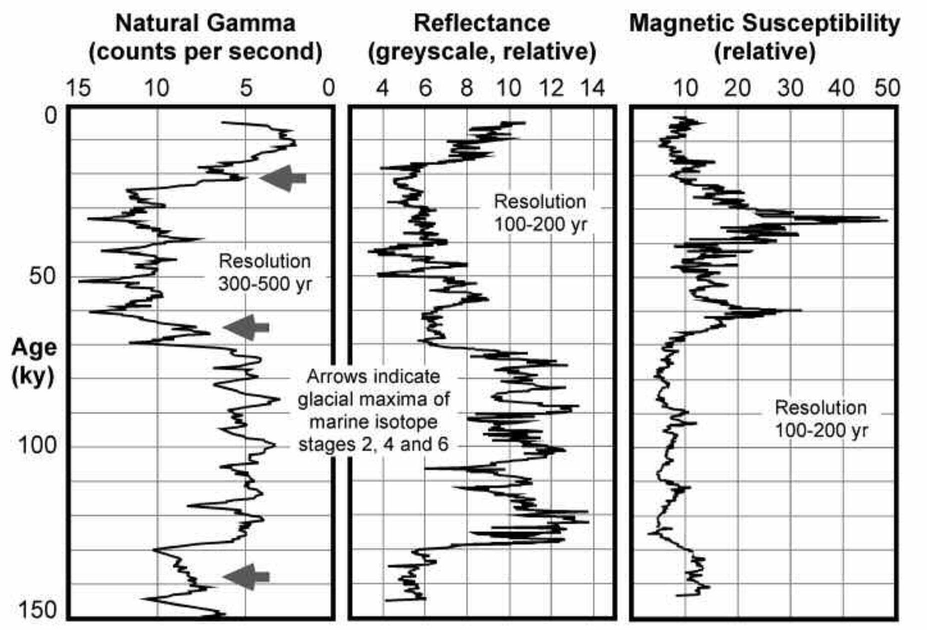

Figure 2. Core log data collected from DSDP Site 594 archive half-cores in the summer of 2004.

Re-evaluating repository core

Site 594 serves as an example of the wealth of data that remains within repository core. Many DSDP and even early ODP cores were obtained prior to the implementation of automated non-destructive core logging techniques. However, even recently obtained cores are not logged with all sensor systems at the high spatial resolutions desired for many studies due to the lack of available shipboard logging time. This is particularly true for techniques that require long measurement times (eg, natural gamma) or techniques that can measure property changes at very small spatial intervals (eg, magnetic susceptibility using a point sensor). If these data were routinely collected post-cruise at the core repository, then shipboard data collection time could be more effectively used.

This potential to return to repository core is particularly timely for two reasons. First, the main workhorse of the IODP program, the *JOIDES Resolution*, will be soon go out of service, and there will be a hiatus in regularly scheduled drilling expeditions. During the interval, scientists might formally propose IODP Expeditions to core repositories to further examine cores, take samples, and integrate data from sites cored in the same area, though not necessarily on the same drilling leg. High-resolution, nondestructive testing with the MSCL-XYZ would complement such an effort. More urgently, as core working halves become depleted, pressure is mounting to allow subsampling from the archive core-halves. Once opened to sampling, portions (generally the most interesting portions!) of these continuous records are destroyed. The community now has the tools necessary to take advantage of what could be a final chance to collect continuous geophysical data on ocean cores drilled over the past three decades.

Opportunity in 2005 at US repositories

Starting in the summer of 2005, there will be a low-cost opportunity to collect multisensor core data from archive halves stored at the IODP West Coast Repository, La Jolla, CA; the Gulf Coast Repository, College Station, TX; and the East Coast Repository, Palisades, NY. The MSCL-XYZ system, with natural gamma, color spectrophotometry, magnetic susceptibility, RGB linescan imaging, and a new IR reflectance imaging spectroscopy sensor (spectra-map.co.uk), will travel to each of these repositories. Investigators are invited to suggest archive cores to be logged. Please contact Geotek (melanie@geotek.co.uk) if you are interested in taking advantage of this opportunity to collect high-resolution data from any of your favorite sites.

