



Annual Science Meeting 2017

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Royal Geographical Society
1 Kensington Gore, London SW7 2AR

Sponsored by



Marine Studies Group

Foreword

The UK IODP Annual Science Meeting is aimed at the UK IODP science community and is an opportunity to highlight important scientific achievements from the current IODP phase.

The UK IODP meeting is an opportunity to give the UK IODP community a chance to demonstrate the value the UK programme.

This one-day conference will cover a range of scientific themes:

- Oceans & Climate: Reading the past, informing the future
- Earth in Motion: Processes and hazards on human time scales
- Earth Connections: Deep Processes and their impact on the surface environment
- Biosphere Frontiers: Deep life and environmental forcing of evolution

The conference aims to showcase post-graduate, PhD and post-doctorate research which has made use of the extensive wealth of data collected during the varied IODP Expeditions.

Students have been encouraged to show their work using IODP data, and three of the best student posters will be awarded prizes, sponsored by the Marine Studies Group (<https://www.geolsoc.org.uk/marine>).

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Conference Programme

9:30	Coffee and Registration. Display posters.
9:55	Welcome and Introduction to the UK IODP, Damon Teagle, Chair of the UK-IODP Programme Advisory Group
10:00 – 12:50	Oceans & Climate, Session Chair: Paul Wilson
10:00	Keynote: Dick Kroon (Edinburgh) Exploring aspects of monsoon development through ocean drilling: What can we expect from the Indian Ocean ‘mission’
10:30	Mark Maslin (UCL) Can understanding the South American Monsoon system be applied globally?
10:50	Freya Mitchison (Cardiff) A geochemical exploration of cyclic calcareous sedimentation in the Eocene Indian Ocean, Exp. 362
11:05-11:45	Tea – Coffee; further poster inspection
11:45	Tom Dunkley Jones (Birmingham) Expedition 363: Neogene and Quaternary records of Western Pacific Warm Pool paleoceanography
12:00	David Bell (Edinburgh) The Plio-Pleistocene development of Atlantic deep-water circulation and its influence on climate trends.
12:20	Keynote: Jane Francis (BAS) A look ahead to IODP drilling around Antarctica?
12:50 – 14:00	Lunch, Posters, and Discussions
14:00-17:05	Earth in Motion, Deep Processes and their impact on the surface environment, Session Chair: Damon Teagle
14:00	Keynote: Julie Prytulak (Imperial) IODP 352: an <i>in situ</i> geochemical record of subduction initiation
14:30	Andrew McCaig (Leeds) No boron enrichment in subducting slab mantle: evidence from IODP Expedition 345 gabbros
14:50	Catriona Menzies (Southampton) A report from expedition 366 Mariana Convergent Margin and South Chamorro Seamount
15:05	Stephen Bowden (Aberdeen) Hydrothermal Mineralisation within the Underthrust Sediments of the Nankai Trough Outer Accretionary Prism Exp. 370
15:25-16:00	Tea – Coffee; further poster inspection
16:00	Chuang Xuan (Southampton) Millennial scale geomagnetic change during late Pleistocene recorded by IODP Expedition 339 cored sediments: implications for geodynamo behaviour and magnetic stratigraphy
16:20	Rebecca Bell (Imperial) A forward look to Hikurangi Subduction Exp. 375
16:35	Keynote: Joanna Morgan (Imperial) Chicxulub: recovery of life at ground zero
17:05 – 19:00	Closing remarks from UK-IODP PAG Chair Drinks Reception, Posters, Networking and Announcement of Best Student Poster

Abstracts for Oral Presentations

KEYNOTE: KROON, D. - EXPLORING ASPECTS OF MONSOON DEVELOPMENT THROUGH OCEAN DRILLING: WHAT CAN WE EXPECT FROM THE INDIAN OCEAN 'MISSION'

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MASLIN, M. - CAN UNDERSTANDING THE SOUTH AMERICAN MONSOON SYSTEM BE APPLIED GLOBALLY?

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The Amazon Basin represents the largest and most intense land-based convection centre on Earth and has a significant impact on extratropical atmospheric circulation. It is drained by the Amazon River, which discharges approximately 20% of all freshwater transported to the oceans and has the largest drainage basin in the world covering an area of 7 million km². Many researchers invoke changes in the seasonal positions of the Inter-tropical Convergence Zone (ITCZ) over both the oceans and continents to explain variations in neotropical rainfall patterns. This generalization is climatologically inaccurate when dealing with continental climate. Instead we should refer to the South American Summer Monsoon (SASM) system which is broadly related to the concept of the continental ITCZ and also the South Atlantic convergence zone (SACZ) theory. The large-scale trends in moisture availability across South America from both continental and ocean drilling records suggests there are two controls on the monsoonal system. First the intensity of rainfall within the SASM is driven by precessionally modulated insolation and controls overall convection strength. Second the Hemispheric temperature gradients control the position of the northern and southern boundaries of the ITCZ and thus affects the areal distribution of rainfall within the continent. Combining these two influences produces the dynamic heterogenic changes in the moisture availability observed over tropical South America since the Last Glacial Maximum. It also explains why some records suggest a wet Amazon during the LGM and others a dry Amazon. This model suggests that the effective moisture in the tropics could be a combined function of precessional modulated convection and Hemispheric temperature gradients and this view may be applicable to other monsoon systems around the World.

**MITCHISON, F. - A GEOCHEMICAL EXPLORATION OF CYCLIC CALCAREOUS
SEDIMENTATION IN THE EOCENE INDIAN OCEAN, EXP. 362**

Freya Mitchison

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A geochemical exploration of cyclic carbonate sedimentation in the Eocene Indian Ocean

DUNKLEY-JONES, T. - EXPEDITION 363: NEOGENE AND QUATERNARY RECORDS OF WESTERN PACIFIC WARM POOL PALEOCEANOGRAPHY

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Record-breaking International Ocean Discovery Program (IODP) Expedition 363 (October 6th to December 8th 2016) achieved the highest amount of sediment core recovered by any IODP Expedition, totalling 6956 m. Nine sites were cored with the IODP Research Vessel, the JOIDES Resolution, two off northwestern Australia and seven in the West Pacific Warm Pool (WPWP). These sediment cores will be used by the International science community to document the regional expression (e.g., temperature, precipitation, and productivity) and driving mechanisms of climate variability in the WPWP on millennial, orbital and geological timescales. Combining sites with rapidly accumulating sediment at marginal locations and more typical open-ocean sites with relatively low accumulation rates offers the opportunity to retrace the evolution of the WPWP through the Neogene (past 25 million years) at different temporal resolutions. Furthermore, spanning a large range of water depths, 875 - 3421 m, the sites allow reconstruction of the thermocline and intermediate water contributions from the Northern and Southern Hemispheres to the low-latitude inter-ocean exchange through the Indonesian Throughflow (ITF), as well as monitoring of water mass changes in response to tectonic- and/or climate-related processes.

References

Rosenthal, Y., Holbourn, A., Kulhanek, D.K., and the Expedition 363 Scientists, in press. Expedition 363 Preliminary Report: Western Pacific Warm Pool. International Ocean Discovery Program. <http://dx.doi.org/10.14379/iodp.pr.363.2017>

BELL, D. - THE PLIO-PLEISTOCENE DEVELOPMENT OF ATLANTIC DEEP-WATER CIRCULATION AND ITS INFLUENCE ON CLIMATE TRENDS.

