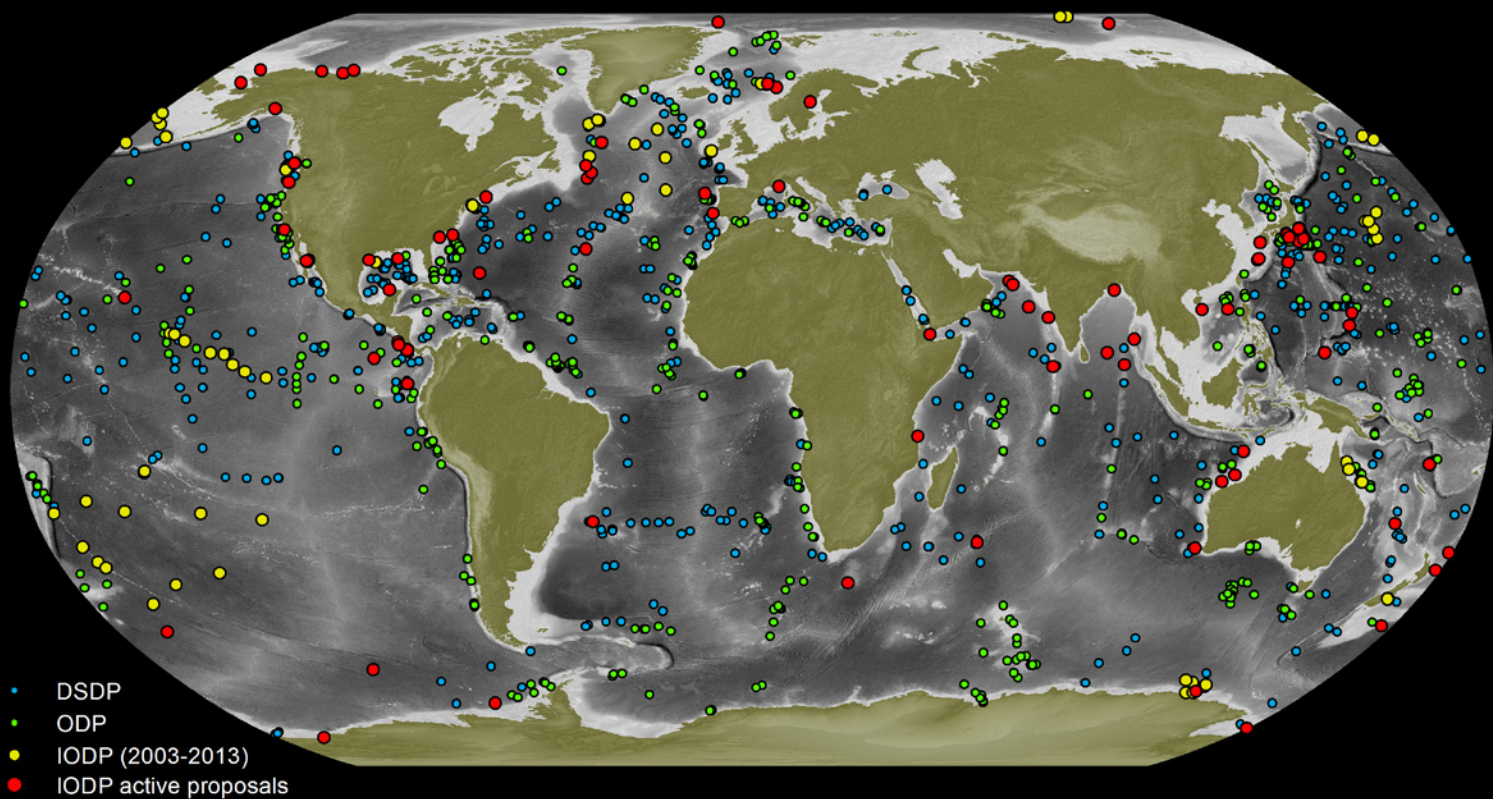
IODP

INTEGRATED OCEAN DRILLING PROGRAM

UK newsletter 38

August 2013

2013–2023: The International Ocean Discovery Program—
the next phase of IODP



NATURAL ENVIRONMENT RESEARCH COUNCIL

ECORD
European Consortium for Ocean Research Drilling

Recent UK based IODP Expedition Participants

Dean Wilson Southampton Exp 338
Jakob Geerson Southampton Exp 338
Kevin Pickering UCL Exp 338
Ian Bailey* NOCS Exp 341
Erin McClymont Durham Exp 341
Christian E. März Newcastle Exp 341
Christopher Smith-Duque Southampton Exp 344
Paola Vannucchi** Royal Holloway Exp 344
Andrew McCaig Leeds Exp 345
Antony Morris Plymouth Exp 345
Susan Gebbles (Outreach) Newcastle Exp 345
Andrew Henderson Newcastle Exp 346
Chuang Xuan* Southampton Exp 346
Martin Ziegler Cardiff Exp 346

*Unable to sail — unanticipated visa delays — still part of Science Party
**Based in US at time of Expedition

Contents

Front cover: Distribution of ocean scientific drilling sites from the Deep Sea Drilling Program (DSDP-*blue*), the Ocean Drilling Program (ODP-*green*), the Integrated Ocean Drilling Program (IODP(2003–2013)-*yellow*), and active drilling proposals for the International Ocean Discovery Program (IODP (2013–2023)-*red*).
Back cover: 2012 UK-IODP Student and Early-Career Scientist Workshop participants. Chicheley Hall. Copyright: UK-IODP.

Editor: Dayton Dove, British Geological Survey, Edinburgh, EH9 3LA
Graphic design: Debbie Rayner

Foreword

Dayton Dove (UKIODP Science Programme Coordinator)), Jessica Surma (Programme Manager-NERC), Mike Webb (Programme Executive Officer, NERC), and the UK-IODP Programme Advisory Group (see p. 42 for membership).

Scientific ocean drilling is arguably the most successful long-running international science collaboration. The ocean floor preserves records of the plate tectonic cycle which continuously repave the surface of Earth, grows continents, and recycles elements within our planet. Plate boundaries within the oceans are the locus for many of the most dynamic and devastating volcanic and tectonic processes but also future energy and minerals resources. The sediments that blanket the igneous rocks of the ocean floor provide high fidelity of records of past climate, the growth and stability of ice sheets, sea-level and rates of sea-level change, biogeochemical cycles and seawater chemistry, atmospheric chemistry including CO_2, and the evolution and resilience of marine life.

