NERC SCIENCE OF THE ENVIRONMENT

UK IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM
scientific ocean research drilling

Annual Science Meeting 2016

15th November 2016

Royal Geographical Society
1 Kensington Gore, London SW7 2AR

Contents

Conference Programme

9:30	**Coffee and Registration. Display posters.**	
9:55	**Welcome and Introduction to the UK IODP** by the Chair of the UK-IODP Programme Advisory Group	**Damon Teagle**
10:00 – 12:00	**Earth in Motion (CHAIR: Damon Teagle)**	
10:00	KEYNOTE: Overview of IODP Expedition 362. The Sumatra Seismogenic Zone – the role of input materials on shallow seismogenic slip and forearc development	**Lisa McNeill**
10:30	The diagenetic evolution of marine sediments influenced by a tectonically induced deep aquifer (IODP Expedition 341, Site U1417)	**Mark Zindorf**
10:45	Subduction of high relief seafloor driving sediment accretion: a seamount flexural moat origin for the Osa Melange, Costa Rica	**Alex Clarke**
11:00	The South Atlantic Transect:A proposed Multidisciplinary IODP Investigation along a Crustal Flow-line across the Western Flank of the Southern Mid-Atlantic Ridge	**Rosalind M. Coggon**
11:15	Physical properties of oceanic lower-crustal and upper-mantle rocks from Atlantis Massif, Mid-Atlantic Ridge	**Gaye Bayrakci**,
11:30	KEYNOTE: The nature of the intrusive crust and Moho at slower spreading ridges: SloMo Leg 1	**Chris J. MacLeod**
12:00	**Lunch, Posters, and Discussions**	
13:00 – 16:00	**Oceans and Climate (CHAIR: Bridget Wade)**	
13:00	KEYNOTE: South African Climates: Highlights from IODP Expedition 361	**Ian Hall**
13:30	Maldives Monsoon - biostratigraphy of a carbonate drift system	**Jeremy Young**
13:45	Oligocene-Miocene Transition in the North Atlantic Interrupted by Warming: New Records from the Newfoundland Margin, IODP Expedition 342	**Richard Smith**
14:00	Late Pliocene onset of sedimentary anoxia in the deep North Atlantic	**David Naafs**
14:15	**Tea – Coffee; further poster inspection**	
15:00	Southern hemisphere climate change during Cretaceous OAEs: new insights and new possibilities	**Stuart A. Robinson**
15:15	Geological evidence for Late Pleistocene variability of the East Antarctic Ice Sheet?	**David Wilson**
15:30	KEYNOTE: IODP-ICDP Expedition 364: Drilling the Chicxulub impact crater	**Joanna Morgan**
16:00 – 17:30	**Closing remarks from UK-IODP PAG Chair** **Reception and Announcement of Best Student Poster**	

Abstracts for Oral Presentations

KEYNOTE: OVERVIEW OF IODP EXPEDITION 362. THE SUMATRA SEISMOGENIC ZONE – THE ROLE OF INPUT MATERIALS ON SHALLOW SEISMOGENIC SLIP AND FOREARC DEVELOPMENT

L. McNeill[1], B. Dugan, K. Petronotis, and the Expedition 362 Scientists

1 Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton, Southampton, UK

IODP Expedition 362 was designed to sample the input section of the Indian oceanic plate that evolves into the North Sumatran subduction zone, the source of the 2004 Mw 9.2 earthquake and tsunami that devastated coastal communities around the Indian Ocean. Specifically, the expedition targeted the sedimentary and rock materials and their evolutionary pathways upon deeper burial on approach to and within the subduction zone to determine a) why seismogenic slip was unexpectedly shallow, increasing the magnitude of the earthquake and tsunami, and b) how the material properties contribute to the evolution of the unusually large and distinctive forearc plateau. The correspondence between the 2004 rupture location and the overlying prism plateau, as well as evidence for a strengthened input section, suggests the input materials are key to driving the distinctive slip behavior and long-term forearc structure. Secondary objectives were to determine the history of Nicobar fan deposition, with links to regional orogenics and monsoon history, and the state of stress of the oceanic plate. This subduction zone is an example of subduction/accretion of a thickened submarine fan sequence, not typically targeted by IODP subduction drilling due to challenges of deep target depths and sand-rich materials.

Expedition 362 was extremely successful, in spite of the loss of 11 days operational time due to a mechanical failure. During the expedition, two sites on the Indian oceanic plate ~250 km southwest of the subduction zone, Sites U1480 and U1481, were drilled, cored, and logged to a maximum depth of 1500 meters below seafloor, in water depths of ~4200 m. Primary holes at both sites were cased to ~750 mbsf in order to reach the deeper section, and significant operational time was gained by drilling in the casing. Site U1480 sampled the full sedimentary sequence and oceanic basement, with partial logging of the upper section. Site U1481 sampled the 1150-1500 mbsf sedimentary section, after drilling down following approval by EPSP, and the entire section was successfully logged with an expanded triple-combo logging string. Large total penetration depths (maximum 5678 m), good core recovery (average 54%) and successful wireline logging to TD within challenging, partially unconsolidated submarine fan materials were very significant achievements. Post-cruise research is a critical part of this expedition: experimental and modeling studies will utilize samples and material properties from the expedition to predict how the mechanical, thermal, compositional, diagenetic and hydrogeological properties of the input section will evolve as the section is more deeply buried and reaches higher pressures and temperatures. As a result of the operational success and predicted post-cruise potential, all of the primary objectives can be met and only the secondary objective of assessing in situ stress conditions of the oceanic plate cannot be fully met due to the lack of image logs, although core paleo-stress analyses can be integrated with existing seismic and seismological datasets. The results will be relevant to our understanding of how and where shallow sesimogenic slip occurs, of fundamental importance to controls on earthquake and tsunami magnitude and to our understanding of fault slip behaviour in general, and to the potential hazards at other subduction zones built from submarine fan sequences, such as the Makran and Lesser Antilles.

We wish to extend our sincere thanks to the entire ship’s crew and IODP staff involved with Expedition 362 for making it such a success.

THE DIAGENETIC EVOLUTION OF MARINE SEDIMENTS INFLUENCED BY A TECTONICALLY INDUCED DEEP AQUIFER (IODP EXPEDITION 341, SITE U1417)

Mark Zindorf & IODP Expedition 341 Scientists

The contact of sulphate- and methane-containing pore-waters in marine sediments (the sulphate-methane transition zone, SMTZ), is a key environment for deep subsurface microbial life and hotspot for the formation of authigenic minerals: Pyrite formation is directly driven by bacterial sulphate reduction and hydrogen sulphide generation during anaerobic oxidation of methane (AOM). Carbonate formation is directly driven by the generation of alkalinity during AOM. Barite formation is resulting from the gradient in pore-water sulphate concentrations. While SMTZs are very common in marine sediments, IODP Site U1417 in the Gulf of Alaska exhibits a remarkable diagenetic pattern: A ~250m wide gap exists between sulphate depletion and methane enrichment. While no SMTZ can be found under present conditions, enrichments of pyrite indicate that such zones have existed in the past. Highly indurated authigenic carbonate-cemented sand layers were partly recovered right above the methane-producing zone, likely preventing continued upward methane diffusion. At the bottom of the sediment succession, a deep aquifer provides sulphate-rich pore-waters and installs an SMTZ at the lower boundary of the methanogenic zone. Calculated accumulation times for authigenic minerals in the deep SMTZ are on the same order of magnitude as the onset of subduction-related bending of the Pacific Plate. We suggest that the deep aquifer is recharged through faults generated by plate bending – a process that has been investigated with respect to subducting plate hydration, but has never been put into context with subsurface microbial activity. Reactive transport modelling is an effective tool to reconstruct the diagenetic history of a sediment succession, and to link it to depositional influences. Our study combines modelling tools and inorganic geochemical data to reveal the complex interplay between primary sedimentary deposition and the input of electron acceptors by the deep aquifer, and their impact on diagenetic evolution and mineral precipitation at Site U1417.

SUBDUCTION OF HIGH RELIEF SEAFLOOR DRIVING SEDIMENT ACCRETION: A SEAMOUNT FLEXURAL MOAT ORIGIN FOR THE OSA MELANGE, COSTA RICA

Alex Clarke, Paola Vannucchi and Jason Morgan; all of us at Royal Holloway, University of London.

The Osa Mélange, together with the Osa Igneous Complex, comprise an accreted igneous terrane located in southwest Costa Rica that forms the forearc of the erosive Middle America Subduction Zone at the depth of seismic nucleation. The tectonic setting in which this mélange formed remains unconstrained with both the ocean trench (DiMarco et al., 1995; Buchs et al., 2009) and seamount flanks (Vannucchi et al., 2006) considered. This mélange is highly heterogeneous and consists predominantly of deformed debris avalanche deposits interlayered with pelagic sediment, and up to 800 metre thick blocks of brecciated basalt with Galapagos seamount affinity (Hauff et al. 1997, 2000; Hoernle et al. 2002). No material derived from the Central American arc or forearc was found. Detailed microstructural, petrological and geomechanical analysis has been conducted on this material in order to characterise its physical properties and constrain its model of formation. Both the brecciated basalts and clastic sedimentary rocks exhibit considerable brecciation and cataclasis not confined to discreet shear zones. This results in the large blocks themselves possessing a pervasive block-in-matrix texture, with comminuted fracture-fill as the mechanical matrix. Extensive hydrothermal alteration of the basalts has also contributed to the deformation of this material. The high sediment volumes and lack of blocks exotic to the Farallon Plate indicate deposition in an oceanic setting, adjacent to a seamount train, and away from the continental margin. We therefore propose that the Osa Mélange was formed in the flexural moat of a Galapagos hotspot-derived seamount complex. Subduction erosion — a process whereby material is removed from the hanging wall of the subduction zone as it migrates upwards — leads to the active entrainment of Osa Mélange material into the plate boundary interface of the Middle America Subduction Zone. Characterising the inputs into this subduction zone is necessary to understand the processes operating at the depth of seismic nucleation — a major objective of the IODP CRISP project. Our improved understanding of the parameters of seismic and aseismic slip within the Middle America Subduction Zone may be extrapolated to other erosive subduction zones around the world.