David Bell
University of Edinburgh

Using benthic stable isotope records from 10 sites in the Atlantic Ocean, including two new records from Walvis Ridge in the Southeast Atlantic (Sites 1264 and 1267), we review changes in Atlantic deep-water circulation in the context of Plio-Pleistocene climate. Overall, we find non-linear responses of Atlantic deep-water circulation to a cooling climate, with differently evolving glacial and interglacial states. Our main conclusion is that peak North Atlantic Deep Water (NADW) production was reached between ~ 2.0 and 1.5 Ma, most prominently seen by a maximum in ventilated (high $\delta^{13}\text{C}$) conditions in the mid-depth Southeast Atlantic (Site 1264). We infer that a major source of NADW at this time was the export of dense overflow water from the Nordic Seas into the abyssal East Atlantic. Sea surface temperature records from the North and South Atlantic support this notion and indicate that the peak NADW production between ~ 2.0 and 1.5 Ma was compensated by a stronger warm surface-water return flow (i.e. Atlantic Meridional Overturning Circulation (AMOC) was enhanced), causing long-term (>105 year) heat piracy from the South to the North Atlantic. In the wider picture of Plio-Pleistocene climate evolution, we find that a long-term enhancement in the average state of AMOC (~ 2.4 –1.3 Ma) coincides with the “41-kyr world”. Hence, we speculate that the transitory negative feedback response of enhanced AMOC to a cooling climate supplied heat to key areas of ice-sheet growth, acting to limit their size and maintain the “41-kyr world”. Once a threshold in global cooling was reached, the strength of AMOC lessened, providing a positive feedback for the Early-Middle Pleistocene Transition and the associated build-up of northern hemisphere ice-sheets.

FRANCIS, J. - KEYNOTE: A LOOK AHEAD TO IODP DRILLING AROUND ANTARCTICA

Jane Francis
British Antarctic Survey

Antarctica plays a critical role in the whole global system, especially through sea level change, atmospheric conditions and ocean circulation. It is the place on Earth most sensitive to global change and is where change happens first, as it has in the past and is happening today. Understanding future change requires accurate reconstructions of past environments and climates, especially of ice sheets and glaciers, yet most of Antarctica's history is buried beneath the present ice cap.

The geological history of Antarctica is being reconstructed through IODP drilling programmes along the margins of the continent, where sedimentary basins contain windows into Antarctica's past. Building on recent successful drilling programmes, a new suite of cruises is planned around Antarctica over the next few years. These will provide new insights into the continent's evolution from a green forested land millions of years ago to its glacial state today.

PRYTULAK, J. - KEYNOTE: IODP 352: AN IN SITU GEOCHEMICAL RECORD OF SUBDUCTION INITIATION

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MCCAIG, A. - NO BORON ENRICHMENT IN SUBDUCTING SLAB MANTLE: EVIDENCE FROM IODP EXPEDITION 345 GABBROS

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Whole rock boron content and boron isotope data are presented from lower crustal olivine gabbros and troctolites altered by seawater in the vicinity of fault zones from IODP Expedition 345 to Hess Deep. Much higher values of both [B] (up to 30 ppm) and $11\text{B}/10\text{B}$ (up to +25.6 per mil) are observed than in previous studies of gabbros from the Oman and Troodos ophiolites. It is inferred that seawater derived boron was incorporated into serpentine, chlorite, saponite and prehnite-rich alteration assemblages. These data are considered to be relevant to bend-fault serpentinisation at subduction zones, where a one-pass model of downward fluid movement driven by the hydration reaction of olivine to serpentine has been suggested. Simple calculations show that in this model, all the boron would be sequestered into the crust, and none would reach the serpentinised upper mantle of the downgoing slab. For significant boron to enter the slab mantle, multipass hydrothermal circulation is required as demonstrated by slot models of thermal convection. This may occur in long-lived transform faults. Even using Oman values for [B] in gabbros, very little boron can enter the mantle at bend faults, and the slab mantle is not therefore the source of boron in arc volcanics, as suggested by some recent models.

MENZIES, C. - A REPORT FROM EXPEDITION 366 MARIANA CONVERGENT MARGIN AND SOUTH CHAMORRO SEAMOUNT

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Geological processes at subduction zone margins control seismicity, plutonism/ volcanism, and ocean-crust-mantle geochemical cycling. The down-going plate experiences dehydration, fluid release and associated metamorphism alters the physical properties of the plate interface. The Mariana convergent margin is non-accretionary, and serpentinite mud volcanoes in the pervasively faulted forearc permit sampling of fluids and materials from the subducting slab and forearc mantle. IODP Expedition 366 drilled into three serpentinite mud volcanoes: Yinazao (13 km depth-to-slab); Fantangisña (14 km) and Asùt Tesoru (18 km), allowing comparison with the previously drilled South Chamorro (18 km) and Conical (19 km) seamounts. The shallowest depth-to-slab seamounts are associated with Ca and Sr enriched, but otherwise solute poor, low alkalinity fluids of pH ~11, at equilibrium with gypsum. The Asùt Tesoru seamount fluids are markedly higher in both Na and Cl, as well as in species like B and K which are associated with the breakdown of slab sheet silicate phases, and are dramatically depleted in Ca and Sr. Higher DIC at this site is attributed to slab carbonate decomposition, while the observed elevated pH (up to 12.5) is likely caused by serpentinization reactions during which released iron is oxidised, producing H₂ and OH⁻. Asùt Tesoru porefluids are similar to those studied at South Chamorro and Conical Seamounts, but display distinctly higher Na and Cl, and 3-4 times lower B contents. Changes in chemistry between sites reflect changes in metamorphic prograde reactions on the downgoing plate with increasing depth (P-T°). At shallowest depths sediment compaction and opal CT dehydration dominate; intermediate depths are characterised by clay diagenesis and desorbed water release; and at greater depths decarbonation and clay decomposition are dominant.

BOWDEN, S. - HYDROTHERMAL MINERALISATION WITHIN THE UNDERTHRUST SEDIMENTS OF THE NANKAI TROUGH OUTER ACCRETIONARY PRISM EXP. 370

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Sedimentologist 370 Expedition Scientists Yes Drilling of sediments in the Nankai subduction zone contributed much to the current knowledge of accretionary prisms and the site can be considered well characterized. However, the deeper regions of the prism remain sparsely explored and the circulation of deep fluids and their possible impact on mineralising processes and the deep biosphere is not well known. Here we present the evidence for epithermal mineralisation within the underthrust sediments of the Nankai accretionary prism, recovered from International Ocean Discovery Program Expedition 370 Site C0023. Distinctive mineralisation is only found in the underthrust domain and can be found as veins and stratabound mineralised intervals, comprising carbonate (rhodochrosite, calcite, dolomite) and sulphate minerals (anhydrite, baryte) surrounded by alteration halos containing newly formed smectite. Fluid inclusion homogenisation temperatures indicate mineralising fluids with temperatures 40 to 80 °C hotter than estimated present-day temperatures at that depth. Numerical modeling of heat flow within the vicinity of veins indicates that thermal effects last only a few days, and that mineralisation halos should be confined to thermal aureoles around veins. This latter prediction is consistent with both visual observations and X-ray computed tomography of the core. Mineralisation in underthrust sediments therefore suggest that seismic activity generates distinctive but short duration geochemical and thermal effects, and moves hot fluids into a deep already high-temperature sedimentary habitat where it has the potential to shape the deep subsurface biosphere.

XUAN, C. - MILLENNIAL SCALE GEOMAGNETIC CHANGE DURING LATE PLEISTOCENE RECORDED BY IODP EXPEDITION 339 CORED SEDIMENTS: IMPLICATIONS FOR GEODYNAMO BEHAVIOUR AND MAGNETIC STRATIGRAPHY

Chuang Xuan

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Palaeomagnetic analyses were performed on continuous u-channel samples collected from the top few tens of meters of sediments cored during Integrated Ocean Drilling Program (IODP) Expedition 339 to the west Iberian Margin. We analysed natural remnant magnetisations (NRM) and a suite of laboratory-induced magnetisations of the samples at every 1-cm interval resolution on a superconducting rock magnetometer, before and after stepwise alternating field (AF) demagnetisation. NRM demagnetization data of the samples reveal a very stable and well-defined primary magnetisation component. Chronology of the “Shackleton Site” U1385 is well constrained (with millennial scale accuracy) and tied to the polar ice cores as well as the absolutely dated Asian speleothem records. We export the Site U1385 chronology to other study sites through unambiguous correlation of millennial scale variabilities in X-ray fluorescence core scan data. Relative palaeointensity (RPI) records of the study sites, when placed on the acquired age models, can be well correlated to a list of RPI records from the North Atlantic and from worldwide on time scales of ~10 kyr. These RPI records also show multi-millennial scale possibly regional variabilities (at high-resolution) observed in other records from the Portuguese Margin and from the North Atlantic. In addition, RPI features recorded at higher sedimentation rate sites appear slightly younger (a few hundreds to a couple of thousand years), possibly due to effects of the sediment magnetisation lock-in process.