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[2] *Marine Geophysical Laboratory, James Cook University, Townsville, Qld. 4811, AUSTRALIA*

Reports on recent meetings

UK IODP one-day short course 'An introduction to logging and petrophysics in IODP missions'

Tim Brewer, University of Leicester

The first UK IODP short course was held on Tuesday 7th December 2004 at the University of Leicester and dealt with logging and petrophysics in IODP missions. This course was aimed at research scientists, both graduate students and established academics, who may be users of logging and/or petrophysical data derived from IODP boreholes or wishing to use legacy data from the ODP or DSDP drilling programmes. A total of 22 people attended the meeting, covering the entire academic spectrum.

The aims of the course were to familiarise non-specialist users with the rationale, scientific background and acquisition methods employed in logging and petrophysics which may be used on all three IODP drilling platforms (i.e. riser, non-riser and mission specific drilling platforms). Through the use of case studies the second part of the workshop illustrated how such data could be applied in addressing key science questions related to individual drilling expeditions.

The programme was presented by a combination of academic and industry speakers all of whom have been or are currently involved the IODP. The morning session kicked off with a presentation from Professor Mike Lovell (University of Leicester and co-chair of the IODP Scientific Measurements Panel) providing an historical perspective on logging in Ocean Drilling and how logging and petrophysics will contribute in the future. This was followed by Dick Woodhouse (Independent Consultant and member of the UK-IODP Industrial Liaison Panel) who discussed the types of logging tools deployed in ODP and IODP expeditions, with particular emphasis on the nature of the measurements and the quality and precision of data derived from in-situ borehole measurements. The final presentation in the morning was given by Dr John Roberts (GEOTEK Ltd) and dealt with measurements on recovered core using multi-sensor track techniques. Over lunch a number of posters dealing with aspects of logging and petrophysics were available, and these were provide by the University of Leicester Borehole Research Group and GEOTEK. Also during lunch tours of the NERC sponsored Log Interpretation Centre at The University took place.

The afternoon sessions, through use of case studies, discussed the application of logging and petrophysical to enhance the science in studies of Ocean Basement (Dr Tim Brewer, University of Leicester and ECORD Since Operator), Palaeoclimate and Sequence Stratigraphy (Dr Heike Delius, University of Leicester and ECORD Since Operator) and Gas Hydrates and in particular pressure coring systems (Tim Francis, GEOTEK Ltd). From the feedback received at the meeting this was a very successful one-day meeting, and we would like to acknowledge the assistance of Janette Thompson (University of Leicester) and Heather Stewart (NERC) in developing and running this workshop. For further information on logging and petrophysics in IODP expeditions please contact Dr Tim Brewer (tsb5@le.ac.uk).

Meeting report of the Micropalaeontological Society - calcareous plankton spring meeting and the joint meeting of the silicofossil and palynology groups

Bridget Wade, Cardiff University

I had the pleasure of attending two meetings organised by The Micropalaeontological Society (http://www.tmsoc.org). These meetings brought together micropalaeon-tologists from both academic institutions and industry. Both meetings were highly successful with presentations and delegates from the UK, Europe and the rest of the world.

The Joint Meeting of Silicofossil and Palynology Groups, was held in the School of Earth, Ocean and Planetary Sciences at Cardiff University (9-10th June, 2004). This was attended by 33 people with representatives from the UK, Europe, USA and Australia. ODP and DSDP data were presented by several delegates. Sarah-Jane Jackett (Switzerland) presented low-latitude radiolarian images from ODP Site 1051A and DSDP Sites 43 and 10; Eocene / Oligocene dinoflagellate data from ODP Site 913 was presented by James Eldrett (Ichron, UK); and Henk Brinkhuis (Utrecht) and Adam Young (Cardiff) presented results from ODP Leg 189.