THE SOUTH ATLANTIC TRANSECT: A PROPOSED MULTIDISCIPLINARY IODP INVESTIGATION ALONG A CRUSTAL FLOW-LINE ACROSS THE WESTERN FLANK OF THE SOUTHERN MID-ATLANTIC RIDGE

Rosalind M. Coggon, Robert S. Reece, Gail L. Christeson, Mark Leckie, Brandi Kiel Reese, Damon A.H. Teagle, William P. Gilhooly III, Jason Sylvan, Nicholas W. Hayman, James Zachos, Brandon R. Briggs, Clifford Heil, Matthew Huber, Julia S. Reece, Svenja Rausch, John Kirkpatrick, Michelle Harris, Debbie Thomas, Miriam Katz, Christopher Lowery

DSDP Leg 3 drilled a transect of sediment holes across the western flank of the southern Mid-Atlantic Ridge to demonstrate that the basal sediment age increased with distance from the ridge, proving the theories of seafloor spreading and plate tectonics. During Leg 3 the sediments were only spot-cored, but revealed moderate to excellent preservation of the CaCO3 microfossils required to generate high-fidelity proxy data for paleoceanographic reconstructions. Given dramatic advances in drilling technology and analytical capabilities since Leg 3, many high priority scientific objectives could be addressed by revisiting the Leg 3 transect. We therefore propose a multidisciplinary IODP transect through the Leg 3 area at ~31 °S, to recover complete sediment sections and the upper 150-250 m of 7, 15, 31, 48 and 63 Ma ocean crust. This transect will simultaneously address multiple IODP Science Plan Challenges, maximizing the scientific output of the drilling effort.

The proposed transect, which follows a crustal flow-line from the slow/intermediate-spreading Mid-Atlantic Ridge, will fill critical gaps in our sampling of intact in-situ ocean crust with regards crustal age, spreading rate, and sediment thickness. These sections are required to investigate the history of the low-temperature hydrothermal interactions between the aging ocean crust and the evolving South Atlantic Ocean, and quantify past hydrothermal contributions to global geochemical cycles (Challenge 10). The transect traverses the hitherto unexplored sediment- and basalt-hosted deep biosphere beneath the South Atlantic gyre, samples of which are essential to refine global biomass estimates and investigate microbial ecosystems' responses to variable conditions in a low energy gyre and aging ocean crust (Challenges 5 and 7). The transect is also located near World Ocean Circulation Experiment (WOCE) line A10, providing access to records of carbonate chemistry and deep-water mass properties (e.g., temperature and composition) across the western South Atlantic through key Cenozoic intervals of elevated atmospheric CO2 and rapid climate change. Reconstruction of the history of the deep western boundary current and deep-water formation in the Atlantic basins will yield crucial data to test hypotheses regarding the role of evolving thermohaline circulation patterns in climate change, and the effects of tectonic gateways and climate on ocean acidification (Challenges 1, 2 and 4 of the Science Plan).

We propose two operational plans: Plan A can be accomplished in a single expedition; our preferred Plan B includes the installation of re-entry cones at each site to establish legacy boreholes for future basement hydrothermal and microbiological experiments.

PHYSICAL PROPERTIES OF OCEANIC LOWER-CRUSTAL AND UPPER-MANTLE ROCKS FROM ATLANTIS MASSIF, MID-ATLANTIC RIDGE

Gaye Bayrakci1, Falcon-Suarez I, Minshull T. A., North L., Best A. & IODP Expedition 357 Scientists

1 Ocean and Earth Sciences, University of Southampton, Waterfront Campus, European Way, SO14 3ZH, Southampton, UK

Mantle peridotite reacts with seawater in a process called serpentinization. The degree of serpentinization depends on the pressure and temperature conditions and the access of water to fresh peridotite. In a wide range of geological settings beneath the oceans, serpentinized peridotite units co-exist with gabbroic units. The physical properties of partially serpentinized ultramafic rocks, (e.g. density and seismic velocity) are similar to the properties of gabbroic rocks. Hence, distinguishing between two types of rocks by remote geophysical methods such as gravity or seismic surveys is challenging, and requires observations from direct sampling. In this study, we have measured and analyzed the physical properties of four gabbro samples acquired at the central dome of the Atlantis Massif (IODP Expeditions 304 and 305, 2006) and four serpentinite samples from the southern wall of the massif (IODP Expedition 357, 2015). The physical property measurements include P- and S-wave velocities and their respective attenuation, electrical resistivity and permeability, over a wide range of effective pressures. Using these measurements, we calculated elastic parameters of each sample, as well as their bulk density and porosity. We compared the properties of Atlantis Massif samples with gabbro and serpentinite samples acquired at other Mid-Atlantic Ridge sites. In general, our samples show lower bulk densities, lower P- and S-wave velocities and higher porosities than in other similar regions, possibly due to their shallow in situ depths and their fully altered states. Our results demonstrate a stress-dependent relationship between measured physical properties. For each samples, we carried out one-dimensional anisotropic electrical resistivity inversion with our resistivity datasets acquired using a 16-electrode acquisition system. For both types of rock, the preliminary inversion results show the signature of a laminated structure, with one high resistivity and two similar and low resistivity axes. The orientations of the high resistivity axes of the serpentinite samples are systematically perpendicular to the equivalent axes of the gabbro samples. Our results suggest that the anisotropy of the electrical resistivity, in combination with seismic methods, might be used as a tool for distinguishing between gabbro and serpentinised peridotite units.

KEYNOTE: THE NATURE OF THE INTRUSIVE CRUST AND MOHO AT SLOWER SPREADING RIDGES: SLOMO LEG 1

Chris J. MacLeod, H.J.B. Dick, P. Blum & IODP Expedition 360 Scientists

International Ocean Discovery Program (IODP) Expedition 360 formed the first leg of Phase I of the 'SloMo' project, a multiphase drilling programme that seeks to investigate the nature of the intrusive crust and Moho at slower spreading ridges by ultimately drilling through the Moho for the first time. In December 2015-January 2016 IODP Expedition 360 commenced drilling Hole U1473A on the summit of Atlantis Bank, an oceanic core complex adjacent to the Atlantis II transform on the SW Indian Ridge at 57degE. On the basis of the discovery of partially serpentinised peridotite on its flanks and summit it has been recognised that Atlantis Bank is the optimum place to investigate the hypothesis that the Moho, which sparse seismic data suggest is at approximately 5km below the exposed surface of the core complex here, may represent a hydration front in the lithospheric mantle rather than the boundary between igneous crust and mantle peridotite. A gabbro-serpentinite boundary is believed to lie some way above the Moho in this location. The goal of SloMo is to drill an ultra-deep hole that ultimately penetrates the Moho beneath Atlantis Bank and determines the nature of this fundamental seismic discontinuity. On its way to this goal SloMo will test the possibility that methanogenesis associated with widespread serpentinisation at depth within the mantle lithosphere may support a substantial deep biosphere, and assess the attendant consequences for global element cycling. Further scientific objectives include determining the mechanisms and spatio-temporal scales of accretion of igneous crust in the footwalls of active detachment faults, and nature of marine magnetic anomalies in such environments. Hole U1473A is located 1-2 km from previous ODP drill Holes 735B and 1105A and, like them, is sited in gabbroic rocks that were emplaced and variably deformed upon incorporation into the footwall of the active Atlantis Bank detachment fault. During Expedition 360 Hole U1473A was drilled to 789.7 m below seafloor, and subsequently deepened to 809.4 mbsf in the course of a brief return to the hole in July 2016 during transit Expedition 362T. Hole U1473A is the deepest hole ever drilled from the seafloor into ocean crust during a single 2 month expedition. Hole U1473A consists of a variety of types of massive and layered gabbro cut by isolated dikes. The shallower part of the hole has been affected by faulting: in the upper 469 m, seven distinct fault systems were encountered, ranging from 5 cm thick cataclasite bands to a 50 m thick carbonate-veined chlorite-rich fault zone. Over this interval, we obtained 44% recovery under relatively poor drilling conditions. From 469 mbsf to the bottom of the hole, however, drilling conditions were excellent, similar to Hole 735B, with 96% recovery in the lowermost 212 m interval cored (577.5–789.7 mbsf). Comparison of Hole U1473A with Holes 735B and 1105A allows us to demonstrate a continuity of process and complex interplay of magmatic accretion and steady-state detachment faulting over a time period of ~128 ky. Preliminary assessment indicates that these sections of lower crust are constructed by repeated cycles of intrusion, represented in Hole U1473A by upwardly differentiated hundreds of metre-scale bodies of olivine gabbro broadly similar to those encountered in the deeper parts of Hole 735B.

KEYNOTE: SOUTH AFRICAN CLIMATES: HIGHLIGHTS FROM IODP EXPEDITION 361

1Hall, I.R., Hemming, S.R., LeVay, L.J. and Expedition 361 Scientists

1School of Earth and Ocean Sciences, Cardiff University, Park Place, Cardiff CF10 3AT UK.

International Ocean Discovery Program Expedition 361 drilled six sites on the southeast African margin and in the Indian-Atlantic Ocean gateway, southwest Indian Ocean, from 30 January to 31 March 2016. In total, 5175 m of core was recovered, with an average recovery of 102%, during 29.7 days of on-site operations. The sites, situated in the Mozambique Channel, at locations directly influenced by discharge from the Zambezi and Limpopo River catchments, the Natal Valley, the Agulhas Plateau, and the Cape Basin were targeted to reconstruct the history of the Greater Agulhas Current System over the past ~ 5 Ma. The Agulhas Current is the strongest western boundary current in the southern hemisphere transporting some 70 Sv of warm and saline surface waters from the tropical Indian Ocean along the East African margin to the tip of Africa. Exchanges of heat and moisture with the atmosphere influence southern African climates including individual weather systems such as extra-tropical cyclone formation in the region and rainfall patterns. Recent ocean model and paleoceanographic data further point at a potential role of the Agulhas Current in controlling the strength and mode of the Atlantic Meridional Overturning Circulation (AMOC) during the late Pleistocene. Spillage of saline Agulhas water into the South Atlantic stimulates buoyancy anomalies that act as a control mechanism on the basin-wide AMOC, with implications for convective activity in the North Atlantic and global climate change. The main objectives of the expedition were to establish the sensitivity of the Agulhas Current to climatic changes during the Plio-Pleistocene, to determine the dynamics of the Indian-Atlantic gateway circulation during this time, to examine the connection of the Agulhas leakage and AMOC, to address the influence of the Agulhas Current on African terrestrial climates and potential links to Human evolution. Additionally, the Expedition set out to fulfill the needs of the Ancillary Project Letter, consisting of high-resolution interstitial water samples that will constrain the temperature and salinity profiles of the ocean during the Last Glacial Maximum. Here we highlight some of the expedition successes and show how it has made major strides toward fulfilling each of these objectives. The recovered sequences allowed complete spliced stratigraphic sections to be generated that span the interval of 0 to between ~0.13 and 7 Ma. These sediments provide an exceptional opportunity to generate decadal to millennial-scale climatic records that will resolve key paleoceanographic and paleoclimatic questions from a region poorly represented in the database of scientific drill sites.