BELL, R. - A FORWARD LOOK TO HIKURANGI SUBDUCTION EXP. 375

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Unlocking the secrets of slow slip- Hikurangi Subduction Margin drilling. Expedition 375, March
2018

MORGAN, J. - KEYNOTE: CHICXULUB: RECOVERY OF LIFE AT GROUND ZERO

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The recovery of marine life following the Cretaceous-Paleogene mass extinction was geographically heterogeneous, both in terms of species richness and primary production. Some data suggest that proximity to the impact site correlates with slower recovery, implying an environmental cause for delayed recovery. If this is correct, we might expect recovery at the impact site to be particularly slow and unusual. Expedition 364 drilled into the peak ring of the Chicxulub impact basin which, shortly after impact, was a local topographic high ~300 m above the crater floor and covered by a few hundred metres of sea water. The crater rocks (impact breccias) are covered by an 80-cm transitional layer and early Paleocene limestones. This presentation will look at the recovery of life through the transitional layer and earliest Paleocene.

Abstracts for Poster Presentations

BERTRAM ET AL., - SEQUENCE OF PLIOCENE DEGLACIAL EVENTS IN EAST ANTARCTICA AND THEIR WIDER IMPLICATIONS

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The extent of the Antarctic ice sheet was reduced during warmer-than-present times throughout the Pliocene (5.3 to 2.6 Ma). Such variations in ice volume resulted in changes to sea level, ocean circulation and ultimately global heat transfer. For example, increased Antarctic glaciation in the Late Pliocene has been invoked to explain global cooling, culminating in Northern Hemisphere Glaciation. However, detailed studies on the Pliocene dynamics of the large East Antarctic ice sheet are scarce. In particular, high resolution records from the East Antarctic margin are needed to unravel the sequence of waxing and waning ice dynamics, their magnitude, and the timescales involved. In order to provide detailed insight into the sequence of Pliocene deglacial events, here we present provenance analyses on Pliocene-aged detrital marine sediment recovered from offshore of the Wilkes Subglacial Basin (IODP Expedition 318, U1361A). Detrital marine sediment was analysed for strontium and neodymium isotopes, which have been shown in previous studies to be effective tracers for sediment provenance changes and, by inference, ice dynamics in this region. Our new high resolution study spanning orbital scale cycles in the Pliocene confirm substantial retreat of the ice margin during warm phases of the Pliocene. For the first time, we can tentatively suggest that deglacial provenance shifts occurred gradually over timescales on the order of a few millennia. This geological evidence corroborates the timescales of East Antarctic ice sheet retreat suggested by recent modelling studies for both the Pliocene and future warming scenarios. Our high resolution sampling also provides novel insights into the concatenation of events during ice retreat in the Wilkes Subglacial Basin. A distinct increase in the amount of iceberg rafted debris (IBRD counts) predates shifts in sediment provenance (detrital radiogenic isotope records) and ocean productivity (XRF scan records) during Pliocene retreat events, providing geological support for large scale ice margin retreat. Furthermore, this sequence of events suggests that upon ice retreat, the changed provenance of sediments may have played a critical role in releasing bioavailable iron into the Southern Ocean, thereby adding to increased ocean productivity during warm conditions. In order to link these events to a broader view of East Antarctic ice sheet dynamics and its role in the onset of Northern Hemisphere Glaciation, we will compare our results from offshore of the Wilkes Subglacial Basin with a new Plio-Pleistocene record of ice dynamics from the Ross Sea (CIROS 2, Ferrar Glacier).

CROCKER ET AL. - ORBITALLY PACED HISTORY OF THE SAHARA REVEALED BY 11 MILLION YEARS OF DUST FLUX TO THE ATLANTIC CROCKER

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The Sahara is the largest hot desert on Earth and the source of about half of the world's atmospheric dust, which acts to modify the global atmospheric energy balance and fertilize photosynthetic productivity in the Atlantic Ocean and Amazon Basin. However, the timing and cause(s) of the inception of the present Saharan hyper-aridity are poorly constrained. Here, we present a high-resolution reconstruction of the accumulation and geochemistry of dust exported from North Africa over the past 11 Million years from ODP Site 659, situated off the northwest African coast, underneath the major summer Saharan dust plume today. We record a long history of Sahara Desert expansion and contraction paced by Earth's orbit of the Sun that overrides major changes in background climate state. Our data contradict suggestions both of a landmark birthdate for the Sahara Desert associated with either the intensification of northern hemisphere glaciation (~2.7 Myr ago) or deposition of aeolian dunes in the Djurab (~7 Myr ago) and of a gradual unabated transition to increasingly arid conditions in North Africa. Instead, we observe a jump in rainfall during favourable orbits ca. 6.5 Myr ago, coincident with the origin of Mega-Lake Chad, lasting until late in the Pliocene epoch (~3.5 Myr ago) and attributable to increased monsoon sensitivity to insolation forcing. Leaf wax biomarker records show a close coupling between the sensitivity of the North African monsoon to insolation forcing and expansion of C4 savanna ecosystems.

CURRINGTON ET AL. - ANATOMY OF THE OLDEST KNOWN HEINRICH EVENTS IN MIS 16 AT SITE IODP1308

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Marine Isotope Stage (MIS) 16 represents one of the largest glaciation of the Quaternary, consisting of the Donian glaciation in Europe. It also marks the start of dynamic behaviour of the Laurentide Ice Sheet through Hudson Strait expressed in North Atlantic sediments as Heinrich layers. We studied IODP Site U1308 (re-occupation of Site 609) in the central North Atlantic to document the first two recorded Heinrich events that occurred near the end of MIS 16. Similar to Heinrich events of the last glacial period, H16.1 and 16.2 were marked by razor-sharp bases, abundant detrital carbonate grains, and low abundance of planktonic foraminifers. However, planktonic foraminiferal assemblages were noticeably warmer during H16.1 and 16.2 than those of their last glacial counterparts and contain rare, but well-preserved, temperate foraminifera (*G. bulloides* & *G. inflata*). Between H16.2 and 16.1, two distinctive silicate-rich peaks of IRD were recorded consisting of well-rounded grains of diverse lithology in the coarsest sediment fraction (>1 mm), perhaps reflecting ice incorporation in coastal region. Quartz dominates in the finer sediment fractions. Although the source of these IRD events awaits completion of Sr and Nd isotope analysis, they may be derived from multiple ice sheets and contain substantial contributions from Eurasia. The older event postdates H16.2 and the younger predates H16.1 with a period of high carbonate content and low IRD between the silicate-rich IRD peaks. The silicate-rich events appear to be closely related to H16.1 and 16.2, however they are not as simple as the precursor events proposed for the last glacial Heinrich events, whereby instability of European ice sheets were suggested as a trigger for Heinrich events. Increased roundness of coarser grains in the silica-rich events, and potential better sorting, suggest not only that these events originated from a different source than the Heinrich events, but that sea-ice may have played a role in the transport of IRD, in addition to ice-bergs.