In Copenhagen, The Calcareous Plankton Spring Meeting (13-15th May, 2004) was attended by 45 scientists from 9 countries, with the aim of bringing together calcareous nannofossil and foraminifera groups. André Bornemann and Daniela Crudeli (Germany) presented posters of microfossil and geochemical data from DSDP Sites 534, 603, and ODP Site 1000. Joachim Schoenfeld (Germany) presented foraminiferal data from ODP Site1002. From the UK, Nadia Al-Sabouni (Royal Holloway), and Jodie Fisher (Plymouth) presented posters of foraminiferal data from Sites 926 and 762. Sabastian Meier (Natural History Museum) showed results from geochemical analysis of dinoflagellates cysts from Site 690. Results on the evolution of foraminifera from DSDP Site 214 were given by Michael Knappertsbusch (Switzerland) and on Pleistocene palaeoceanography of the South China Sea, Sites 1146, 1143 and 144 by Jian Xu (Shanghai).

The presentations at these two meetings of ODP and DSDP material emphasized its importance to studies in biostratigraphy, evolution, taxonomy and palaeoceanography for both the calcareous and siliceous microplankton groups.

Southern Ocean Drilling (Report of USSSP(JOI)-UCol-IUPUI workshop) University of Colorado, Boulder 21 - 23 January 2005

Peter Barker

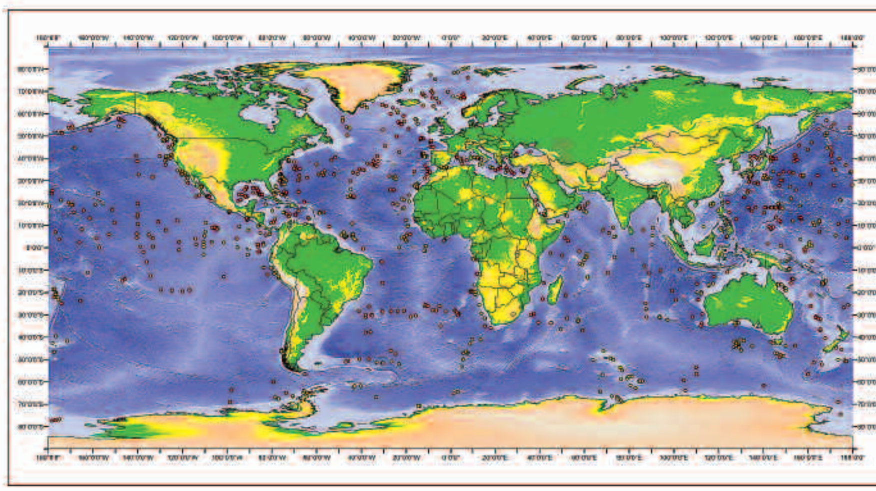

Figure 1. Illustration of the number of drill sites in the Southern Ocean, defined here as the area south of the southern capes (below ~40°S). Ten legs have visited this remote region over the history of the Ocean Drilling Program.

The Workshop aims were to summarise and celebrate the achievements of Southern Ocean drilling over the 30 years of DSDP and ODP, and to identify potential key contributions, to further understanding of global palaeoclimate, of further drilling in the region under IODP.

The Workshop was organised by Gabe Filippelli and Detlef Warnke with Jose-Abel Flores of Spain, and Tom Marchitto as local host. About 30 people attended, the majority from the USA. Peter Schultheiss (Geotek Ltd.) and I were the only UK participants.

After brief introductory statements by participants, the first morning was occupied with seven synthesis presentations, overviews of past achievements in regional palaeoclimatic and palaeoceanographic evolution and of remaining questions, ranging from the Cenozoic to the Holocene and decadal/millenial timescales. Participants then split into breakout groups on both topical and time-related themes, aiming to identify key unsolved problems that could be tackled by further drilling. After breakout group reports and plenary discussion, a final session was devoted to identifying deliverable commitments to a compendium of about 30 papers, ranging from broad, multi-author syntheses to (usually) single-author contributions on focussed research topics, intended as a resource for the next generation of graduate students.