MALDIVES MONSOON - BIOSTRATIGRAPHY OF A CARBONATE DRIFT SYSTEM

Jeremy Young, D. Kroon, & IODP Expedition 359 Scientists

The Maldives are a string of atolls on the Chagos-Laccadive Ridge which runs N-S through the Indian Ocean. Sedimentation on this ridge is controlled by monsoonal currents flowing across it, which have built up massive drifts of atoll-derived carbonate. This system provides a unique record of monsoonal effects through the Neogene, the expanded carbonate sands, however, proved challenging both for drilling and biostratigraphy. We will outline our experiences, with some discussion of lessons for practical biostratigraphy.

OLIGOCENE-MIOCENE TRANSITION IN THE NORTH ATLANTIC INTERRUPTED BY WARMING: NEW RECORDS FROM THE NEWFOUNDLAND MARGIN, IODP EXPEDITION 342

Richard Smith, D. Liebrand, T.E. van Peer, S.M. Bohaty, O. Friedrich, A. Bornemann, P. Blum & P.A. Wilson

National Oceanography Centre Southampton, University of Southampton

The beginning and end of the Oligocene epoch were marked by major Antarctic glaciation events. While the Eocene-Oligocene transition is known to have initiated sustained major ice sheets on Antarctica, the intensification of glaciation associated with the Oligocene-Miocene Transition (OMT) ~23 Ma appears to have been ephemeral. The inference of rapid growth and then retreat of large Antarctic ice sheets on orbital time scales is difficult to reconcile with the strong hysteresis seen in the results of numerical ice sheet model experiments and the modest variability seen in published records of atmospheric CO_2. A number of benthic foraminiferal proxy records have been generated at orbital resolution across the OMT, but high-resolution sea-surface records are sparse, particularly in the mid to high latitudes of the northern hemisphere, with none yet produced in the Atlantic Ocean.

IODP Site 1406 (40°N, 3799 m water depth, Expedition 342: Newfoundland Sediment Drifts) recovered an interval spanning the OMT in the North Atlantic. We present planktic foraminiferal stable isotope data from this interval (23.5 22.5 Ma) with an average sample spacing of ~2 kyrs. Our high-fidelity sea surface record benefits from exceptional 'glassy' preservation of clay-hosted foraminifera. Variability in our record shows prominent ~100 kyr eccentricity pacing (cycle amplitude typically >1.0 ‰ in $\delta^{18}O$ and >0.6‰ in $\delta^{13}C$) and a strong precessional influence. Intriguingly, while the rise in $\delta^{18}O$ associated with the OMT is fairly smooth in benthic records, our planktic data show that after over two-thirds of the total 1.6‰ rise in $\delta^{18}O$ had already taken place, a ~50 kyr recovery to pre-OMT $\delta^{18}O$ values occurred, preceding a rapid transition to the OMT $\delta^{18}O$ maximum.

Our results demonstrate for the first time the North Atlantic sea surface response to OMT events. The structure in our new planktic stable isotope record differs markedly from that seen in published benthic records. Interruption of the OMT $\delta^{18}O$ excursion in our record implies that during initial Antarctic glaciation across the OMT, North Atlantic surface waters underwent a dramatic temporary warming.

LATE PLIOCENE ONSET OF SEDIMENTARY ANOXIA IN THE DEEP NORTH ATLANTIC

David Naafs, R.D. Pancost, R. Stein, and G.H. Haug

We present abundance records for lipid biomarkers indicative of primary productivity and anaerobic sedimentary bacteria in marine sediments from the deep North Atlantic (IODP Site U1313). During the late Pliocene, anaerobic bacterial biomarkers were absent (and algal biomarker abundances were low). Afterwards, anaerobic bacterial biomarkers became abundant during glacials but remained absent during interglacials. These results demonstrate that the deep North Atlantic played a crucial role in regulating glacial/interglacial carbon cycle variations throughout the Quaternary.

SOUTHERN HEMISPHERE CLIMATE CHANGE DURING CRETACEOUS OAES: NEW INSIGHTS AND NEW POSSIBILITIES

Stuart A. Robinson, A. J. Dickson, A. Pain, G. Richards, B. D. Naafs, R. D. Pancost, H. C. Jenkyns, A. Sluijs, C. O'Brien

Conceptual models of oceanic anoxic events (OAEs) often invoke global changes in Earth surface temperatures and the hydrological cycle to explain many of the environmental variables thought to be key in the development of organic-carbon-rich sedimentation (e.g. changing ocean circulation and nutrient supply). Oceanic anoxic event 2 (Late Cenomanian) is a prime example, exhibiting globally distributed deposition of "black shales" and evidence for carbon-cycle perturbations and climate change. However, most of the reconstructions of climate change come from sites in the circum-North Atlantic region. There are currently no quantitative climate reconstructions from the southern hemisphere, thus severely limiting the ability to understand whether the relationships between climate, carbon cycling and oceanographic change during OAE2 were truly global or regional. Here, we present the first southern hemisphere sea-surface temperature records of OAE 2 using samples from ODP Sites 763 (Exmouth Plateau) and 1138 (Kerguelen Plateau). During the Late Cretaceous these sites were at palaeolatitudes of ~43˚S (Site 763) and ~57˚S (Site 1138), and thus provide a unique opportunity to explore changes in climate and depositional environments during OAE2 outside the more hydrographically restricted basins of the Atlantic and NW Tethys. New high-resolution integrated stratigraphy (δ13C, biostratigraphy) demonstrates the presence, at both sites, of positive carbon-isotope excursions associated with increased total organic carbon; consistent with these being local records of OAE 2. The well-preserved, thermally immature organic matter allows use of the organic geochemical palaeothermometer, TEX86. Our TEX86 data suggests significant warming at both sites during OAE2 and provides tantalizing evidence for the existence of transient cooling events, possibly correlative with the well-known Plenus Cold Event in the northern hemisphere. The long-term pattern of temperature change from the Cenomanian–Turonian is broadly consistent with other temperature records from the North Atlantic and northern Europe, demonstrating that global temperatures remained elevated sometime after the end of OAE2; suggesting that the relationships between climate, carbon cycling and ocean circulation were not as straightforward as some models suggest. In 2017, IODP Expedition 369 will core Cretaceous sediments offshore of southwestern and southern Australia. Thus our results are extremely timely and provide hypotheses to be explored if more complete stratigraphic records of OAE2 are recovered. We will discuss these hypotheses with specific reference to the proposed drilling during Expedition 369.

GEOLOGICAL EVIDENCE FOR LATE PLEISTOCENE VARIABILITY OF THE EAST ANTARCTIC ICE SHEET?

David Wilson, E.F. Needham, R.A. Bertram, T. van de Flierdt, K.J. Welsh, A. Mazumder, F.J. Jimenez-Espejo, C. Escutia

Understanding ice sheet behaviour in the geological past is essential for evaluating the role of the cryosphere in the climate system, and for predicting likely rates and magnitudes of sea level rise in future warming scenarios. Recent estimates of past and future sea level rise from ice sheet modelling point towards an Antarctic ice sheet that is more sensitive to oceanic and atmospheric warming than previously envisioned. However, given our incomplete understanding of ice sheet dynamics, it is crucial that such estimates are independently constrained by geological reconstructions. Data and models both indicate instability of marine-based sectors of the East Antarctic Ice Sheet during Pliocene warm periods. However, the threshold for this instability is unclear, and potential variability during interglacial periods of the Late Pleistocene remains unconstrained. To address these questions, we use detrital sediment provenance measurements from IODP core U1361 to explore the ice sheet behaviour in the Wilkes Subglacial Basin during the Late Pleistocene. Five diatom-rich intervals with elevated Ba/Al ratios correspond to the past five interglacial periods, allowing us to constrain sediment provenance changes from MIS 1 to MIS 12 using neodymium isotopes. Results reveal clear changes in sediment provenance between interglacial and glacial periods, and differences between individual interglacials. In a global palaeoclimate context, our data provide new evidence supporting the notion that the East Antarctic Ice Sheet contributed to elevated sea levels during warm Late Pleistocene interglacials (e.g. MIS 5, MIS 11). Furthermore, its stability during the Holocene may be atypical of past interglacial climate states.

KEYNOTE: IODP-ICDP EXPEDITION 364: DRILLING THE CHICXULUB IMPACT CRATER

Joanna Morgan, S. Gulick & IODP Expedition 364 Scientists

In April/May 2016, joint IODP/ICDP Expedition 364 drilled into the peak ring of the Chicxulub impact crater. The principal aims of the drilling were to: better understand large crater formation, ascertain how rocks are transiently weakened during the impact process, examine the potential of large impacts as hosts of microbial life, and investigate the recovery of life in the post-impact ocean basin. The Chicxulub peak ring is formed from fractured basement rocks with very unusual physical properties, covered by a ~100-m thick layer of impact melt rock and suevite (melt-rich, lithic impact breccia). There are indicators of standing wave and/or tsunami deposits, and preliminary microbiology results suggest the presence of modern deep biosphere. Early Paleocene sediments reveal an atypical recovery of life in the ocean basin, which may have been affected by hydrothermal venting into the ocean.

Abstracts for Poster Presentations

UK IODP KNOWLEDGE EXCHANGE

Zeinab* Adeyemi & Sally Morgan

**zaoa1@le.ac.uk*

International Ocean Discovery Program, Department of Geology, University of Leicester

Two-thirds of the way through the current UK IODP Knowledge Exchange Fellowship and progress is being made to identify, catalogue and communicate the impact of the UK IODP science community's research.

Case Study Portfolio: A series of impact case studies are in progress for submission to the NERC Impact Case Study Database (4 submitted), in tandem with which, each case study has a narrative for publication in end-user facing periodicals (1 published, 1 in review). UK IODP scientists have also been invited to complete the Impact Capture Survey which will identify further potential case studies.

A ***UK IODP Corporate Alumni Group*** is currently under development, cataloguing science party membership from the last 50 years. The aim of this is to establish an active network for collaboration and knowledge sharing across the disciplines and to develop relationships with those scientists now working in end-user communities.

Influencing Policy: Research arising from UK IODP has high potential for influencing policy both nationally and internationally. There is already evidence for this, but more can be done to maximize the impact of the community's science. UK IODP has been shortlisted for the 2016 Royal Society Policy Placement Scheme in which there will be the opportunity to raise the profile of IODP with policymakers.

Events: Development of relationships with industry including collaboratively hosting a seminar and a summer school has enhanced the visibility of the programme more widely, engaging with a range of companies and organisations. These events provide excellent opportunities for UK IODP scientists to network with end-users.

Resources:

Discretionary funding for travel & subsistence is available to UK IODP scientists wanting to initiate or develop their relationships with end-users.

A series of 6 free-standing banners are available for short-term loan for any events that relate to or are funded by UK IODP.