Scientific ocean drilling is essential for deep Earth sampling to test models and remote geophysical observations, and to collect high resolution records of the past Earth system. Ocean drilling complements ice core and lacustrine records of climate by providing records from the modern into deep time (~200 Ma) and over far greater geographic distributions.

Largely as a result of its participation in IODP, the UK is now world leading in research into palaeo-oceanography, deep-sea sediment biodiversity and the long-term evolution of ocean basins and the Earth's climate. Participation in IODP is spread widely amongst the UK Earth science community within UK universities and research institutes.

From October 2013 through 2023, IODP will be the International Ocean Discovery Program. The UK participates in IODP through the European Consortium for Research Drilling (ECORD), and ECORD now has MOU's for future involvement e.g. scientific berths, in the programme with the other implementing organizations in the US and Japan (see p. 42 for further detail). Over the next 10 years there should be at least as many, though likely more berths available to ECORD, and by extension UK scientists, as there was in the preceding phase of IODP (2003–2013).

Commensurate with the renewal of the international programme, NERC's directed UK-IODP research programme has also been renewed for 2013–2018. Following the evidence gathering campaign over the last couple years, the programme's renewal was recently accepted by NERC Council, and the UK-IODP management office is busy refining the structure of the new programme. Unfortunately, we have lost the pot of 'ring-fenced' grant funding, but this is being replaced by post-cruise funding for all cruise participants. Site-Survey grant rounds have been continued, and there will be a part-time Knowledge Exchange Fellow to improve the links between the research and business communities.