It was clear from the syntheses and from posters presented by participants that past Southern Ocean drilling (Figure 1) had made very large contributions to our understanding of palaeoclimate, globally as well as of the far South (palaeocirculation and Antarctic glaciation), on a wide range of time scales, over some six orders of magnitude: the region is and has been both a crucial active component of global climate, and a sensitive passive recorder. However, the Workshop was more interested in future prospects. Among the key potential contributions and unsolved problems identified were (not in priority order):

1. The relative importance of ocean circulation and atmospheric greenhouse gas concentrations in influencing palaeoclimate, and the roles of orbital forcing and tectonics.
2. Many aspects of Cenozoic Antarctic glacial history, in particular the extent of early-middle Miocene deglaciation, at a time of low atmospheric pCO_2.
3. The time of onset and development of the Antarctic Circumpolar Current, and its influence (perhaps even causal influence initially) on Antarctic glaciation.
4. West Antarctic Ice Sheet history, particularly its stability during warm periods (eg Isotope Stages 11, 31, the warm Pliocene, e-m Miocene: important for the near future).
5. The high-resolution post-glacial (Holocene) climate record within basins of the inward-sloping Antarctic shelf (to improve global coverage, and for correlation with nearby continental ice-core records).
6. Lead/lag relations at Terminations (ice volume, CO_2, SST and sea-ice proxies etc), the keys to forcing.
7. Inter-hemispheric comparisons, particularly complicated at short time scales.

Current IODP Southern Ocean proposals are:

- 482. Cenozoic glacial history and sea-level change of the Wilkes Land margin, Antarctica. Escutia et al. Carried forward from ODP (ANTOSTRAT) and intended to examine the sedimentary record of the least easily glaciated region of East Antarctica - a major contribution to (2) above, and to the history of continental glaciation in general.
- 638 Ancillary. Adelaide Drift. Dunbar et al. High-res Holocene shelf section off Wilkes Land, major contribution to (5) above. Logistic link to 482.
- 625-pre. Pleistocene history of S Ocean, Pacific Sector Transect. Gersonde et al. Addresses (6) and parts of (4) and (7) above, S Pacific palaeoceanography and a wide range of Pleistocene studies.
- 634-pre. The Antarctic Circumpolar Current - origin, evolution and influence on climate and biota. Barker & Thomas. Scotia Sea region, close to final deep-water barrier. ESSEP review recommended continuation to full proposal. Addresses (3) above, with a major contribution to (1).

These were all endorsed. The meeting also advised resurrection of 489 (Eastern Ross Sea, Barrett et al: ODP/ANTOSTRAT), addressing (4), and stressed the value of close links with future non-IODP onshore and nearshore continental drilling activities (ANDRILL, SHALDRILL) in the construction of proximal-distal transects at appropriate locations around Antarctica (eg Prydz Bay, Pine Island Bay). It drew attention also to the potential value of a focus of national commitments within the upcoming International Polar Year (IPY 2007-2008).

In all, the Workshop succeeded in its aims: participants found time also for fruitful informal discussion, often difficult in larger meetings.

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 non-riser vessel, 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 any expedition is encouraged to complete an application as instructed on the ESSAC website (www.geo.vu.nl/users/essac/). Guidelines and application forms can be found under 'APPLY TO SAIL' on the ESSAC homepage. Additional information about all the expeditions can be found at www.isas-office.jp/scheduled.html and the ESSAC website.

All UK applicants must submit their application to sail to ESSAC (essac.amsterdam @falw.vu.nl), the UK IODP Science Coordinator (ukiodp@bgs.ac.uk) and Paul Wilson (Paul.Wilson@soc.soton.ac.uk). Remember to submit both digital and paper copies to ESSAC. 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 (Heather Stewart, ukiodp@bgs.ac.uk).