NEOGENE ANTARCTIC CLIMATE AND OCEANOGRAPHIC RECONSTRUCTIONS USING MOLECULAR AND ISOTOPIC BIOMARKER PROXIES

James Bendle*, Bella Duncan, Rob McKay, Tim Naish, Richard Levy, Todd Ventura, Heiko Moossen, Srinath Krishnan, Mark Pagani

** j.bendle@bham.ac.uk*

Atmospheric CO_2 concentrations ranged between 500 and 300 ppm across intervals of significant Neogene climate and environmental change. As a result, major climate thresholds were passed during periods of relatively modest CO_2 variation. This implies the Earth's climate system is highly sensitive to feedbacks associated with changes in global ice sheet and sea-ice extent, as well as terrestrial and marine ecosystems. In particular, moderately elevated CO_2 (350->400 ppm) levels were present during the Mid-Miocene Climate Optimum (MMCO, ~17-15 ma) and the Pliocene Warm Period (~5-3 Ma). Modelling of global climate, vegetation, and ice sheet extent has tried to reconcile the various feedbacks that led to a global warming of 3°C, and up to 6°C of warming at the poles, during these periods. Advances have been made regarding the timing and extent of ice sheet and oceanic variability from studies on continental margin drill cores offshore of Antarctica, such as those provided by ANDRILL and the Integrated Ocean Drilling Program. However, better reconstructions of past hydrology, land and sea surface temperature using geological proxies are required to understand marine-terrestrial climate linkages at the Antarctic margin, and to reconcile data-model comparisons.

Here we present emerging proxy climate reconstructions using terrestrial and marine organic biomarkers from Antarctic drill cores and outcrop samples that span the MMCO, the Pliocene Warm Period, and the subsequent rapid cooling events that followed (14-13.5 Ma and 3-2.5 Ma, respectively). Variations in *n*-alkane abundance, concentration and isotopic composition are used to identify changes in the distributions of terrestrial vegetation. Bacterial tetra-ether lipids are be analysed to determine terrestrial mean annual temperatures and soil pH (via the methylation and cyclisation indexes of branched tetraethers – MBT and CBT, respectively). Tetra-ether lipids of crenarchaeota found in marine sediments sampled from the continental shelves around Antarctica will be used to derive sea surface temperatures using the TEX_{86} index.

DETECTING FORAMINIFERAL PHOTOSYMBIONTS IN THE FOSSIL RECORD: A COMBINED MICROPALAEONTOLOGICAL AND GEOCHEMICAL APPROACH

Rehemat Bhatia*, Bridget Wade, Shari Hilding-Kronforst, John Spratt, David P. Mattey & David Thornalley

**rehemat.bhatia.13@ucl.ac.uk*

Dept of Earth Sciences, University College London, UK

Modern symbiotic planktonic foraminifera exhibit cyclic Mg/Ca banding in their shell walls. Here we present electron microprobe data of well-preserved Eocene and Miocene planktonic foraminifera to investigate this feature in extinct taxa. In conjunction with $\delta^{13}C$ and $\delta^{18}O$ data, we further disentangle foraminiferal palaeoecology.

Surface dwelling species Globigerinoides subquadratus and Acarinina praetopilensis and deep dwelling species Dentoglobigerina tripartita and Parasubbotina hagni were analysed. Geochemical results indicate distinct ecological preferences between species. All surface dwelling species exhibit prominent Mg bands, whilst in thermocline dwelling species Mg bands were less prominent or absent. The spatial distributions of the $\delta^{13}C$ and $\delta^{18}O$ data on a carbon-oxygen cross-plot also correlate with the occurrences of Mg banding observed in the microprobe maps. Surface dwellers were $\delta^{13}C$ enriched, whilst thermocline dwellers were $\delta^{18}O$ enriched.

Having established these relationships, the evolution of photosymbiosis in middle and late Eocene hantkeninids was studied. Preliminary microprobe and $\delta^{13}C$ data suggest an asymbiotic ecology in the middle Eocene and a photosymbiotic ecology in the late Eocene. The evolution of a photosymbiotic partnership in hantkeninids correlates with a depth habitat migration from deep to surface dwelling. Our data indicates that Mg banding is preserved in fossil planktonic foraminifera, and by combining micropalaeontological and geochemical data, more can be understood about extinct planktonic foraminiferal palaeoecologies.

RECONSTRUCTING INDIAN SUMMER MONSOON VARIABILITY DURING THE LATE PLIOCENE

Yasmin Bokhari Friberg*, Pallavi Anand, Kate Littler and Phil Sexton

** yasmin.bokhari-friberg@open.ac.uk*

Environment Earth and Ecosystem Sciences, The Open University

The Indian Monsoon, a subsystem of the Asian Monsoon, is one of the best examples of interaction between solid Earth and atmospheric processes. The late Pliocene (~3.5–2.5 Ma), when the Northern Hemisphere Glaciation (NHG) was intensifying, presents a good time interval to test the response of Indian Summer Monsoon (ISM) rainfall due to change in internal boundary conditions. The project aims to reconstruct the ISM rainfall and runoff, stratification and productivity changes before and after the initiation of NHG using a multi-proxy approach from the core monsoon region of the Bay of Bengal (BoB). Firstly, the late Pliocene stratigraphy will be developed using benthic foraminifera oxygen isotope signal that will be tuned with the global benthic stack (LR04). Thereafter, a few key cycles before and after the initiation of NHG will be selected to pick seasonally abundant planktonic foraminifera species (*Globigernoides ruber* and *Neogloboquadrina dutertrei*) for coupled oxygen and Mg/Ca measurements to reconstruct salinity changes in response to ISM runoff. The new records will be compared with benthic oxygen isotope (ice volume) and published atmospheric CO_2 records to test the response of ISM due to internal boundary conditions. Further, new ISM rainfall and runoff records will also be compared with orbital parameters and northern and southern hemisphere climate records to evaluate forcing factors controlling ISM hydroclimate during the late Pliocene. This project will primarily use newly drilled continuous sedimentary successions from the BoB (IODP Expedition 353 Sites U1444 and U1445).

BIOGEOGRAPHIC RANGE SHIFTS IN THREE SPECIES OF PLANKTONIC FORAMINIFERA DURING THE INTENSIFICATION OF NORTHERN HEMISPHERE GLACIATION

Anieke Brombacher*, Paul A. Wilson, Ian Bailey, Thomas H.G. Ezard

** j.brombacher@noc.soton.ac.uk*

National Oceanography Centre Southampton, University of Southampton, Waterfront Campus, European Way, Southampton SO14 3ZH, UK

Every species occupies a preferred geographical range around a specific environmental optimum. If environmental changes provoke a shift in that optimum, species are expected to migrate along with their preferred habitat. As environmental changes will not be constant throughout a species' range, we need high-resolution fossil records from multiple locations to study the drivers of species' geographical range shifts through time.

Here we present a 0.5 million year-long Plio-Pleistocene record of abundance and morphology of 31,000 individuals from six populations ((I)ODP Sites 981, U1313, 606, 659, 925 and 1264) across an Atlantic latitudinal transect of the planktic foraminifera species Truncorotalia crassaformis, Globoconella puncticulata and Globoconella inflata. We focus on Earth's last great climate transition: the intensification of Northern Hemisphere glaciation (iNHG). T. crassaformis and G. inflata survived the onset of glacial-interglacial cyclicity and are still alive today, whereas G. puncticulata became globally extinct in glacial Marine Isotope Stage (MIS) 96, providing an opportunity to study the driving mechanisms of geographic range shifts under contrasting evolutionary scenarios.

T. crassaformis is largest and most abundant at the low latitude sites and no temporal changes are detected in any of its populations, implying high resilience to environmental stressors. G. inflata is restricted to the southern hemisphere, with isolated occurrences in the North Atlantic driven by pronounced glacial events. G. puncticulata peaks in mean size and abundance in the mid-latitudes, but after the onset of 41-kyr glacial cyclicity (MIS G6, 2.72 Ma) average size and abundance decrease, leaving all populations in suboptimal conditions. Following MIS 100 stepwise population extinctions starting at the high northern latitudes result in a shift of the species' preferred geographical range to the subtropics, before ultimately going extinct. Comparisons of size and abundance to site-specific climatic reconstructions show that changes in morphology are driven by a combination of all studied climatic variables, rather than to single parameters such as temperature alone. Our results imply that the multivariate nature of global climate change related to the intensification of Northern Hemisphere glaciation drove the species to extinction.

HOW OLD IS THE SAHARA DESERT? AFRICAN HYDROCLIMATE OVER THE PAST 11 MA

Anya J. Crocker*, B. David A. Naafs, Thomas Westerhold, Ursula Röhl, Rachael H. James, Richard D. Pancost, Colin P. Osborne, Paul A. Wilson, David J. Beerling

**anya.crocker@noc.soton.ac.uk*

Ocean and Earth Science, National Oceanography Centre Southampton, University of Southampton Waterfront Campus, European Way, Southampton, SO14 3ZH U.K.

The climate of North Africa during the late Neogene was punctuated by numerous "Green Sahara" periods (GSPs) when much of the region was vegetated, with abundant lakes and rivers. GSPs are thought to be driven by increased monsoonal precipitation during times of high summer insolation and may have played a role in the migration and evolution of hominids. A notable reconstruction of North African hydroclimate over the last 5 Myr is provided by the accumulation of terrigenous material at ODP Site 659, a site situated off the coast of Mauritania, underneath the major modern Saharan dust plume (Tiedemann et al. 1994). Here we present new high-resolution proxy records of dust accumulation and provenance and chemical weathering derived from XRF core scan data and radiogenic isotopes from a 200 m-long revised composite section at Site 659 extending back to 11 Ma. Our data show strong orbital alternations between humid and arid intervals with significant dust accumulation throughout our study interval. This result suggests that precession-forced desertification of the Sahara region pre-dates previous estimates by several million years. We also report three unusually prolonged humid intervals or "Mega Green Sahara Periods" during the late Pliocene. In addition, our records show that the C_3/C_4 plant transition across northern Africa was extremely gradational, with a ~6–8 ‰ shift in $\delta^{13}C$ of plant-derived long-chain *n*-alkanes occurring over approximately 10 Myr.

MID-PLEISTOCENE OCEANOGRAPHY IN THE BERING SEA – INSIGHTS FROM DEEP OCEAN TEMPERATURE, CONTINENTAL ICE VOLUME, AND SEA ICE RECORDS

Henrieka Detlef*, Sindia Sosdian, Ian R. Hall, Caroline H. Lear, Sev Kender[3], Melanie J. Leng and Simon T. Belt

** DetlefH1@cardiff.ac.uk*

School of Earth and Ocean Sciences, Cardiff University

The Mid-Pleistocene Transition (MPT, 1.25-0.7 Myr) marks a fundamental shift in periodicity of northern hemisphere glaciations from 41-kyr to 100-kyr together with an increase in amplitude of glacial/interglacial (G/IG) cycles. A mismatch between external forcing and the climatic response suggest mechanisms internal to the Earth's climate system as the driving force. Potential feedbacks include the intensification of sea-ice extent in high latitudes effectively controlling the moisture supply to continental ice sheets (sea-ice switch model).