With 13 expedition participants over the last year, and at least 100 IODP-related publications by UK authors, the UK-IODP scientific community is in very good shape. Over the past year we held a General UK-IODP conference as well as a three-day Student and Early-Career Scientist Workshop which turned out to be a fantastic event, buoyed by the expertise and enthusiasm of the participating scientists. Enclosed within this year's newsletter are many, and varied examples of the excellent research and training associated with IODP. At the advent of the new international and domestic programmes, all signs point to the continued importance, and success of scientific ocean drilling.

Scientific Results from Recent Expeditions

Expedition 342: Paleogene Newfoundland Sediment Drifts

1 June 2012 – 30 July 2012 Bermuda to St Johns

Philip F Sexton (The Open University), Paul A Wilson (University of Southampton), Paul R Bown (University College London), Diederik Liebrand (University of Southampton)

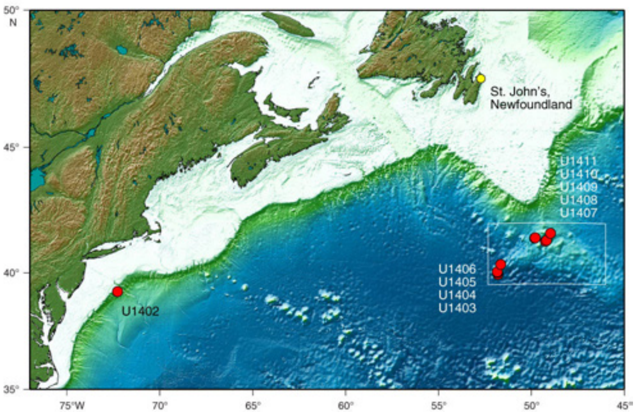
1 Scientific Motivation

In searching for insight into future anthropogenic climates from the geological record it is critical that we target records that have adequate fidelity to study the processes that we seek to understand. A long-standing approach to reconstructing Paleogene and Cretaceous palaeoclimates has been to drill sediments that record the long sweep of Earth's history. This methodology has allowed reconstruction of ocean climate and ecosystem changes over the past ~165 m.y. and has allowed many 'extreme climate' events to be placed into context both with respect to broad climate trends and increasingly well resolved chronologies. These sorts of records, however, necessarily involve a trade-off between outlining long histories and understanding ocean dynamics on timescales similar to (or shorter than) the ~1500 year mixing time of the ocean. The majority of recent work on Pliocene–Pleistocene climate dynamics has addressed this by targeting archives with finely resolved chronologies (millennial to century scale) and, in the case of ocean sediments, high deposition rates. This focus on highly resolved records has the potential to reveal dynamics that operate on timescales that have relevance to human society. Expedition 342 is founded on the objective of extending this dynamics-focused approach, for the first time, into the archives of the past greenhouse Earth.

Integrated Ocean Drilling Program Expedition 342 was designed to recover Paleogene sedimentary sequences with unusually high deposition rates in comparison to the modest rates of accumulation (~0.5–1 cm/k.y.) typical of Paleogene deep-sea sediments. We targeted 'sediment drifts' that accumulate faster than typical deep-sea sediments to enable us to reconstruct the history of a warm Earth with unusual fidelity. A related objective was to acquire these records along a depth transect of drill sites across a wide range of water depths (Sites U1403–U1411) (Figure 1). Because the ocean is layered, with different water masses formed in various regions around the world arranged above one another, our depth transect of drill sites will permit a detailed reconstruction of the chemistry, circulation, and history of greenhouse Earth's oceans. The drilling area (Figure 1) was positioned to capture sedimentary and geochemical records of ocean chemistry and overturning circulation beneath the flow of the Deep Western Boundary Current in the northwest Atlantic Ocean. A further target of the expedition was to reconstruct the Paleogene carbonate compensation depth (CCD) in the North Atlantic to enable comparison with recently obtained high-fidelity records of the CCD in the equatorial Pacific (IODP Expedition 320 and ODP Leg 199; Palike *et al.*, 2012).

Figure 1.
Operational area of Expedition 342. Red circles show the Expedition 342 drill sites and the white box indicates the area of the multibeam bathymetry survey. The expedition left from Bermuda (not on map) and ended in St. Johns, Newfoundland (yellow circle).