Drilling proposals

The Integrated Ocean Drilling Program Management International Inc. (IODP-MI) is now accepting drilling proposals. The submission of proposals gives individuals/groups of scientists the opportunity to respond to IODP's scientific priorities as expressed in the Initial Science Plan, and to recommend appropriate targets for drilling.

All submitted items *must* arrive in the IODP-MI Sapporo Office by 23:59 GMT on the semiannual deadlines of either the 1 April or the 1 October.

The IODP evaluates these proposals through a science advisory structure (SAS) and through external peer review. The science coordinators in the IODP-MI, Sapporo Office manage all aspects of the proposal submission and review process, and the ODP Site Survey Data Bank continues serving as the repository for site-survey data until further notice.

At the present time (prior to the 1 April 2005 deadline) there are 127 proposals active within IODP. In relation to the IODP Initial Science Plan categories, 61 proposals relate to environmental change, processes and effects, 38 to solid earth cycles and geodynamics and 28 proposals fall into the deep biosphere and subseafloor ocean category. These can further breakdown into 92 riser-less drilling, 17 multiple platforms, 11 mission specific platforms, 5 riser drilling and 2 complex drilling proposals.

For more information on proposal requirements and submission procedures please visit www.iodp-mi-sapporo.org/proposal.html or contact the UKIODP Science Coordinator.

Expedition Schedule

Expedition		Scheduled dates
307	Porcupine Carbonate Mounds	26 April - 31 May
308	Gulf of Mexico Overpressures	31 May - 6 July
309	Superfast Spreading 1	6 July - 24 August
310	Tahiti Sea Level	To be confirmed
311	Cascadia Gas Hydrates	24 August - 7 October
312	Monterey Bay Engineering	7 October - 24 November
313	Superfast Spreading 2	24 November - 8 January 2006

Cruise dates may be subject to modification.
For more information please visit www.iodp-mi-sapporo.org/scheduled.html

Participation

Scientists who have participated in Legs since June 2004:

Roz Coggon	SOC	Leg 301	Juan de Fuca Hydrogeology
Mike Kaminski	UCL	Leg 302	Arctic Coring Expedition
Heiko Pälike	SOC	Leg 302	Arctic Coring Expedition
Lucia de Abreu	Cambridge	Leg 303	North Atlantic Climate 1
Sasha Leigh	St Andrews	Leg 303	North Atlantic Climate 1
Andrew McCaig	Leeds	Leg 304	Oceanic Core Complex 1
Antony Morris	Plymouth	Leg 304	Oceanic Core Complex 1
Roger Searle	Durham	Leg 304	Oceanic Core Complex 1
Angela Halfpenny	Liverpool	Leg 305	Oceanic Core Complex 2

Scientists who are participating in forthcoming Legs:

Patrizia Ferretti	Cambridge	Leg 306	North Atlantic Climate 2	2 March - 26 April
Ian Bailey	UCL	Leg 306	North Atlantic Climate 2	April
Sandy Tudhope	Edinburgh	Leg 310	Tahiti Sea Level	Date to be finalised
Alex Thomas	Oxford	Leg 310	Tahiti Sea Level	Date to be finalised

Forthcoming events

Palaeoceanography and Palaeoclimate Change: announcing the following conference:

ESSAC
ECORD Science Support & Advisory Committee

Palaeoclimate Change: High-latitudes and Ocean Circulation

Thursday 2 and Friday 3 June 2005
The Geological Society of London, Burlington House

Workshop
Hosted by the UK Integrated Ocean Drilling Program (IODP), NERC, with sponsorship from IMAGES, The Tyndall Centre, RAPID, Geotek Ltd, BP, Exxon Mobil International, Fugro Robertson and Statoil.