The Bering Sea offers a unique opportunity to study sea-ice buildup versus continental ice volume increase across the MPT. We use multi-species benthic foraminifera trace metal and paired oxygen isotope records (between 0.3-1.5 Myr) to reconstruct bottom water temperature (BWT) and continental ice volume at IODP site U1343. After a detailed diagenesis study analyzed foraminifera species include *Elphidium batialis*, *Uvigerina* spp., and *Islandiella norcrossi*. Sea-ice reconstruction is based on the Arctic sea-ice biomarker IP_{25}, measured across three key intervals (Marine Isotope Stages: 48-45, 26-21, and 13-10).

This approach allows investigation of the phasing and rate of change in BWT and continental ice volume across both 41-kyr and 100-kyr G/IG cycles as well as elucidate variations in sea-ice conditions. Unravelling the timing of sea-ice buildup during glacials across the past 1.5 Myr will enable us to comment on the sea-ice switch model with regard to the MPT.

NEW MULTI-PROXY RECONSTRUCTIONS OF SHALLOW WATER PALAEO-OCEANOGRAPHY FROM THE SOUTHERN SEA OF JAPAN OVER THE MID-PLEISTOCENE TRANSITION (IODP EXP. 346, SITE U1427)

Sonja Felder*, Andrew CG Henderson, Melanie J Leng, Thomas Wagner & Exp. 346 Scientists

** s.felder1@newcastle.ac.uk;*

School of Geography, Politics and Sociology; 5th Floor Claremont Tower; Newcastle University Newcastle upon Tyne; NE1 7RU; United Kingdom

During the Mid-Pleistocene Transition (MPT, ~1.2-0.6 Ma), the global climate cyclicity changed in amplitude and frequency (41 ka to 100 ka), crucially without changes in orbital parameters. Internal feedback mechanisms within the Earth's climate system must have caused this shift in cyclicity. While no agreement has been reached on what these feedbacks are, intensity fluctuations in the Asian monsoon have been proposed as one possible driver of the MPT. We aim to test this proposal.

In 2013, IODP Expedition 346 recovered sediments from the Sea of Japan/ East Sea, including Site U1427 in the southern part of the basin. The site is ideally located for studying variations of the Asian monsoon and eustatic sea level in high-resolution due to its specific location (underneath a branch of the Tsushima Warm Current and in a shallow water depth of 330 m), its high and continuous sedimentation rates (average 3.6 cm/ ka), and good foraminifera preservation. We will be presenting new geochemical records from U1427 (including $\delta^{18}O$ and $\delta^{13}C$ of the benthic foraminifera *Uvigerina spp.*, $CaCO_3$, TOC) and compare these with existing shipboard records (e.g. colour reflectance b*). In terms of their relationships to each other, all our data show a clear division into two parts. From ~700 ka (top of record) to ~910 ka, all our proxy data show close correlations with each other, while from ~910 ka to ~1200 ka (bottom of record) these correlations are much less obvious. This shift is synchronous with the "900 ka event" (global cooling with enhanced terrigenous input, Elderfield et al., 2012). We therefore hypothesize that the 900 ka event was at the heart of the MPT, and must have played a fundamental role for the reorganisation of the climate system.

DEVELOPMENT OF THE ASIAN MONSOON AND BIOTIC RESPONSE IN THE BAY OF BENGAL: PRELIMINARY RESULTS FROM IODP EXPEDITION 354

Lyndsey Fox*, Kara Bogus, Sev Kender, Melanie Leng, and the Exp. 354 science party

** Lyndsey.fox@nhm.ac.uk*

Department of Earth Sciences, The Natural History Museum, London, SW7 5BD, UK

International Ocean Discovery Program (IODP) Expedition 354 drilled an E-W transect of seven sites on the Lower Bengal Fan at 8^{o} 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 $\delta^{18}O$ 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 $\delta^{18}O$ and $\delta^{13}C$ from benthic and planktonic foraminifera. We use benthic $\delta^{18}O$ 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.

NORTH ATLANTIC PLANKTIC FORAMINIFERA TURNOVER AND UPPER OCEAN STRUCTURE DURING THE EOCENE-OLIGOCENE TRANSITION: INSIGHTS FROM THE NEWFOUNDLAND MARGIN

Max Holmström*, Helen Coxall, Steven Bohaty, Paul Wilson.

** m.j.holmstrom@soton.ac.uk*

The Eocene-Oligocene transition (EOT) was a time of major evolutionary turnover in several marine plankton groups, including planktic foraminifera. However, the nature of the turnover in the North Atlantic has remained uncertain due to difficulty in recovering complete sections of the EOT. Utilizing drill cores from IODP Exp. 342 Site U1411 (Southeast Newfoundland Ridge), containing a complete section of the EOT, planktic foraminifera assemblages were studied to investigate the biotic turnover and its relationship to the characteristic stable isotope shifts of the EOT in this region. Throughout the studied interval (33.5-35.1 Ma) assemblages are dominated primarily by thermocline and sub-thermocline species. The results show that the main planktic foraminifera turnover events and abundance shifts did not coincide with the isotopic steps diagnostic of global cooling and Antarctic ice growth but instead are focused in two waves of turnover and extinction: the first around 34.3 Ma, and the second focused around the Eocene-Oligocene boundary. These observations are consistent with the behaviour of planktic foraminifera at a low latitude East African sites (Tanzania), and other fossil groups globally, and raises questions about the role played by the mechanisms responsible for the EOT benthic foraminiferal $\delta^{18}O$ and $\delta^{13}C$ stable isotope shifts. Diversity changed less at Site U1411 than in the tropics probably because the most common species already had acquired some degree of cold adaptation or preference for variable conditions. Grouping of species into surface, thermocline and sub-thermocline 'eco-groups' reveals that the upper ocean pelagic habitats suffered no net loss in diversity. Instead, complex patterns of species interchange occurred internally within the habitats, indicating stress and change within all upper ocean layers.

OLIGOCENE RECORD OF EAST ANTARCTIC ICE SHEET DYNAMICS FROM MAUD RISE, SOUTHERN OCEAN

Claire E. Huck*, Steven M. Bohaty, Tina van de Flierdt, Diederik Liebrand, Ursula Röhl and Paul A. Wilson.

* *c.e.huck@soton.ac.uk*

Ocean and Earth Science, National Oceanography Centre, University of Southampton Waterfront Campus, European Way, Southampton SO14 3ZH, UK

The onset of continental-scale Antarctic glaciation at the Eocene-Oligocene transition (34 Ma) is a key step in the shift of Earth's climate to the modern 'Icehouse' regime. However, little is known about the size and stability of the early Antarctic ice sheets during the Oligocene epoch, an interval with reconstructed atmospheric CO_2 estimates ranging from current concentrations to ~750 ppm. High-amplitude variability in Oligocene deep-sea benthic foraminiferal oxygen isotope ($\delta^{18}O$) records has been interpreted to indicate large fluctuations in ice volume due to waxing and waning of the Antarctic ice sheet (AIS). While these deep-sea climate records suggest that the AIS was highly dynamic, they cannot inform us on more specific details such as how different regions of Antarctica responded to the glacial–interglacial cycles.

To improve our understanding of the role of the AIS in the variability recorded by benthic $\delta^{18}O$ records, we focus on a ~2 Myr period during the mid-Oligocene characterised by particularly large $\delta^{18}O$ fluctuations between 26 and 28 Ma. We present high-resolution X-ray fluorescence scanning and benthic foraminiferal stable isotope datasets from Ocean Drilling Program Site 689 (Maud Rise, Southern Ocean), which exhibits prominent orbital-scale cyclicity throughout the study interval. We complement this dataset with detrital neodymium (Nd) isotope records as a provenance tracer to provide insight into the erosional history of the adjacent Dronning Maud Land region of Antarctica. Using this combined proxy approach, we aim to directly link evidence for terrestrial AIS oscillations with records of global climate cycles from the marine realm.

RECONSTRUCTING INDIAN SUMMER MONSOON INDUCED RIVER RUNOFF DURING MARINE ISOTOPE STAGE 5

K. Kerr*., P. Anand., P. F. Sexton and M. J. Leng

* *Katrina.kerr@open.ac.uk*

School of Environment, Earth and Ecosystem Sciences, Faculty of Science, Technology, Engineering and Mathematics, The Open University, Walton Hall, Milton Keynes, MK76AA

The Indian Monsoon, a subsystem of the Asian Monsoon, comprises one of the strongest hydrological regimes affecting Earth's most densely populated areas. In order to accurately constrain and model future monsoon behaviour a robust record of past variability is crucial in order to understand the influence of external and internal forcing parameters. IODP Exp. 353 recovered expanded marine sediment sequences within the core region of the Indian Monsoon, the Bay of Bengal, with the potential to fill the gap in our spatial-temporal understanding of the dynamics of the Indian Monsoon's past behaviour. Termination II (TII, ~135-130 ka) and the Last Interglacial Period (LIG, ~130-118 ka) present a suitable case study for investigating the sensitivity of the monsoon to climatic forcing operating during a period of abrupt climate change.

Preliminary elemental ratios from bulk sediment using portable X-ray fluorescence have been used to assess variation in terrigenous sediment flux to study sites, U1446 (Northern Bay of Bengal) and U1448 (Andaman Sea) throughout Marine Isotope Stage 5 (MIS 5). Ti/Ca ratios from U1446 reveal millennial scale variability throughout MIS 5 and are interpreted to reflect variation in the intensity of the Indian Summer Monsoon (ISM). Increased sediment flux, associated with strengthened ISM occurs following TII interrupted by a brief weakening prior to attainment of peak interglacial conditions. This record provides an initial working model to investigate internal teleconnections operating between the Indian Monsoon with the East Asian Monsoon and high latitude climate during different climatic states.

HIGH LATITUDE NEOGENE PLANKTONIC FORAMINIFERA BIOSTRATIGRAPHY: A REASSESSMENT FROM OCEAN DRILLING PROGRAM LEG 120 SITE 747 (KERGUELEN PLATEAU)

David J. King*, Bridget S. Wade, C. Giles Miller, Mark Leckie

** Department of Earth Sciences, University College London, London, United Kingdom*

Ocean Drilling Program Leg 120 Site 747 is located on the Kerguelen Plateau within the Southern Ocean (54°48.68'S, 76°47.64'E) and contains a near complete Miocene sequence. Previous studies have shown that planktonic foraminifera are a common and consistent component through the Miocene sequence and there are clear magnetic reversals, so several magnetostratigraphic interpretations have been inferred. However, there are conflicting interpretations of the bio- and magnetostratigraphy, which creates uncertainty when assigning an absolute chronology. Presented is a reassessment of the biostratigraphy, with a particular focus on *Paragloborotalia*, and a review of the magnetostratigraphy and the implications this has on defining bioevent datums. Quantitative analysis of the coiling direction of the genera *Paragloborotalia* and *Globorotalia* indicate phases of preferred coiling, although further assessment is needed in order to better under the controls which lead to these changes.