A



In addition to an unusually detailed climate history and a detailed assessment of the structure and circulation of the warm-world ocean, a third major objective of Expedition 342 was to recover clay-rich sequences with well-preserved microfossils suitable for palaeoceanographic reconstructions using trace element and isotope geochemistry, and faunal studies to examine ecology, ecosystem functioning and evolution on a warm Earth.

2 Shipboard Results

Five principal sedimentary sequences are evident on the Newfoundland ridges, bounded by seismic reflection Horizons A–D (Figures 2, 3). One of the main advantages of drilling the Newfoundland sediment drift complex is the near-absence of Neogene sedimentary cover (Figure 2). Most areas were swept by sufficiently strong currents during the later Cenozoic to prevent extensive deposition of younger strata on the southern side of the ridges or in patches around the seamounts. The packages of older sediment are characterized by remarkable thickness, absence of internal seismic reflectors and drift morphology, suggesting an expanded Paleogene section (Figures 2, 3), with sedimentation rates much higher than the 1–2 cm/k.y. typically encountered in the deep sea. We targeted Paleogene drifts that are not deeply buried (Figure 2) and so can be accessed using the IODP advanced hydraulic piston coring system and are likely to host well-preserved microfossils.

Expedition 342 is focused on the Paleogene record on the J-anomaly and Newfoundland ridges (Figure 2). Furthermore, our particular area of focus was the middle Eocene to Oligocene interval where thick sediment drift deposits (Figures 2, 3) preserve unusually expanded records of the transition from the greenhouse world of the Eocene climatic optimum to the glaciated world of the Oligocene.

Expedition 342 drill sites are in plastered drifts that exist in two places: (1) the southern flank of J-Anomaly Ridge and (2) the slopes of seamounts on Southeast Newfoundland Ridge (Figures 1, 2). Both accretionary drifts and plastered drifts have formed adjacent to passages between bathymetric highs, most commonly on the northeastern and southwestern sides of seamounts. Some of these drifts are highly localized features that form lenticular bodies whose long axis extends over a depth gradient of >1000 m in some cases, which gives them their typical 'slug-like' appearance on seismic reflection profiles (Figure 2). Other drifts are clearly accretionary features that have built toward moats adjacent to seamounts.

Expedition 342 cored four of these drift sequences, each covered by a thin veneer of Pliocene and Pleistocene, or sometimes