Organisers:
Paul Wilson (Southampton Oceanography Centre), Ian Hall (Cardiff), Mike Bickle (Cambridge) and Juergen Thurow (UCL)

The aim of the meeting is to bring together the UK and ECORD community in the broad field of Palaeoceanography and Palaeoclimate Change to discuss exciting new results emerging from recent initiatives (eg, IODP drilling in the Arctic, IMAGES, RAPID) aimed at improving our understanding of extreme and rapid changes in Earth's past climate, with special emphasis on the high latitudes and ocean circulation.

This two-day meeting will take the same form as the 2001 William Smith Meeting of the Geological Society and consist of a series of invited 30 minute lectures from senior overseas and UK scientists. The list of speakers includes:

Jan Backman, Stockholm
David Beerling, Sheffield
Henk Brinkhuis, Utrecht
Rob DeConto, Massachusetts
Gerry Dickens, Rice
Bob Dickson, CEFAS
Harry Elderfield, Cambridge
Eystein Jansen, Bergen
Jochem Marotzke, Hamburg
Jerry McManus, Woods Hole
Didier Paillard, Gif-sur-Yvette
Heiko Pälike, SOC
Eelco Rohling, SOC
Stefan Schouten, NIOZ
Thomas Stocker, Bern
Paul Valdes, Bristol
Peter Wadhams, Cambridge
Rainer Zahn, Barcelona

If you would like to attend this event (for which there will be a small fee), please use our on-line registration form, which can be found on the conference website (www.nerc.ac.uk/funding/earthsci/iodpconference.shtml), to send us your details.

If you have further questions about the event please contact Charlotte Dew at NERC (IODPJUN05@nerc.ac.uk), Paul Wilson (paw1@soc.soton.ac.uk) or Ian Hall (hall@cardiff.ac.uk).

UK IODP Grants

Applicants should refer to the current conditions and eligibility requirements, which can be found on the NERC website at www.nerc.ac.uk/funding/forms/ 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/downloads/IODP_Init_Sci_Plan.pdf.

NERC IODP research grants

To support UK membership in the UK Integrated Ocean Drilling Program (IODP), 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 legs, 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.

Closing dates for applications for both small and standard grants: **1 May** and **1 November** of each year. Completed forms should be sent to NERC: they will be reviewed by external referees and assessed by the UK IODP Steering Committee.

If you would like any further information or advice please contact the Science Coordinator, Heather Stewart (ukiodp@bgs.ac.uk) or the Programme Administrator, Helen Bell (hebe@nerc.ac.uk).

UK IODP rapid response grants

IODP Rapid Response Awards are for the purpose of supporting a limited number of small-scale, short research activities specifically related to IODP Leg objectives. Rapid research grants are typically awarded to assist with initial sample processing costs or small equipment purchases related to IODP involvement. The normal limit on these Awards is £2,000, but in exceptional cases, this may be exceeded. 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 Leg Co-Chief Scientists and/or (for students) from an appropriate member of the departmental academic staff.

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 Heather Stewart (ukiodp@bgs.ac.uk) as early as possible in advance of the proposed starting date.

UK IODP urgency grants

UK-IODP Urgency grants are to allow exploitation of scientific opportunities where the normal grant application procedures are likely to be too slow. Funding will be limited to topics related to IODP-supported science, and awards considered only in exceptional circumstances. Only small sums will be considered.

Application procedures and limitations

Applications should be made using standard NERC grant application forms under the published rules for research grants. Urgency funding will be limited to only those aspects of the research which are time-limited. For example collection of data or samples during a window-of-opportunity would qualify for funding whereas support for subsequent analyses, interpretation or publication would not. The later funding would either need to be in place or be sought subsequently through the normal application process. Applications should be made with a full case justifying both the science case and the resources sought. Only those applications that are considered urgent, have a highly graded science case, and for which it is probable that resources will ultimately be available for follow-up work and publication will be funded.