INTEGRATED STRATIGRAPHY OF THE OLIGOCENE-MIOCENE CLIMATIC TRANSITION AT IODP SITE U1406

Diederik Liebrand*, André Bornemann, Oliver Friedrich, Kyoungnam Jo, Caroline H. Lear, Tim E. van Peer, Richard E. Smith, Iris Möbius, Nevin Blum, Peter Blum, Rosanna Greenop, Wendy E. C. Kordesch, Dominik Leonhardt, Yuxi Jin, Elaine M. Mawbey, Megan R. Spencer, Victoria E. Taylor, Steven M. Bohaty, Peter C. Lippert, Zhonghui Liu, Brian Romans, Paul A. Wilson, Chuang Xuan

** Ocean and Earth Science, National Oceanography Centre, University of Southampton Waterfront Campus, European Way, Southampton SO14 3ZH, UK*

The first high-resolution benthic foraminiferal carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotope records spanning the Oligocene-Miocene Transition (OMT) were generated on strata recovered from the western equatorial Atlantic Ocean. These records revealed a long-term, step-wise increase in benthic δ13C and a transient ~1‰ increase in δ18O. These events are interpreted to be predominantly paced by Earth's eccentricity cycle, through the modulation of precession. The transient nature of the high-amplitude δ18O excursion across the OMT is difficult to reconcile with model-based predictions of ice-sheet stability, due to the high thermal inertia of the Antarctic ice-cap in model simulations.

Additional OMT stable isotope records were generated on sediments from the equatorial and South Atlantic Oceans, the Southern Ocean and the equatorial Pacific Ocean, but no records currently exist from the mid-to-high latitude North Atlantic Ocean. This limits our understanding of both the response of the high northern latitudes to events on Antarctica and possible forcing roles played by the North Atlantic region in global climate change at the OMT. This is a major knowledge gap because the present-day North Atlantic Ocean is (1) a crucial region for deep-water formation and primary driver of Atlantic and global overturning circulation, (2) in close proximity to the Greenland ice cap and well located to record past changes in ice-sheet dynamics, and (3) characterized by a strong latent heat transport through the Gulf Stream, playing a pivotal role in meridional teleconnections and moderating climate in northern Europe.

In 2012 the Integrated Ocean Drilling Program sailed to the Newfoundland Ridges (northwestern Atlantic) to recover sediments in the path of the Deep Western Boundary Current and the Gulf Stream. At Site U1406 (3799 meters below sea level, J-Anomaly Ridge) an expanded late Eocene-to-early Miocene clay-rich sedimentary record was recovered, including a stratigraphically complete OMT section. Here we present the first results of an integrated magnetostratigraphic and cyclostratigraphic study based on X-ray fluorescence core scanning, coarse fraction data, and benthic foraminiferal stable isotope records of the OMT interval of Site U1406. We present the data on revised composite depth scale and an astronomically tuned age-model. We test for the presence of astronomical pacemakers and show that there are clear oscillations in the data on frequencies related to the obliquity and eccentricity.

ICE SHEET-VOLCANO INTERACTIONS IN THE NW PACIFIC ~40 KA BP? EVIDENCE FROM MARINE CORES AND ICEBERG TRAJECTORY MODELLING

MSc Thesis (2014)

Ambrose McCarron, Grant Bigg, Mike Rogerson

* *amccarron1@sheffield.ac.uk*

Department of Geography, University of Sheffield, Winter Street, Sheffield S10 2TN.

Marine sediment cores and tephrochronology show that ice cover on the Kamchatka Peninsula appears to have retreated away from the coast after around 40 ka BP. Pilot work shows a near-synchronous spike in IRD and coarse-grained volcanic ash in ODP Core 1207 (37.79°N, 162.75°E) at a depth of 1.6-1.69 mbsf, similar in character to sediments from ODP 883 (51.2˚N, 167.8˚E) described in Bigg et al. (2008), who proposed ice-volcano coupling as a possible mechanism in the apparent collapse of the Kamchatka ice sheet. However, ^{14}C dating of planktic foraminifera immediately above the ash layer in ODP 1207 yields an age of ~45 ka BP, inferring that this is not the 40 ka BP ash/IRD event. This is confirmed by subsequent geochemical analysis which shows that the ash originates from a Hokkaido eruption. Greyscale image analysis of eight cores from across the NW Pacific does not appear to display a clear 40 ka signal in all cores, although this method contains a high degree of error due to moisture variation and imperfect core recovery. Inter-core comparison is also greatly restricted by a lack of NW Pacific age-depth profiles. Iceberg trajectory modelling seeded with palaeo-ice stream locations based on geomorphological evidence from Kamchatka infers that a basin-wide signal for IRD should be expected in other marine cores to the south-east and east of the peninsula to as far as around 30˚S and 180˚E. Cores that fall within this region should be inspected for the presence of IRD and ash layers. Model results also show that key sources of IRD are SW, SE, NE and central Kamchatka. The results presented here provide scope for further research which should focus on developing a high resolution regional stratigraphy as a means to gain greater understanding of the deglaciation of the NW Pacific and its complex earth system interactions. Particular attention should be given to deciphering depositional history, sediment transport mechanisms, and the interplay between regional volcanism and ice sheet change. My PhD, supervised by Grant Bigg (The University of Sheffield), Mike Rogerson (The University of Hull) and Jim Marshall (The University of Liverpool) will begin to address some of these issues in the Late Quaternary history of the NW Pacific.

USING MARINE RECORDS TO STUDY TERRESTRIAL BURNING: A CHARCOAL RECORD FOR THE LAST GLACIAL CYCLE FROM OFFSHORE NORTHWEST AFRICA

Harriet R Moore*, Anya J Crocker, Claire M Belcher, Paul A Wilson, Colin P Osborne, David J Beerling

**hrm2g10@soton.ac.uk*

National Oceanography Centre Southampton, University of Southampton, Southampton, SO14 3ZH, UK.

Fire is a major driver of ecological change, responsible for shaping many of the Earth's ecosystems including some of the world's most densely populated regions. It is important to understand the factors driving fire activity in order to predict the fire future of these regions and the implications for their human populations. Records of charcoal accumulation provide a way to assess changes in fire activity in the geological past. Most published charcoal records are generated from terrestrial or lacustrine sediments, but these archives typically do not span long geological ranges and can be subject to large dating uncertainties. Marine records of charcoal accumulation have the potential to overcome these issues. Here, we present a record of charcoal flux from ODP Site 658, offshore Mauritania (NW Africa), across the last glacial cycle. Our record shows pronounced variability indicating a close relationship between changes in hydroclimate and fuel availability for wildfires. Specifically, major changes in fire activity are closely associated with well-documented hydroclimate shifts occurring in North Africa over the past 150 kyr including the Younger Dryas and Heinrich Event 1 (fire minima); the Bølling-Allerød, and sapropels S3 and S4 (fire maxima).

LATE MIOCENE ICE VOLUME AND BOTTOM WATER TEMPERATURES FROM PRISTINELY PRESERVED BENTHIC FORAMINIFERA.

Michael Nairn*, Dr. Caroline Lear, Prof. Paul Pearson, Dr. Alexandra Nederbragt, Dr. Simon Beavington-Penney

**NairnMG@cardiff.ac.uk*

School of Earth and Ocean Sciences, Cardiff University, Main Building, Park Place, Cardiff, CF10 3AT.

The Neogene offers an opportunity to understand the dynamic coupling between climate and Antarctic ice sheet variability. However, Late Miocene glacioeustatic reconstructions based on geochemical proxies are poorly constrained as they typically rely on foraminifera from carbonate rich deep sea settings whose geochemistry may be compromised by carbonate ion effects and diagenesis. Here we analyse pristinely preserved foraminifera from an industry well drilled in hemipelagic clays offshore Kenya in the Lamu Basin, 723.3m water depth. We analyse the benthic foraminifera *Uvigerina peregrina* for $\delta^{18}O$, $\delta^{13}C$ and trace metal composition. The Mg/Ca of this infaunal species may provide a more reliable record of bottom water temperature than epifaunal species, which may be more influenced by changes in bottom water carbonate saturation state. Our reconstructed bottom water temperature records reflect a combination of local subsidence and regional temperature trends. In combination with $\delta^{18}O$ the records suggest that global ice volume was not stable following the expansion of the Antarctic Ice Sheet across the MMCT.

GLOBAL CALCAREOUS NANNOPLANKTON EXTINCTION AND POPULATION TURNOVER ACROSS THE EOCENE-OLIGOCENE TRANSITION

Cherry Newsam*, Paul Bown, Tom Dunkley Jones

**cherry.newsam.11@ucl.ac.uk*

Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT, UK

The Eocene-Oligocene transition (EOT) was a fundamental event in the Cenozoic marking the transition from a greenhouse into an icehouse world, associated with widespread climatic and oceanographic change, including climatic cooling, Antarctic ice sheet formation and expansion, deepening of the calcite compensation depth (CCD), sea level fall, changes in ocean chemistry and elevated marine biotic disruption, with elevated rates of plankton extinction and turnover. Calcareous nannoplankton (marine calcifying algae) dominated the phytoplankton record in the early Paleogene and were highly diverse yet underwent severe diversity loss from the middle Eocene which intensified across the EOT, a time when this group also exhibits major population shifts.

Here we present new observations of the calcareous nannoplankton response to the EOT in the North Atlantic from IODP Expedition 342, Site U1411, which has high sedimentation rates and exceptionally well preserved calcareous nannofossils. Semi-quantitative data and relative abundance counts highlight diversity change, species bioevents and major shifts in abundance patterns. In addition, we have compiled a global synthesis of EOT calcareous nannofossil data from a range of additional sites that vary in latitude, ocean basin and oceanographic setting, in order to document the timing and magnitude of these widely observed assemblage shifts. We identify significant and coeval population restructuring, including striking reorganisation of the dominant reticulofenestrid group, close to the Eocene-Oligocene boundary and prior to the early Oligocene climatic shift reflecting widespread perturbation to surface water environments. Range retractions, elevated rates of extinction and protracted declines in abundance in warmer water oligotrophic taxa are associated with a reduction of optimal habitat space for many coccolithophores, whilst increases and acmes occur in taxa that favoured cooler waters and elevated levels of nutrients or pulsed delivery of nutrients. Determining the precise timing of these events at widespread localities allows us to examine the relationship between calcareous nannoplankton evolution and the strongly shifting palaeoceanographic conditions through the EOT.