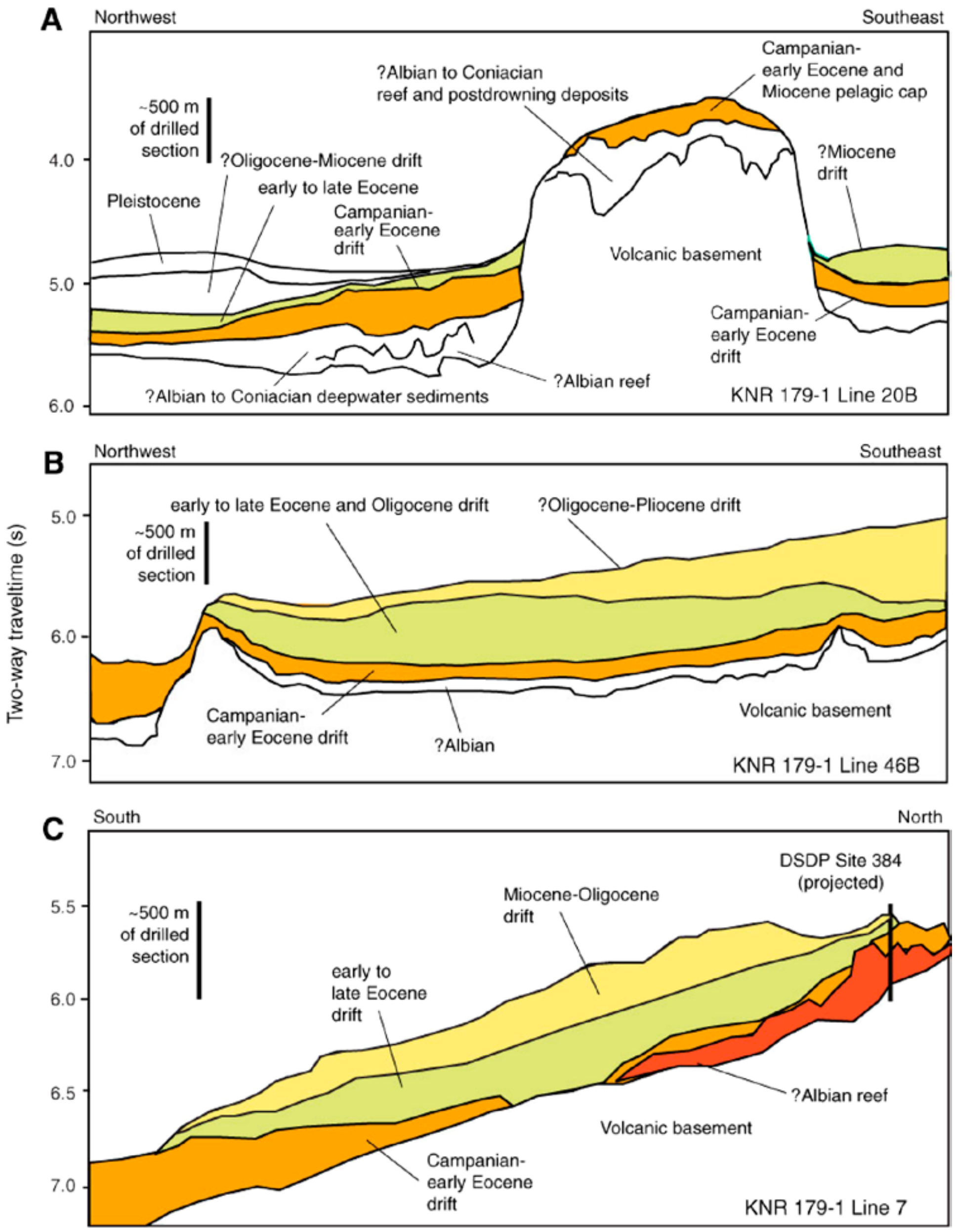


Figure 2.
Interpreted seismic records from (A) Southeast Newfoundland Ridge seamount area, (B) Southeast Newfoundland Ridge eastern end, and (C) J-Anomaly Ridge. The approximate age range of the various seismic units are shown in different colors. Note the large variations in thickness and distribution of drift packages.