Potential applicants should in the first instance contact the Science Coordinator (Heather Stewart, ukiodp@bgs.ac.uk) with a brief resume of their case to obtain guidance that an urgent application process is appropriate. Applications should then be submitted via email to the UK IODP Programme Administrator at NERC (Helen Bell, hebe@nerc.ac.uk).

Review process

Applications will be sent to 3 external reviewers, and selected members of the UK-IODP Committee will make a final decision by e-mail and/or phone communication. The Programme Administrator will oversee the application/review process and ensure that it is completed in a timely manner.

General guidelines

- As with applications to any other NERC grant scheme, applications must be led by a Principal Investigator from an eligible UK institution. All eligibility criteria are the same as for all other NERC thematic grant applications.
- Applications will be subject to peer review.
- Applications should be made using the NERC Small Grant application form, i.e. including a 2-page case for support.
- Applications can be made at anytime. However, no studentships will be awarded under this scheme, and instead such applications should be submitted to the UK IODP 1 May and 1 November grant rounds.

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.

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 IODP Special Topic grants rounds (1st May and 1st November). Application procedures (separate from the main IODP Special Topic grant rounds) 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:

- The grants will be for a maximum of £12,000 (including all overheads) 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:

- The grants will be for a maximum of £6,000 (including all overheads) 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.

IODP UK contacts

UK IODP Science Co-ordinator
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IODP Panel Members from the UK

Science Planning and Policy Oversight Committee
Mike Bickle, Department of Earth Sciences, University of Cambridge

Science Planning Committee
Julian Pearce, School of Earth, Ocean and Planetary Sciences, Cardiff University

SSEP-Interior
Damon Teagle, School of Ocean and Earth Science, Southampton Oceanography Centre

SSEP-Environment
Jürgen Thurow, Department of Earth Sciences, University College London

Technology Advice Panel
Peter Schultheiss, Managing Director, Geotek Ltd., Daventry

Scientific Measurements Panel
Mike Lovell, Department of Geology, University of Leicester

Site Survey Panel
Roger Searle, Department of Earth Sciences, University of Durham

Environmental Protection and Safety Panel
Bramley Murton, School of Ocean and Earth Science, Southampton Oceanography Centre

Useful websites

IODP Central Sites

IODP Management International Inc. - www.iodp.org/

IODP Science Advisory Structure Office - www.iodp-mi-sapporo.org/

Initial Science Plan for IODP - www.iodp.org/downloads/IODP_Init_Sci_Plan.pdf

JAMSTEC - www.jamstec.go.jp/jamstec-e/odinfo/index.html

ECORD Sites

European Consortium for Ocean Research Drilling - www.ecord.org/index.html

ECORD Science Support Advisory Committee - www.geo.vu.nl/users/essac/

IODP Implementing Organisations

JOI-Alliance US Implementing Organisation - www.oceandrilling.org/

Centre for Deep Earth Exploration (CDEX) - www.jamstec.go.jp/jamstec-e/odinfo/cdex_top.html

ECORD Science Operator - www.ecord.org/eso/eso.html

IODP Related Sites

National Science Foundation - www.nsf.gov/

European Science Foundation (ESF) - www.esf.org/

MEXT Ministry of Education, Culture, Sports, Science and Technology - www.mext.go.jp/english/