FELDER - INVESTIGATING THE EXPRESSION OF THE MID-PLEISTOCENE TRANSITION IN THE MARGINAL BASIN OF THE SEA OF JAPAN, USING MARINE SEDIMENTS FROM IODP SITE U1427

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A high-resolution, multi-proxy study from the southern Sea of Japan (IODP Exp. 346) The amplitude and frequency of global climate cyclicity shifted from 41 to 100 ka during the mid-Pleistocene transition (MPT, ~1.2-0.6 Ma), crucially without changes in orbital parameters. This suggests internal feedback mechanisms must have caused the change in the Earth's climate dynamic. While no agreement has been reached on what these feedbacks are, multiple drivers have been proposed, including variations in the Asian monsoon intensity. Long-term records across the MPT at a resolution high enough to record variations in the Asian monsoon are few. However, the newly recovered sediments from IODP Site U1427, located in the southern part of the Sea of Japan, offer a chance to examine monsoon variations. The site experienced high and constant sedimentation rates, has good foraminifera preservation and lies underneath the main branch of the Tsushima Warm Current (TWC), a current whose strength is closely linked to freshwater input via the Yangtze River. Fluctuations in Asian monsoon intensity control the river runoff and, in turn, the strength of the TWC and the amount of freshwater and nutrients entering the Sea of Japan. Here, we present geochemical records across the MPT at Site U1427, including $\delta^{18}O$ of benthic foraminifera (*Uvigerina* spp.), and organic and inorganic carbon content and compare these to shipboard data. The proxies show a distinct pattern prior and post the MPT: From 1.2 to 0.91 Ma there is little correlation between our proxies, while between 0.91 and 0.7 Ma our proxy data show close correlation with each other. These data suggest a change in the behaviour or in sensitivity to regional climatic and oceanographic changes. The shift in this relationship is concomitant with the "900 ka event" identified by Elderfield et al. (2012), who suggested this as a global cooling event possibly with enhanced terrigenous input.

FOX ET AL. - DEVELOPMENT OF THE ASIAN MONSOON AND BIOTIC RESPONSE IN THE BAY OF BENGAL: RESULTS FROM IODP EXPEDITION 354

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International Ocean Discovery Program (IODP) Expedition 354 drilled an E-W transect of seven sites on the Lower Bengal Fan at 8° N to investigate the interactions between the uplift of the Himalayas and development of the Asian Monsoon. The climates of Asia are affected significantly by the extent and height of the Himalayan Mountains and the Tibetan Plateau. Uplift of this region began about 50 Myr ago, and further significant increases in altitude of the Tibetan Plateau are thought to have occurred through the Miocene and more recently. However, the climatic consequences of this uplift remain unclear. Given that the present day monsoon brings large changes in precipitation to the Bay of Bengal, one way to characterize this is by reconstructing of past $\delta^{18}\text{O}$ of sea surface water, which is linked to salinity and temperature. IODP Sites U1450 and U1451 recovered material from a succession of late Miocene to Recent distal turbidites. The sediments predominantly consist of sand, silt and clay with occasional bioturbated calcareous clays containing varying proportions of foraminifera. These calcareous clays are thought to represent hemipelagic sedimentation during channel-levee inactivity, and were sampled for this study. We generated paired records of surface and deep $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ from benthic and planktonic foraminifera. We use benthic $\delta^{18}\text{O}$ to constrain the biostratigraphic age model produced on the ship, and surface water changes to put constraints on the possible long-term evolution of surface water salinity from the late Miocene to Pleistocene.

FYFFE, BOWDEN - NATURALLY OCCURRING TRANS-FATTY ACIDS WITHIN THE IHEYA NORTH HYDROTHERMAL FIELD IODP EXPEDITION 331

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The Iheya North Hydrothermal Field is an ideal location for studying the interactions between a hydrothermal system driven by magmas of felsic-intermediate composition and organic matter bearing sediments of terrigenous-autochthonous origin. The purpose of this research is to determine whether or not trans-fatty acids are produced naturally within hydrothermal systems and to reproduce these findings under hydrothermal conditions in a laboratory setting. This was achieved by taking chromatographic data from samples throughout the hydrothermal system for comparison with industry standard samples, and by running a series of experiments using industry standard samples and key hydrothermal minerals to identify suitable mineral catalysts. Trans-fatty acids were found to be present within samples from multiple sites throughout the Iheya North Hydrothermal Field. Experimental data shows that some sulphide minerals are capable of functioning as catalysts for producing trans-fatty acids under simulated hydrothermal conditions. These findings show that the conditions for hydrogenation processes can be met within hydrothermal systems. Trans-fatty acids are forming naturally in potentially significant quantities as oceanic water circulates through hydrothermal ridges, a natural occurrence of what was previously thought to be producible only through industrial processes.

GRANT - TRANSITION FROM THE GREENHOUSE CLIMATE SYSTEM THAT DOMINATED THE MESOZOIC AND EARLY EOCENE INTO THE ICEHOUSE CLIMATE OF THE CENOZOIC

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Transition from the greenhouse climate system that dominated the Mesozoic and early Eocene into the icehouse climate of the Cenozoic is perhaps best represented by analysis of the Oligocene climate system. Calcareous nannofossil assemblages have been analysed in order to observe the response of these surface dwelling organisms to changes in surface productivity. ODP leg 199, Site 1218 was situated at the palaeoequatorial Pacific during the Oligocene, therefore, representing a high productivity area situated within the equatorial upwelling zone. Fluctuations are recorded in the planktonic $\delta^{13}\text{C}$ at eccentricity (100kyr) timescales, indicating orbitally induced changes in upwelling intensity and nutrient supply to low latitudes. The highest abundance of eutrophic taxa (particularly *C. floridanus*) coincides with both a positive $\delta^{18}\text{O}$ excursion of 1.21‰ and the extinction of *Paragloborotalia opima*. This study has revealed that calcareous nannofossils only show a clear response to changes in $\delta^{13}\text{C}$ during times of either particularly intense upwelling, or times of increased nutrient supply. Abundance of eutrophic taxa at times of high surface $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ indicate low latitude productivity during cooling. Strengthening of the production of SAMW due to cooling associated with the MOGI is believed to be the primary driver of increasing nutrient supply to the equatorial Pacific at this time.

HOLMSTRÖM ET AL. - THE NORTH ATLANTIC SIGNATURE OF THE EOCENE-OLIGOCENE TRANSITION

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Results from benthic foraminiferal stable isotopes at IODP Site U1411 The onset of continent-wide Antarctic glaciation during the Eocene-Oligocene Climate Transition (EOT; ~34 Ma) marks a fundamental reorganisation of Earth's climate system from a greenhouse to an icehouse state. The EOT is characterised by a two-step increase in benthic foraminiferal $\delta^{18}\text{O}$ and a synchronous transient increase in $\delta^{13}\text{C}$, alongside the first appearance of ice-rafted debris in the Southern Ocean. This evidence has been interpreted to reflect contemporaneous deep-sea cooling, ice growth, and carbon cycle changes across the transition. However, many previously drilled EOT sections are highly condensed or suffer from hiatuses in the important boundary interval. This limits our understanding of the structure and timing of the transition, especially in the North Atlantic Ocean where continuous sequences have not been previously identified. This study utilises drillcores recovered at Integrated Ocean Drilling Program (IODP) Site U1411 (Exp. 342, Newfoundland Sediment Drifts), situated in the Northwest Atlantic on the Southeast Newfoundland Ridge. The EOT section at Site U1411 is highly expanded relative to most deep-sea sequences and stratigraphically complete. The sediments are also clay-rich which has resulted in excellently preserved calcareous microfossils. We report an initial coarse resolution benthic foraminiferal $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ isotope stratigraphy spanning the EOT (~34.5 to 32.5 Ma). A distinct positive ~0.9‰ shift in $\delta^{18}\text{O}$ is observed at the base of Chron C13n (33.7 Ma), corresponding to the second globally recognised $\delta^{18}\text{O}$ step at the EOT. Benthic $\delta^{13}\text{C}$ also increases by ~0.6‰ at the base of C13n. This increase is preceded by a prominent negative $\delta^{13}\text{C}$ excursion of 0.5‰ at ~34.3-34.1 Ma. Higher resolution data are needed to fully resolve the EOT benthic isotope stratigraphy at Site U1411, and future work will focus on generating a record with sub-orbital resolution. This will allow us to assess the timing, duration and stratigraphy of the EOT as well as the role of the North Atlantic in the development of the Antarctic ice-sheet.