GLACIAL DISCHARGE, PRODUCTIVITY AND OCEANIC VARIABILITY FROM THE ANTARCTIC COASTAL ZONE: RESULTS FROM A 171 M HOLOCENE SEDIMENT CORE FROM IODP EXPEDITION 318

Kate Newton*, James Bendle, Robert McKay, Anya Albot, Heiko Moossen, Osamu Seki, Veronica Willmott, Stefan Schouten, Christina Riesselman, and Robert Dunbar

**ken155@student.bham.ac.uk*

School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, B15 2TT

Antarctica and the Southern Ocean play a vital role in controlling global changes in climate, sea level and the carbon cycle, through variations in processes such as ice melt, primary production and bottom water formation. Yet, the Southern Ocean remains the least studied region on Earth with respect to Holocene climate variability. A 171m core of laminated diatom ooze spanning the Holocene, recovered from the Adélie drift during IODP 318, presents a new opportunity to study Antarctic climatic evolution on this timescale, within a climatically-sensitive coastal polynya. Compound-specific carbon and hydrogen isotope analysis of fatty acid and sterol biomarkers are used to reconstruct changes in primary productivity, via CO_2 drawdown, and inputs of isotopically-depleted glacial meltwater, while grain-size and core image analyses captures changes in freshwater inputs and ocean currents.

Our data records deglacial meltwater inputs from retreating East Antarctic glaciers until ca. 8.2 ka, after which freshwater signals appear to originate from the Ross Ice Shelf, transported by easterly coastal currents and recorded at our site. Inputs of meltwater broadly follow the pattern of temperature change recorded in Antarctic ice cores, showing a long-term decline over most of the Holocene with a mid-Holocene peak at ca. 4.5 ka, possibly representing the final pulse of deglaciation from the Ross Ice Shelf. Changes in productivity show some coherence with meltwater inputs and changes in air temperature, and displays a cyclicity with a period of ca. 2.3 ka, close to a known cycle of Holocene solar activity.

MAPPING DEEP SEA SEDIMENTS PRE AND PEAK PALAEOCENE-EOCENE THERMAL MAXIMUM

James O'Neill*

**james.o'neill.12@alumni.ucl.ac.uk*

University College London, Gower Street, London

Deep Sea sediments provide a geological record of the biotic, chemical and physical condition of Earth's atmosphere-ocean system at their time of deposition. The distribution and composition of these sediments can be used to reconstruct the planet's changing climate over the past 65Ma. This study focussed on the largest and most dramatic climate perturbation of the Cenozoic- the Palaeocene-Eocene Thermal Maximum (PETM) ~56Ma.

EARLY-TO-MID OLIGOCENE STRATIGRAPHY AND PALAEOCEANOGRAPHY OF NEWFOUNDLAND MARGIN SEDIMENT DRIFTS (IODP EXP. 342)

Gwen Owen Jones*, Steve Bohaty, Pete Lippert, Tim van Peer

***** *G.A.Owen-Jones@soton.ac.uk*

Ocean & Earth Science, National Oceanography Centre, Waterfront Campus, European Way, Southampton, UK, SO14 3ZH

The Oligocene represents the early phase of the modern 'Icehouse' climate system, following the onset of rapid high-latitude cooling and the contemporaneous initiation of Antarctic glaciation at the Eocene-Oligocene Transition (EOT, ~34 Ma). Our understanding of the Oligocene time interval, however, is currently limited by the scarcity of continuous high-resolution records from mid-to-high latitude regions of the Northern Hemisphere. Thick hemipelagic drift sediments, recovered at IODP Expedition 342 Sites U1406 and U1411 on the J-Anomaly and Southeast Newfoundland ridges (Northwest Atlantic), are characterised by high sedimentation rates and exceptional preservation of calcareous and organic-walled microfossils. These drill cores provide an excellent opportunity to fill the current knowledge gap via development of high-resolution palaeoceanographic records for the early-to-mid Oligocene interval. Here we compile X-ray fluorescence (XRF), coulometric %$CaCO_3$, grain size, magnetostratigraphic, and biostratigraphic data spanning ~26 to 31 Ma (Chron C9n to C12n) for Site U1411. This compiled record will be used to evaluate trends in carbonate deposition and cyclicity, as well as to construct a tentative correlation scheme between Site U1411 and Site U1406. Although both Sites U1406 and U1411 likely contain Oligocene hiatuses, a near-continuous record can be obtained through site-to-site correlation. The composite record will enable development of high-resolution palaeoceanographic proxy records for the Oligocene, documenting orbital-scale environmental changes on the Newfoundland margin.

ESTIMATION OF THE BASEMENT DEPTH IN THE CENTRAL RED SEA FROM GRAVITY AND MAGNETIC DATA

Wen Shi*, Neil Mitchell, Lara Kalnins

* *wen.shi@manchester.ac.uk*

School of Earth and Environmental Sciences, University of Manchester

Rock salt, kilometers in thickness, were widely deposited in the Red sea, because of the dry climate and the isolation of the sea from the world oceans. Since the weak rheology of rock salt, they tend to flow on geological timescales. In the Red Sea, this is caused by the rifting and subsidence in the centre of the sea, leaving the salt tilted and exposed along faults. However, the pattern of flow and causes (in a quantitative sense) are poorly known. This is potentially important for understanding other continental margins, such as the South Atlantic and Gulf of Mexico, which both went through this stage when they too were isolated. We are unable to study those margins now because the salt is deeply buried and has been mobilized by the pressure of overlying rocks. The Red Sea salt deposits are geologically young (only 5.3 million years) and will help to understand these older margins, many of which are associated with oil and gas reserves. The salt movement strongly depends on the basement structure. Basement depth is required during working out the differential stress distribution, the salt flux, and the temperature distribution. These properties determine how the salt flows. In this study, the depth to basement was derived from gravity data under the assumptions of oceanic and continental crust. Seismic reflection data were used to constrain the basement depths. The results revealed the basement surface relief characteristic of the Red Sea.

OLIGOCENE-MIOCENE TRANSITION IN THE NORTH ATLANTIC INTERRUPTED BY WARMING: NEW RECORDS FROM THE NEWFOUNDLAND MARGIN, IODP EXPEDITION 342

Richard Smith*, Diederik Liebrand, Tim Eelco van Peer, Steven M Bohaty, Oliver Friedrich, André Bornemann, Peter Blum, Paul A Wilson

**National Oceanography Centre Southampton, University of Southampton*

The beginning and end of the Oligocene epoch were marked by major Antarctic glaciation events. While the Eocene-Oligocene transition is known to have initiated sustained major ice sheets on Antarctica, the intensification of glaciation associated with the Oligocene-Miocene Transition (OMT) ~23 Ma appears to have been ephemeral. The inference of rapid growth and then retreat of large Antarctic ice sheets on orbital time scales is difficult to reconcile with the strong hysteresis seen in the results of numerical ice sheet model experiments and the modest variability seen in published records of atmospheric CO_2. A number of benthic foraminiferal proxy records have been generated at orbital resolution across the OMT, but high-resolution sea-surface records are sparse, particularly in the mid to high latitudes of the northern hemisphere, with none yet produced in the Atlantic Ocean.

IODP Site 1406 (40°N, 3799 m water depth, Expedition 342: Newfoundland Sediment Drifts) recovered an interval spanning the OMT in the North Atlantic. We present planktic foraminiferal stable isotope data from this interval (23.5 22.5 Ma) with an average sample spacing of ~2 kyrs. Our high-fidelity sea surface record benefits from exceptional 'glassy' preservation of clay-hosted foraminifera. Variability in our record shows prominent ~100 kyr eccentricity pacing (cycle amplitude typically >1.0 ‰ in $\delta^{18}O$ and >0.6‰ in $\delta^{13}C$) and a strong precessional influence. Intriguingly, while the rise in $\delta^{18}O$ associated with the OMT is fairly smooth in benthic records, our planktic data show that after over two-thirds of the total 1.6‰ rise in $\delta^{18}O$ had already taken place, a ~50 kyr recovery to pre-OMT $\delta^{18}O$ values occurred, preceding a rapid transition to the OMT $\delta^{18}O$ maximum.

Our results demonstrate for the first time the North Atlantic sea surface response to OMT events. The structure in our new planktic stable isotope record differs markedly from that seen in published benthic records. Interruption of the OMT $\delta^{18}O$ excursion in our record implies that during initial Antarctic glaciation across the OMT, North Atlantic surface waters underwent a dramatic temporary warming.

THE EOCENE-OLIGOCENE GREENHOUSE-ICEHOUSE TRANSITION: HIGH AND LOW LATITUDE PERSPECTIVES

Amy Sparkes*, Caroline Lear, Paul Wilson, Steve Bohaty, Dan Lunt, Tina van de Flierdt, Claire Huck, Helen Coxall

**sparkesav@cardiff.ac.uk*

School of Earth and Ocean Sciences, Cardiff University

The Eocene-Oligocene Transition (EOT) marks the initiation of a widespread ice sheet on Antarctica and a transition from the warmth of the Eocene greenhouse to the Oligocene icehouse. Understanding of the relationship between Antarctic glaciation and the response of climatic parameters at low and high northern latitudes remains somewhat limited; including the relationship between AIS initiation and changes in atmospheric and oceanic circulation. Extensive work has been carried out in the South Atlantic and Atlantic sector of the Southern Ocean. However, there is a distinct lack of records from the North Atlantic across the EOT and, given the absence of bipolar glaciation at the EOT and disparity in land mass cover, it is reasonable to expect a differential interhemispheric response of climatic feedbacks.

Results from ODP site 925 (Ceara Rise, western equatorial Atlantic) spanning the EOT document the two-step, ~1.5‰ shift in $\delta^{18}O$ from benthic foraminiferal calcite. Neodymium isotopes from fish teeth at this low latitude site depict exceedingly negative, non-radiogenic values (~-14.5) prior to the ice growth that become more radiogenic (~-12.9) across the EOT, representing the most non-radiogenic εNd values thus far attributed to the EOT. High latitude cooling likely caused an increase in thermal gradients between the poles and the subtropics and a northward shift in the ITCZ (as documented in the Pacific across the EOT). Hence, we interpret this as a change in weathering regime in a more arid Amazon basin delivering highly non-radiogenic values from areas such as the Guiana shield (dominated by εNd values as low as -20). The intensification of meridional winds due to increased thermal gradients also likely caused an invigoration of localised ocean currents and thus increased export production and biological productivity, possibly explaining a peak in U/Ca and a decrease in B/Ca values of benthic foraminiferal calcite coincident with the $\delta^{13}C$ excursion.