NERC - www.nerc.ac.uk/

ODP Legacy Sites

Ocean Drilling Program - www.oceandrilling.org/

Science Operator Texas A&M University - www-odp.tamu.edu/index.html

Joint Oceanographic Institutions for Deep Earth Sampling - www.whoi.edu/joides/

Joint Oceanographic Institutions, ODP Program Manager - www.joiscience.org/

ODP Wireline Logging Services - www.ldeo.columbia.edu/BRG/ODP/

UK Academic Institutions

British Antarctic Survey - www.antarctica.ac.uk/

British Geological Survey - www.bgs.ac.uk/

Bullard Labs, Cambridge - www.esc.cam.ac.uk/geophysics/geophys.html

Cardiff Earth Sciences - http://servant.geol.cf.ac.uk/

Durham Geology - www.dur.ac.uk/~dgl0www/

Edinburgh Geology & Geophysics - www.glg.ed.ac.uk/

Leicester Borehole Research Group - www.le.ac.uk/gl/re/resprofs/borehole.html

Oxford MG&G Group - www.earth.ox.ac.uk/~tony

SAMS Scottish Association for Marine Sciences - www.sams.ac.uk/

Southampton Oceanography Centre - www.soc.soton.ac.uk/

Societies And Organisations

American Geophysical Union - www.agu.org/

Challenger Society - www.soc.soton.ac.uk/OTHERS/CSMS/index.html

European Geophysical Society - www.copernicus.org/EGS/

European Union of Geosciences - http://eost.u-strasbg.fr/EUG

Geological Society of America - www.geosociety.org/

Geol Soc London - www.geolsoc.org.uk/

Hydrographic Society - www.hydrographicsociety.org/

International Hydrographic Bureau - www.iho.shom.fr/

Intergovernmental Oceanographic Commission - http://ioc.unesco.org/

Ocean US network - www.ocean.us.net/

The Royal Society - www.royalsoc.ac.uk/

Royal Astronomical Society - www.ras.org.uk/ras

Scientific Committee on Oceanic Research (SCOR) - www.jhu.edu/~scor/

Society for Underwater Technology - www.sut.org.uk/

Oceanography English website directory - www.mth.uea.ac.uk/ocean/vl/

Mid-Ocean Ridge Links

BRIDGE - http://earth.leeds.ac.uk/~bridge/

NOAA Vents Programme - www.pmel.noaa.gov/vents

RIDGE - http://ridge.oce.orst.edu/

DeRIDGE - www.palmod.uni-bremen.de/FB5/Ozeankruste/DeRidge/deridge.html

Margins Links

Stratagem - www.stratagem-europe.org/

US Margins Programme - http://doherty.ldgo.columbia.edu/margins/

NERC Marine Programmes

Autosub Under Ice Programme - www.soc.soton.ac.uk/aui

Ocean Drilling Programme (UK) - www.bgs.ac.uk/iodp/home.html and www.nerc.ac.uk/funding/earthsci/iodp.shtml

COAPEC (Coupled Ocean-Atmosphere Processes and European Climate) - www.soc.soton.ac.uk/coapec/coapec.php

Ocean Margins LINK Programme - www.nerc.ac.uk/funding/thematics/oceanmargins/

Rapid Climate Change (RAPID)- www.soc.soton.ac.uk/rapid/rapid.php

Global Ocean Mapping

GOMaP - http://mp-www.nrl.navy.mil/marine_physics_branch/gomap.htm

Notes

Expedition Schedule

Expedition		Scheduled dates
307	Porcupine Carbonate Mounds	26 April - 31 May
308	Gulf of Mexico Overpressures	31 May - 6 July
309	Superfast Spreading 1	6 July - 24 August
310	Tahiti Sea Level	To be confirmed
311	Cascadia Gas Hydrates	24 August - 7 October
312	Monterey Bay Engineering	7 October - 24 November
313	Superfast Spreading 2	24 November - 8 January 2006

Cruise dates may be subject to modification.
For more information please visit www.iodp-mi-sapporo.org/scheduled.html

Back cover: The *JOIDES Resolution* was built in Halifax, Nova Scotia in 1978 and converted in Pascagoula, Mississippi, in 1984. The *JOIDES Resolution*, is 470 feet long and 70 feet wide. The ship's derrick towers 202 feet above the waterline. A computer-controlled dynamic positioning system, supported by 12 powerful thrusters and two main shafts, maintains the ship over a specific location while drilling into water depths up to 27,000 feet.

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INTEGRATED OCEAN DRILLING PROGRAM

UK newsletter 30

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