INWOOD - A SYNTHESIS OF RESEARCH CARRIED OUT BY RESEARCH ASSOCIATES AT THE UNIVERSITY OF LEICESTER ON VARIOUS IODP EXPEDITIONS (INCLUDING ALL RECENT MSP EXPEDITIONS)

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JEWELL ET AL. - SURFACE OCEAN CHANGES AT ODP LEG 108 SITE 659 DURING THE PLIO-PLEISTOCENE AND LINKS WITH NORTH AFRICAN HYDROCLIMATE

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The Sahel region in North Africa has one of the largest inter-annual rainfall variability ranges in the world, and yet the future of this rainfall variability over the next century is extremely uncertain: numerical simulations disagree even about the sign of predicted change. The region is also home to millions of some of the poorest in the world, providing a strong incentive to improve our understanding of the drivers of rainfall variability. The geological record demonstrates that North Africa has undergone many major past oscillations between arid and humid conditions. At the orbital time scale, we observe a strong response to insolation forcing paced by the precession of Earth's orbit. Yet during minima in eccentricity modulation, the coupling between North African hydroclimate and insolation forcing appears to weaken, resulting in prolonged humid conditions that persist over several precessional cycles. Furthermore, at millennial time scales North African hydroclimate is shown to be sensitive to sea surface temperatures in the North Atlantic Ocean, for example during Heinrich events. Here we present stable isotope records of planktic foraminiferal calcite from ODP Site 659. This site is located on the Northwest African margin and is ideally situated for assessing changes in the hydrography of the subtropical Atlantic and North African hydroclimate. Our study suggests that while changes in the hydrography of the subtropical North Atlantic are generally synchronous with obliquity paced insolation forcing, an extended interval of warm and/or fresh sea surface conditions may have played a role in maintaining the eccentricity-forced extended humid period observed in North Africa at ~2.4 Ma.

**JING ET AL. - THE EXTINCTION OF PALEOGENE PLANKTONIC FORAMINIFERA
OPPORTUNIST TURBOROTALIA AMPLIAPERTURA**

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To determine the timing and casual mechanism for the extinction of the Paleogene planktonic foraminifera species *Turborotalia ampliapertura*, we analyzed the abundance changes in ~24 samples from Integrated Ocean Drilling Program Expedition 320/321 Site U1334 (eastern equatorial Pacific Ocean). We show that the abundance of *Turborotalia ampliapertura* decreased significantly in the early Oligocene (Chron C12r), more than one million years before its extinction in Chron C11r. The timing of the extinction at Site U1334 is compared to Deep Sea Drilling Project Sites 558, 522 and 516.

LYMER ET AL. - RECOGNITION AND UNDERSTANDING OF HYPER-EXTENSION AT RIFTED MARGINS

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The recognition and understanding of hyper-extension at rifted margins worldwide has been driven by observations at the Galicia margin, west of Spain. An important feature of the margin is the S reflector, which has been interpreted as the crust-mantle boundary, the brittle-ductile transition, or a detachment fault. The importance of the Galicia margin in understanding the process of rifting to breakup led to the submission in 2008 of IODP proposal 740-Full, which focused on determining the timing of fault movements and an analysis of the kinematics and rate of rifting, information critical to test current numerical models of breakup. Among the principal recommendations of the SSEP was that the proposal should be revised once the Galicia3D seismic data had been acquired, processed and evaluated. As all previous surveys across the Galicia Margin are two-dimensional, the three-dimensional aspects of the hyperextension processes are unconstrained. The 3D data, measuring 68.5x20km and recorded to 14s TWT, were collected in 2013 (Rice University led) and have now been processed (Birmingham led) through to 3D prestack time migration followed by iterative depth conversion based on wide-angle velocities. The 3D depth volume can now be used to identify optimum drilling targets at the classic magma-poor margin. Key results of the 3D volume show that the organisation of the crustal blocks is far more variable (along strike) than expected in terms of size, geometry and period of activity. Interpretation of the S reflector reveals a series of corrugations, highlighting its role as a detachment and providing data on the kinematics during rifting. The mapping of the fault network and the faults heaves suggest that several faults were active simultaneously during the extension, thus requiring a modification of 2D models that support only one fault being active at any one time. Finally, we show that the detachment fault was active at low angles, which demonstrate the weakness of the underlying serpentinitized mantle. In order to constrain the nature of the structures observed in seismic and the timing of deformation processes, we now aim to use the exceptional high resolution provided by the 3D data to propose an IODP expedition across the Galicia margin, complementing previous drilling expeditions (leg 103 and Legs 149 and 173 further south). Proposed targets include: the syn-rift sequence, to constrain the ages and, critically, the rates of rifting and sedimentation in order to calibrate the interpretation of fault movement; the nature of the basement above the S, not yet sampled by drilling; the detailed anatomy of the Peridotite Ridge: Legs 149 and 173 demonstrated that simple interpretations are incorrect; and potentially the S detachment itself, a challenging target as in most places the S is buried deep below the crust.

MAHONY ET AL. - DSDP, ODP, IODP GLOBAL TEPHRA DATASET

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In order to develop a more complete picture of global volcanism, the entire IODP visual core description (VCD) resource was searched to identify tephra occurrences back through time. In 2018 this global compilation of all visible tephra layers identified in the shipboard VCDs of all ocean drilling programs cores will be published and made available to the community in an IODP Technical Note. There are data on over 30,000 volcanic ash layers, collected from 3,582 drill holes, representing 414,208 km of core. Records from every drill hole where material was described were searched for mentions of tephra. Every tephra occurrence has information on its form (layer vs. patch), the depth of the base and top, thickness, calculated age, as well as any descriptive notes. The ages are calculated using the most up to date age-depth model where available. For more information or to join the dataset mailing list, please email sue.mahony@bristol.ac.uk.

MINTON ET AL. - PRODUCING A HIGH-RESOLUTION RECORD OF STABLE ISOTOPES AND BIOTIC RESPONSE DURING THE LATE MIDDLE MIOCENE (FROM ~13.3 MA – 10.5 MA) FOR THE EASTERN EQUATORIAL PACIFIC

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The purpose of the research is to produce a high-resolution record of stable isotopes and biotic response during the late middle Miocene (from ~13.3 Ma – 10.5 Ma) for the eastern equatorial Pacific. Following a period of global warmth from ~15-17Ma (mid Miocene climate optimum), the long-term Cenozoic cooling trend resumed with a sharp step at ~13.8Ma (mid Miocene climate transition). The gradual cooling through the late middle and late Miocene is not as well studied as more dramatic warm intervals and cooling steps in the climate record. Mechanisms driving gradual cooling are still inadequately understood and reliable sea surface temperature estimates are required for comparison with data derived from benthic foraminifera and other climate proxies to gain further insight into ocean/atmosphere conditions and forcing mechanisms. There are currently very few high-resolution records derived from planktonic foraminifera for this interval. Site U1338 (Expedition 321) represents part of the IODP Pacific Equatorial Age Transect. The cores recovered consist of ~415m of biogenic carbonate sediments deposited within 2° of the equator from 4200m water depth; they date 0-17Ma with mid-late Miocene deposition rates estimated at 20-30m/Myr (Pälike et al., 2010). This study is in its very early stages but aims to produce a multi-species record of planktonic foraminiferal geochemistry (principally based on oxygen and carbon isotopes and Mg/Ca), as well as examining the relationship between apparent slow climate cooling and planktonic foraminiferal evolution.