DOES PRODUCTIVITY DRIVE THE DEMISE OF MAGNETOTATIC BACTERIA ACROSS THE EOCENE-OLIGOCENE TRANSITION? INSIGHTS FROM IODP EXPEDITION 342 SITE U1411 (SE NEWFOUNDLAND RIDGE, NW ATLANTIC)

Taylor VE*; Lippert PC; Xuan C; Bohaty SM; Wilson PA; Liebrand D

**vet1g12@soton.ac.uk*

National Oceanography Centre, Waterfront Campus, European Way, Southampton, UK, SO14 3ZH

The Eocene-Oligocene Transition (EOT; ~34 Ma) represents a pivotal tipping point in the development of the Earth's modern climate system triggering a climate state sufficiently cool to sustain extensive Antarctic ice sheets. Drift sediment sequences recovered at IODP Expedition 342 Site U1411 (SE Newfoundland Ridge, NW Atlantic) present a unique opportunity to study the EOT in unprecedented temporal resolution from a Northern Hemisphere perspective. Site U1411 benefits from high sedimentation rates, exceptional carbonate microfossil preservation and retention of a detailed record of the behaviour of the Earth's magnetic field. This enables development of a comprehensive stratigraphic framework for palaeoceanographic studies from a region where very little is known about EOT climate history. Here we present a revised magnetostratigraphy for Site U1411spanning C13r/C15n up to the base of C12r. These magnetochrons provide key age constraints for site-to-site correlations across the EOT between ocean basins and provide the framework to investigate rates of environmental change. Environmental magnetic data complemented by x-ray fluorescence (XRF), bulk isotopes and elemental data reveal cyclic variability across this interval. A large-scale reorganisation of North Atlantic environmental conditions in response to Antarctic ice sheet growth is documented, denoted by a two-order of magnitude decrease in environmental magnetic intensity. We infer changes in the magnetotatic bacteria (MTB) community responsible for this intensity shift. Data presented here portrays changes in water column and sediment-water interface conditions leading to the redox shift responsible for MTB disappearance. Sea level and productivity are speculatively identified as the main drivers of these changes, exemplifying the impacts of Antarctic glaciation on the Northern Hemisphere.

POST-ERUPTIVE SUBMARINE TERRACE DEVELOPMENT OF CAPELINHOS, AZORES

Zhongwei Zhao, Neil Mitchell, Rui Quartau, Fernando Tempera, Lucy Bricheno

**zhongwei.zhao@postgrad.manchester.ac.uk*

School of Earth and Environmental Sciences, University of Manchester, Manchester, UK

Erosion of the coasts of volcanic islands by waves creates shallow banks. Subsided older versions of these features (guyots) have been targetted by scientific ocean drilling in the past so it may be useful to know more about how they originate, but how erosion proceeds with time to create banks and how it relates to wave climate is unclear. In this study, historical and recent marine geophysical data collected around the Capelinhos promontory (western Faial Island, Azores) offer an unusual opportunity to characterize how a submarine terrace developed after the eruption. The promontory was formed in 1957/58 during a Surtseyan eruption that terminated with extensive lava forming new rocky coastal cliffs. Historical measurements of coastline position are supplemented here with coastlines measured from 2004 and 2014 Google Earth images in order to characterize coastline retreat rate and distance for lava- and tephra-dominated cliffs. Swath mapping sonars were used to characterize the submarine geometry of the resulting terrace (platform edge position, gradient and morphology). Limited photographs are available from a SCUBA dive and drop-down camera deployments to ground truth the submarine geomorphology. The results reveal that coastal retreat rates have decreased rapidly with the time after the eruption, possibly explained by the evolving resistance to erosion of cliff base materials. Surprisingly, coastline retreat rate decreases with terrace width in a simple inverse power law with terrace width. We suspect this is only a fortuitous result as wave attenuation over the terrace will not obviously produce the variation, but nevertheless it shows how rapidly the retreat rate declines. Understanding the relationship between terrace widening shelf and coastal cliff retreat rate may be more widely interesting if they can be used to understand how islands evolve over time into guyots.

List of Attendees

	Zeinab	Adeyemi	Leicester University
Dr	Pallavi	Anand	The Open University
Dr	Gaye	Bayrakci	University of Southampton
	James	Bendle	University of Birmingham
	Rehemat	Bhatia	University College London
Dr	Steven	Bohaty	National Oceanographic Centre and School of Ocean & Earth Science, University of Southampton
	Sandra Yasmin	Bokhari Friberg	The Open University
Prof	Paul	Bown	University College London
	Anieke	Brombacher	National Oceanography Centre, University of Southampton
Dr	Leon	Clarke	Manchester Metropolitan University
	Alex	Clarke	Royal Holloway, University of London
Dr	Rosalind	Coggon	University of Southampton
Dr	Anya	Crocker	University of Sheffield
Prof	David	Cronan	Imperial College London
Prof	Sarah	Davies	University of Leicester
	Henrieka	Detlef	Cardiff University
	Loren	Eggenschwiler	Universität Zürich (UZH)
Dr	Ake	Fagereng	Cardiff University
	Sonja	Felder	Newcastle University
	Heather	Ford	University of Cambridge
	Gavin	Foster	National Oceanography Centre, University of Southampton
Dr	Lyndsey	Fox	The Natural History Museum, London
	Luz	Gomis	University of Manchester
	Kourosh	Haddadi Moghaddam	International Sturgeon Research Institute
Prof	Ian	Hall	Cardiff University
	Matthew	Hall	Cardiff University
	Max	Holmström	University of Southampton
Dr	Claire	Huck	University of Southampton
	Mads	Huuse	University of Manchester
	Rachael	James	University of Southampton
	Amy	Jewell	University of Southampton
	Song	Jing	University College London
	Kirstin	Johnson	British Geological Survey
	Katrina	Kerr	Open University
	David	King	University College London

	Daniel	Knight	NERC
	Ali	Kobeissi	University College London
	Dick	Kroon	Edinburgh University
	Helen	Lacey	Imperial College London
	Erwan	Le Ber	Leicester University
Prof	Caroline	Lear	Cardiff University
Prof	Melanie	Leng	British Geological Survey
Dr	Sabine	Lengger	University of Bristol
Dr	Diederik	Liebrand	National Oceanography Centre, University of Southampton
Prof	Christopher	MacLeod	Cardiff University
Dr	Christian	März	University of Leeds
	Andrew	McCaig	University of Leeds
	Ambrose	McCarron	The University of Sheffield
Prof	Lisa	McNeill	University of Southampton
Dr	Zrinka	Mendas	University of Bolton
Prof	Tim	Minshull	University of Southampton
	Harriet	Moore	University of Southampton
Prof	Joanna	Morgan	Imperial College London
Dr	Sally	Morgan	International Ocean Discovery Program
	Anthony	Morris	Plymoth University
Dr	David	Naafs	University of Bristol
	Michael	Nairn	Cardiff University
	Amila	Nanayakkara	University of Ruhuna
	Cherry	Newsam	University College London
	Kate	Newton	University of Birmingham
	Matthew	Nichols	University of Southampton
Dr	Uisdean	Nicholson	Heriot-Watt University
	Lauren	O'Connor	University of Oxford
	James	O'Neill	University college london
	Gwen	Owen Jones	National Oceanography Centre, University of Southampton
Prof	Daniel	Parsosns	Universoty of Hull
	Michele	Paulatto	Imperial College London
	Laurence	Phillpot	Leicester University
	Kevin	Pickering	University College London
	Emanuela	Piga	Cardiff University; The Natural History Museum
	Andry Herizo	Rasolomaharavo	Centre Nationale de Recherche Océanographique (CNRO), Madagascar.
	Rebecca	Rimmer	University College London

Dr	Stuart	Robinson	University of Oxford
	Claire	Routledge	University College London
Dr	Micha	Ruhl	University of Oxford
	Ritwika	Sengupta	University of Oxford
Dr	Philip	Sexton	The Open University
	Wen	Shi	The University of Manchester
	Richard	Smith	National Oceanography Centre, University of Southampton
	Amy	Sparkes	Cardiff University
Dr	Stephen	Stukins	The Natural History Museum, London
	Jessica	Surma	NERC
	Vicki	Taylor	University of Southampton
	William	Taylor	University College London
	Damon	Teagle	National Oceanography Centre and School of Ocean & Earth Science, University of Southampton
	David	Thornalley	University College London
Dr	Tina	van de Flierdt	Imperial College London
Prof	Bridget	Wade	University College London
	Michael	Webb	NERC
Prof	Paul	Wilson	University of Southampton
Dr	David	Wilson	Imperial College London
Dr	Jeremy	Young	University College London
	Will Zhongwei	Zhao	The University of Manchester
	Mark	Zindorf	Newcastle University

Glossary

www.iodp.org/acronyms/

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

SAS	Science Advisory Structure
SASEC	Science Advisory Executive Committee
SOC	Science Operating Costs
SPC	Science Planning Committee
SSEP	Science Steering and Evaluation Panel
SSP	Site Survey Panel
STP	Scientific Technology Panel
TAP	Technology Advice Panel
USAC	United States Advisory Committee for Scientific Ocean Drilling
USIO	United States Implementing Organization
USSAC	United States Science Advisory Committee
USSSP	United States Science Support Program

Useful Websites

Integrated Ocean Drilling Programme (UK)

www.ukiodp.bgs.ac.uk

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

ECORD Sites

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

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

IODP Central Sites

IODP Management International Inc. - www.iodp.org

Initial Science Plan for IODP - www.iodp.org/isp

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

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

IODP Implementing Organisations

Centre for Deep Earth Exploration (CDEX) –

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

ECORD Science Operator - www.eso.ecord.org

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

IODP National Offices

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

France - www.iodp-france.org/

Germany - www.iodp.de/

Italy - www2.ogs.trieste.it/iodp/

Netherlands - www.iodp.nl/

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

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

Switzerland - www.swissiodp.ethz.ch

IODP China – www.iodp-china.org/chs/

IODP Korea - www.kodp.re.kr

ODP Australia - www.odp.usyd.edu.au

IODP Related Sites

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

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

International Continental Scientific Drilling Program (ICDP) –

www.icdp-online.org/contenido/icdp/front_content.php

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

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

National Science Foundation - www.nsf.gov

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

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

ODP Legacy Sites

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

Consortium for Ocean Leadershio - www.oceanleadership.org/

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

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

Mid-Ocean Ridge Links

InterRidge Office - www.interridge.org
NOAA Vents Programme - www.pmel.noaa.gov/vents

DeRIDGE - www.deridge.de

Margins Links

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

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

NERC Marine Programmes

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

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

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

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

Completed NERC Marine Programmes

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

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

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

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