MORGAN - UK IODP KNOWLEDGE EXCHANGE

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NICHOLS ET AL. - LATE PLEISTOCENE MEDITERRANEAN OUTFLOW WATER VARIABILITY: PRELIMINARY RESULTS AND AGE MODEL

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Mediterranean outflow water (MOW) has been shown to be a significant modulator of Atlantic meridional overturning circulation (AMOC), particularly, during periods of Atlantic freshening where the saline outflowing water preconditions AMOC for re-instating more vigorous overturning. Sites U1391, U1390 and U1385 (the “Shackleton Site”) were occupied on Integrated Ocean Drilling Program (IODP) Expedition 339 to the southwest Iberian margin. In combination, they provide an excellent opportunity to explore the relationship between MOW and AMOC strength during millennial scale climate perturbations and over differing glacial and interglacial settings back to ~400ka, where this relationship is relatively unexplored. Magnetic grain size changes at Sites U1391 and U1390 approximate flow strength variations in the lower limb of the MOW. Preliminary data, presented here, from Site U1391 of the last ~63kyr shows a promising palaeoclimatic signal with evidence of Heinrich events and co-variability between magnetic and X-ray fluorescence (XRF) grain size proxies. These records are being extended back to ~400ka to incorporate a more diverse range of climatic backdrops. A well constrained chronostratigraphy already exists for Site U1385 which can be transferred to Site U1391, utilising the strong correlation of Ca/Ti and magnetic susceptibility between the two sites. XRF records and environmental magnetic data from Site U1391 is interpreted in terms of varying MOW strength and will be compared with those from Site U1390 and nearby deeper Site U1385, that is less likely to be under the direct influence of MOW. Our records will be compared to other published MOW reconstructions in order to capture the spatial variability of MOW through time. These analyses greatly facilitate our understanding of the nature of MOW’s relationship with AMOC.

**PEARSON ET AL. - EXPEDITION 363 INDO-PACIFIC WARM POOL
BIOSTRATIGRAPHY: SHIPBOARD SYNTHESIS AND SOME INITIAL POST-CRUISE
RESULTS**

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This poster presents summaries and initial age: depth plots for the sites drilled on Expedition 363: U1482, U1483, U1484, U1485, U1486, U1487, U1488, U1489, and U1490. Preliminary post-cruise data on high resolution coiling patterns in the planktonic foraminifer *Pulleniatina* from one site (U1486) are presented and discussed. Other planned post-expedition work is described.

PORCHIER, ANAND - THE STRENGTH OF THE INDIAN SUMMER MONSOON IN THE ANDAMAN SEA (IODP EXP353 SITES U1447 & U1448)

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The Indian Monsoon influences the lives of billion of people. This meteorological phenomenon can impact people living in its area of occurrence by causing floods and droughts. The Indian Summer Monsoon (ISM) is believed to have started due to a complex interplay of tectonic and climate through interaction of land^{1,2} (via the orographic effect), ocean and atmosphere. Therefore, understanding the evolution of the ISM in terms drivers and impacts on climate and regional tectonics is critical. Global climate model are used to predict the variability of the ISM in the future. However, paleoclimate data are needed in order to quantify how and when the present day monsoon evolved, how it has subsequently developed and how it has varied through time. Here we will present data from two IODP sites in the Andaman Sea. This study will test the current knowledge of the ISM intensification around 8Ma due to change in vegetation³ while other oceanic data in the Arabian Sea⁴ proposed an intensification around 12 and 13 Ma. We will present results for mass accumulation rates, change in percent terrestrial content, calcium carbonate, organic fraction as well as element ratio.

TAYLOR ET AL. - THE EOCENE-OLIGOCENE TRANSITION IN THE EASTERN EQUATORIAL PACIFIC

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Low sedimentation rates and incomplete core recovery in many pelagic sequences drilled by the (Integrated) Ocean Drilling Program have hindered our ability both to resolve the sequence of events leading up to the Eocene-Oligocene Climate Transition (EOT; ~34 Ma) and to differentiate between regional- and global-scale environmental changes in response to earliest Oligocene glaciation. The benchmark benthic foraminiferal stable isotope stratigraphy for the EOT comes from ODP Site 1218 (Coxall et al., 2005; Coxall and Wilson, 2011) and is characterised by a two-step transition in benthic oxygen isotopes ($\delta^{18}\text{O}$) signifying the development of sustained continental-scale Antarctic glaciation and a closely coupled carbon cycle perturbation. Yet carbonate contents are low and inter-sample assemblage variability is high in sediments of latest Eocene age at Site 1218, meaning that these benthic $\delta^{18}\text{O}$ records are not monospecific. Furthermore, the occurrence of a non-calcareous ‘dead zone’ immediately below the stepwise increase in $\delta^{18}\text{O}$ prohibits full documentation of the series of events leading up to the establishment of a sustained ice cap on Antarctica. Here we present preliminary monospecific epifaunal benthic stable isotope stratigraphies from more stratigraphically expanded and carbonate-rich IODP Sites U1334 and Site U1333, together with newly acquired high-resolution x-ray fluorescence (XRF) records. The carbonate content of uppermost Eocene strata at Sites U1334 and U1333 does not fall to the very low levels recorded at Site 1218, making it possible to improve upon published records by developing more continuous and monospecific stable isotope stratigraphies. Cyclic variations in carbonate content occur throughout the latest Eocene across all three sites but the magnitude of ~% CaCO_3 variability at Site U1334 (~2-70 wt%) far exceeds that at Sites 1218 (~0-30 wt%) and U1333 (~1-60 wt%). Variations in lithophile element ratios are synchronous among Sites U1334, U1333 and 1218, but our preliminary benthic stable isotope records suggest a different EOT benthic oxygen isotope structure to that observed at Site 1218, despite a comparable $\delta^{13}\text{C}$ stratigraphy. Collectively, these three drill sites from the equatorial Pacific present an opportunity to develop the most comprehensive record to date of stratigraphic and palaeoceanographic change across the most pivotal climate event of the Cenozoic.

TEAGLE ET AL. - THE OMAN DRILLING PROJECT - QUANTIFYING HYDROTHERMAL ALTERATION IN THE LOWER OCEAN CRUST

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Studies of ridge processes at sea have always been complemented by onshore investigation of ophiolites. Although it is apparent that ophiolites are not identical to Pacific Ocean crust, studies of obducted blocks of crust and upper mantle formed at spreading ridges have formed a vital touchstone used for interpreting geophysical data and sparse samples from dredging and drilling in the context of idealized crustal sections and hypotheses about along-strike variation. In a recent, ambitious example of this dialectical relationship, a significant proportion of the ocean ridge community is currently focused on the Samail ophiolite in Oman, the largest and best exposed slice of ocean crust and its underlying mantle preserved on-land. Phase 1 of the IODP Oman Drilling Project has just ended, with 1500 m of diamond drill hole recovered from the lower crust and mantle of the Samail ophiolite, with scientific ocean drilling quality core characterisation having just been completed aboard the D/V Chikyu. The combination of excellent 3-dimensional exposures, decades of meticulous field geology, wireline geophysical logs, and 100% rates of core recovery provides exceptional new opportunities to understand and quantify the processes operating in ophiolites and the ocean ridges. New facilities such as continuous X-ray tomography, core scanning XRF, and near visible infrared scanning available aboard Chikyu have been used at scale for the first time and enable objective quantification of features to complement traditional visual core description, sampling and analysis. The huge amount of data generated by these new techniques necessitates new machine learning approaches of data analysis and verification. The Oman Drilling Project observations provide a unique opportunity to quantitatively integrate drill cores, wireline logs, and outcrop observations, and master techniques for future deployment in scientific ocean drilling.

THOMAS, HODELL - CHANGES IN PALAEO DEEP-WATER OXYGEN CONCENTRATIONS ALONG THE IBERIAN MARGIN ACROSS THE MID-PLEISTOCENE TRANSITION USING A BENTHIC CARBON ISOTOPE GRADIENT PROXY

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Deconvolution of the benthic oxygen isotope signal at Site 1123 into its temperature and seawater components suggests an abrupt increase in glacial ice volume occurred at 900 ka (MIS 24-22) during the MPT. At the same time, neodymium and carbon isotopic evidence suggests a major change occurred in deep-water circulation. Benthic $\delta^{13}\text{C}$ values are among the lowest at many sites during MIS 22-24, suggesting increased carbon storage in the deep sea. This should have affected atmospheric CO_2 and indeed lower values of glacial CO_2 have been observed after 900 ka. To study the changes in nutrient regeneration and apparent oxygen utilization across the MPT we used a recently calibrated stoichiometric proxy for palaeoxygen based on the carbon isotope gradient between epifaunal *Cibicides wuellerstorfi* and infaunal *Globobulimina affinis* on the Iberian Margin (Hoogakker et al., 2015). We have thus far measured, from MIS 30 to 22, the $\delta^{13}\text{C}$ of these two species at Site U1385 (“Shackleton site”) from cores obtained during IODP Expedition 339. Sharp decreases in the $\delta^{13}\text{C}$ gradient are observed at terminations 26/25, 24/23 and throughout much of MIS 22 suggesting oxygen concentrations as low as 135 $\mu\text{mol kg}^{-1}$, similar to values obtained for values observed during some Heinrich events (Hoogakker et al., 2015). Further work is needed to assess whether there was a step change in glacial deep-sea oxygen concentrations at 900 ka.

ZINDORF ET AL. - THE OXYGEN DEFICIENT ZONE IN THE GULF OF ALASKA RECORDED BY MARINE ANAMMOX BIOMARKERS AND TRACE METALS (IODP SITE U1419)

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In the modern Gulf of Alaska, an oxygen deficient zone (ODZ) occurs in water depths of 670 to 1060 m. Under current climatic conditions, this ODZ is most pronounced during spring and autumn and disappears in summer. While its modern behaviour is well constrained, the extent and intensity of this ODZ in the past is not well understood. Improved understanding of ODZ behaviour is, however, important for the cycling and burial of bioavailable carbon and nitrogen as the biogeochemical conditions in an ODZ can promote enhanced burial of carbon into the sediments, but also the loss of nitrogen to the atmosphere. The latter process of nitrogen loss is facilitated by anaerobic ammonium oxidation (anammox), which only takes place under suboxic to anoxic conditions. With the BHT-isomer (bacteriohopanetetrol-stereoisomer), the microorganisms performing anammox leave a distinct biomarker in the sediments. This biomarker is well preserved compared to other anammox proxies (e.g., ladderanes) and while BHT is produced by a broad range of microbes, the BHT-isomer is only produced by anammox bacteria. The ratio between BHT and BHT-isomer can, therefore, be used as a reliable proxy for anammox under suboxic-anoxic conditions in the overlying water column at the time of deposition. Another commonly used proxy to reconstruct past water column oxygenation is the accumulation of specific redox-sensitive trace elements, such as Cr, Cu, Mo, Ni, U and V. These elements get enriched in sediments deposited under reducing waters as well. We here present the application of this BHT-isomer for new high-resolution sediment record from the continental slope off SW Alaska (IODP Expedition 341, Site U1419) that provides a 50 ka archive of paleo-redox conditions. The BHT-isomer displays significant variability and partly very high concentrations, indicating periods of sub- or anoxic conditions in the overlying water column. These fluctuations are in phase with northern hemispheric climate as recorded by NGRIP ice core $\delta^{18}O$. Elemental ratios such as Cr/Al, Cu/Al, Mo/Al, Ni/Al, U/Al and V/Al do not show the same pattern in the respective sediment intervals. However, these proxies can be affected by authigenic mineral formation due to changes in sedimentary redox conditions in the course of early diagenesis. This leads to redistribution of these elements in the sediment column which impacts their usefulness as paleo-redox proxies. Furthermore, high sedimentation rates at Site U1419 likely prevented the efficient enrichment of trace elements but lead to a good preservation of the biomarker signal at the same time. Therefore, the BHT-isomer ratio appears to be a robust proxy for water column oxygenation and much better suited than the accumulation of redox-sensitive trace elements under the depositional conditions that prevailed at Site U1419 during the past 50 ka.

List of Attendees

Dr	Rebecca	Bell	Imperial College London
	Rachel	Bertram	Imperial College London
	Jerome	Blewett	University of Bristol
	Stephen	Bowden	University of Aberdeen
Prof	Paul	Bown	University College London
	Anieke	Brombacher	University of Southampton
	Natalie	Cheng	University College London
Dr	Leon	Clarke	Manchester Metropolitan University
	Rosalind	Coggon	University of Southampton
Dr	Anya	Crocker	University of Southampton
	Abbie	Currington	University of Cambridge
	Sarah	Davies	University of Leicester
Dr	Alex	Dickson	Royal Holloway University of London
Dr	Tom	Dunkley Jones	University of Birmingham
Dr	Ake	Fagereng	Cardiff University
	Sonja	Felder	Newcastle University
Prof	Rachel	Flecker	Bristol University
Dr	Lyndsey	Fox	The Natural History Museum
Prof	Jane	Francis	British Antarctic Survey
	Symone	Fyffe	University of Aberdeen
	Marise	Gorton	University of Bradford
	Lewis	Grant	University College London
	Maria	Gusarevich	Imperial College London
	Max	Holmström	University of Southampton
Dr	Gordon	Inglis	University of Bristol
Dr	Jennifer	Inwood	University of Leicester
	Amy	Jewell	University of Southampton
	Song	Jing	Cardiff University
	Kirstin	Johnson	British Geological Survey, UK IODP Science Coordinator
	Lorna	Kearns	University of Southampton
	Hojung	Kim	University College London
	Nicola	Kirby	University of Southampton
	Dan	Knight	NERC
Prof	Dick	Kroon	University of Edinburgh
	Marcin	Latas	University College London
	Harold	Leah	Cardiff University
	Rachael	Lem	University of Plymouth
Dr	Juan	Liu	Oxford University
Dr	Gael	Lymer	University of Birmingham
Dr	Sue	Mahony	University of Bristol
Dr	Christian	März	University of Leeds
Prof	Mark	Maslin	University College London
Dr	Andrew	McCaig	University of Leeds
	Andrew	McIntyre	Open University
Dr	Catriona	Menzies	University of Southampton
	Paul	Minton	University College London

	Freya	Mitchison	Cardiff University
Dr	Maryline	Mleneck-Vautravers	Godwin Laboratory for Paleoclimate Research
Prof	Joanna	Morgan	Imperial College London
Dr	Sally	Morgan	UK IODP
Dr	Cherry	Newsam	University College London
	Matthew	Nichols	University of Southampton
Dr	Uisdean	Nicholson	Heriot-Watt University
	Emma	Ownsworth	Durham University
	Sophie	Page	Imperial College London
Prof	Martin	Palmer	Southampton University
Prof	Paul	Pearson	Cardiff University
	Albertine	Pegrum-Haram	Imperial College
Prof	Kevin	Pickering	University College London
Dr	Jennifer	Pike	Cardiff University
	Cecile	Porchier	The Open University
	Naomi	Pratt	Imperial College London
Dr	Julie	Prytulak	Imperial College London
Prof	Stephen	Roberts	University of Southampton
	Libby	Robinson	University of Southampton
Dr	Stuart	Robinson	University of Oxford
Dr	Mike	Rogerson	University of Hull
	Claire	Routledge	University College London
	Ritwika	Sengupta	University of Oxford
Dr	Zvi	Steiner	University of Cambridge
	Jessica	Surma	NERC
	Ze	Tao	University College London
	Vicki	Taylor	University of Southampton
Prof	Damon	Teagle	University of Southampton
	Nicola	Thomas	University of Cambridge
Dr	Alexandra	Turchyn	University of Cambridge
Dr	Tina	van de Flierdt	Imperial College London
Prof	Bridget	Wade	University College London
	Stephen	Watkins	Imperial College London
Dr	Jessica	Whiteside	University of Southampton, National Oceanography Centre Southampton
	Chuang	Xuan	University of Southampton
	Chin	Yik	
Dr	Jeremy	Young	University College London
	Mark	Zindorf	Newcastle University
Dr	Paul	Wilson	University of Southampton, National Oceanography Centre Southampton

Glossary

www.iodp.org/acronyms/

ACORK	Advanced Circulation Obviation Retrofit Kit
ADP	Amphibious Drilling Project
AGU	American Geophysical Union
ANZIC	Australia-New Zealand IODP Consortium
APL	Ancillary Project Letter
BCR	Bremen Core Repository
BoG	Board of Governors
CAPES	Coordination for the Improvement of Higher Education Personnel (Brazil)
CDEX	Center for Deep Earth Exploration
CDP	Complex Drilling Projects
CEREGE	Centre Européen de Recherche et d'Enseignement des Géosciences de l'Environnement
CIB	Chikyu IODP Board
CORK	Circulation Obviation Retrofit Kit
CPP	Complementary Project Proposal
DOI or doi	Digital Object Identifier
DSDP	Deep Sea Drilling Project
D/V	Drilling Vessel
ECORD	European Consortium for Ocean Drilling Research
EDP (old)	Engineering Development Panel (SAS)
EFB	ECORD Facility Board
EMA	ECORD Management Agency
EPC	European Petrophysical Consortium
EPSP	Environmental Protection and Safety Panel (SAS)
ESO	ECORD Science Operator
ESSAC	ECORD Science Support and Advisory Committee
ETF (old)	Engineering Task Force
FB	Facility Board (e.g. ECORD and JOIDES <i>Resolution</i> FB's; Chikyu IODP board (CIB))
GCR	Gulf Coast Repository
HSE	Health, Safety and Environment
ICDP	International Continental Scientific Drilling Program
IIS-PPG	Industry-IODP Science Program Planning Group
ILP	Industry Liaison Panel (ECORD)
IO(s)	Implementing Organization(s)
IODP	International Ocean Discovery Program (2013-2023)
IODP	Integrated Ocean Drilling Program (2003-2013)
IODP-MI	Integrated Ocean Drilling Program – Management International

ISP	Initial Science Plan
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JANUS	USIO Database System
J-CORES	Japanese Database System
J-DESC	Japan Drilling Earth Science Consortium
JOI	Joint Oceanographic Institutions, Inc.
JOIDES	Joint Oceanographic Institutions for Deep Earth Sampling
JR	JOIDES <i>Resolution</i>
JRFB	JOIDES Resolution Facility Board
JRSO	JOIDES Resolution Science Operator
IGC	International Geological Congress
KCC	Kochi Core Center Repository
KIGAM	Korea Institute of Geoscience and Mineral Resources
K-Pg	Cretaceous-Paleogene
LDEO	Lamont-Doherty Earth Observatory
LIMS	Laboratory Information Management System
LTBMS	Long-Term Borehole Monitoring System
LUBR	Leicester University Borehole Group
LWD	Logging while drilling
MDP	Multi-phase Drilling Project
MEXT	Ministry of Education, Culture, Sports, Science, and Technology (Japan)
MOST	Ministry of Science and Technology (People's Rep. of China)
MSP	Mission Specific Platform
Mw	Moment magnitude
NanTroSEIZE	Nankai Trough Seismogenic Zone Experiment
NERC	Natural Environment Research Council (UK)
NJGS	New Jersey Geological Survey
NSF	National Science Foundation (USA)
ODP	Ocean Drilling Program
OTF (old)	Operations Task Force (SAS)
PANGAEA	Publishing Network for Geoscientific & Environmental Data
PDF	Portable Document Format
PEP	Proposal Evaluation Panel (SAS)
PI	Primary Investigator
POC	Platform Operations Costs
POOH	Pull Out Of Hole
RCB	Rotary Core Barrel
SAS	Science Advisory Structure
SASEC (old)	Science Advisory Executive Committee (SAS)

SCIMPI	Simple Cabled Instrument for Measuring Parameters In-situ
SEG-Y	Seismic data (designated Y) file in the Society for Exploration Geophysicists' (SEG) "standardized" format
SEP	Science Evaluation Panel
SIO	Scripps Institution of Oceanography
SIPCom	Science Implementation and Planning Committee (SAS)
SOC	Science Operating Costs
SCP	Site Characterization Panel (SAS)
SPC (old)	Science Planning Committee (SAS)
SSDB	Site Survey Data Bank
SSEP (old)	Science Steering and Evaluation Panel (SAS)
SSP (old)	Site Survey Panel (SAS)
SSO	Science Support Office
STP (old)	Scientific Technology Panel
TAP (old)	Technology Advice Panel
TP	Technology Panel (SAS)
USAC	United States Advisory Committee for Scientific Ocean Drilling
USIO	United States Implementing Organization
USSAC	United States Science Advisory Committee
USSSP	United States Science Support Program
WDC-MARE	World Data Center - Marine
WOW	Wait On Weather

Useful Websites

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

ECORD SITES

European Consortium for Ocean Research Drilling (ECORD) - www.ecord.org

ECORD Science Support Advisory Committee – www.essac.ecord.org

IODP Central Sites

IODP Management International Inc. - www.iodp.org

Science Plan for IODP (2013-2023) - <http://www.iodp.org/science-plan-for-2013-2023>

JAMSTEC - www.jamstec.go.jp/chikyu/eng/index.html

IODP Science Advisory Structure - www.iodp.org/sas

IODP IMPLEMENTING ORGANISATIONS

Centre for Deep Earth Exploration (CDEX) –

www.jamstec.go.jp/chikyu/eng/index.html

ECORD Science Operator - www.eso.ecord.org

JOI-Alliance US Implementing Organisation - www.iodp-usio.org

IODP Core Repositories:

Bremen Core Repository (BCR) (Germany); Gulf Coast Core Repository (GCR) (US); Kochi Core Repository (KCC) (Japan). Access through central IODP website: <http://www.iodp.org/repositories>

Access data and samples: <http://www.iodp.org/access-data-and-samples>

IODP NATIONAL OFFICES

Canada - <http://www.iodpcanada.ca/>

Finland - <http://iodpfinland.oulu.fi/>

France - www.iodp-france.org/

Germany - www.iodp.de/

Italy - <http://www.iodp-italia.cnr.it/index.php/it/>

Netherlands - www.iodp.nl/

Portugal - <http://e-geo.ineti.pt/ecord/>

Spain - <http://carpe.usal.es/~iodp/>

Sweden - <https://www.ssdp.se/>

Switzerland - www.swissiodp.ethz.ch

IODP China – www.iodp-china.org/chs/

IODP Korea - www.kiodp.re.kr

IODP Australia and New Zealand - <http://iodp.org.au/>

IODP India - <http://www.ncaor.gov.in/iodps>

IODP Brazil - <https://www.capes.gov.br/bolsas/programas-especiais/iodp/>

IODP Related Sites

Consortium for Ocean Leadership - <http://www.oceanleadership.org/> ; and

<http://www.oceanleadership.org/scientific-programs/scientific-ocean-drilling/>

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

Japan Drilling Earth Consortium (J-DESC) – www.j-desc.org/

International Continental Scientific Drilling Program (ICDP) - www.icdp-online.org/contenido/icdp/front_content.php

Lamont Doherty Earth Observatory - www.ldeo.columbia.edu

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

National Science Foundation - www.nsf.gov

Natural Environment Research Council - www.nerc.ac.uk

USSSP U.S. Science Support Program - www.ussp-iodp.org

ODP Legacy Sites

Joint Oceanographic Institutions for Deep Earth Sampling - www.ifm-geomar.de

Consortium for Ocean Leadership - www.oceanleadership.org/

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

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

Mid-Ocean Ridge Links

InterRidge Office - www.interridge.org

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

DeRIDGE - www.deridge.de

Margins Links

HERMES (hotspot ecosystem research on the margins of European seas) - www.eu-hermes.net/

US Margins Programme - www.nsf-margins.org/

NERC Marine Programmes

Joint Climate Research Programme - www.nerc.ac.uk/research/programmes/jointclimate/

Oceans 2025 - www.nerc.ac.uk/research/programmes/oceans2025/

RAPID - www.nerc.ac.uk/research/programmes/rapid/

Technology Proof of Concept - www.nerc.ac.uk/research/programmes/technologypoc/

Completed NERC Marine Programmes

Autosub Under Ice (AUI) Programme - www.nerc.ac.uk/research/programmes/autosubunderice/

COAPEC (Coupled Ocean-Atmosphere Processes and European Climate) -
www.nerc.ac.uk/research/programmes/coapec/

Ocean Margins LINK Programme - www.nerc.ac.uk/research/programmes/oceanmargins/

Surface-Ocean/Lower-Atmosphere Study (SOLAS) -
www.nerc.ac.uk/research/programmes/solas/