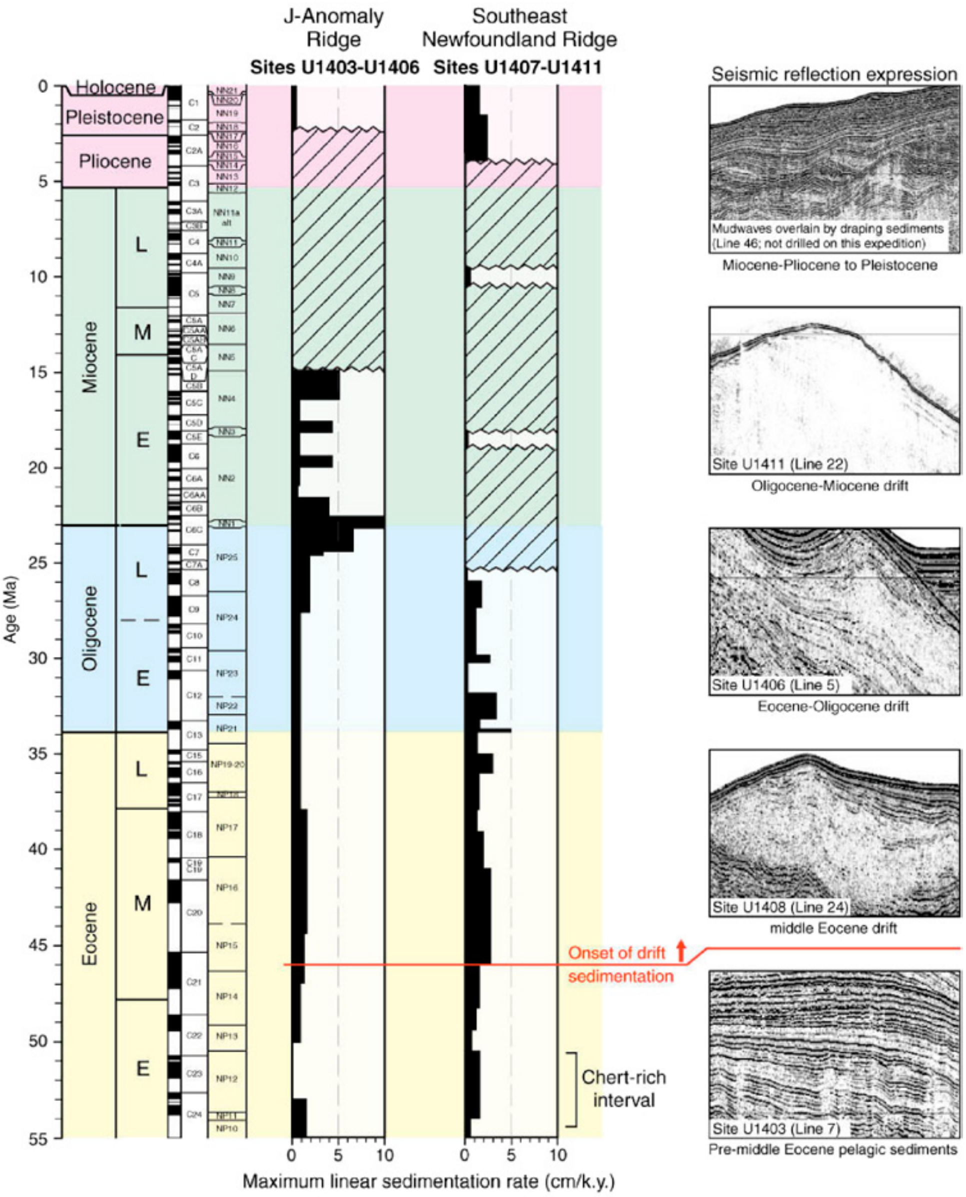


Figure 3.
Generalized Paleogene to early Neogene history of drift sedimentation at J-Anomaly Ridge and Southeast Newfoundland Ridge with images of the acoustic expression (right side of figure) of each major lithostratigraphic unit. Sedimentation rates refer to maximum linear sedimentation rate as determined from age-depth plots combined from the multiple sites in each of the two areas. Hatched areas represent hiatuses or intervals where age cannot be determined. Onset of drift sedimentation interpreted from combination of oldest occurrence of distinctive greenish gray clay-rich lithology and relatively high sedimentation rates.

Miocene to uppermost Oligocene, sediment. The sites in the deepest water were drilled on J-Anomaly Ridge, where drilling encountered a carbonate-rich Cretaceous to Paleocene sequence overlain by a clay-rich Eocene to lower Miocene sequence (Sites U1403–U1406) (Figure 2). Three further drifts were drilled on the crest of Southeast Newfoundland Ridge, near the wreck of RMS *Titanic*. Each of these drifts appears to preserve a middle Eocene to Lower Cretaceous sequence overlying an Albian or older reef complex (Figure 2). Coring at Sites U1407 and U1408 recovered much of this sequence in one of the drifts. Coring in another drift (Sites U1409 and U1410) focused on the younger, middle Eocene to Palaeocene portion of the record. Finally, Site U1411 targeted still another drift that proved to have a highly expanded record of the upper Eocene and Oligocene overlying an uncored section that is likely of middle Eocene age.

Results from Expedition 342 indicate that the onset of drift deposition, dates to the early middle Eocene (~47 Ma) at both J-Anomaly Ridge and Southeast Newfoundland Ridge (Figure 3). This result closely matches new findings of the timing of drift onset in the Greenland-Scotland Ridge basins of the northeast Atlantic (Hohbein *et al.,* 2012). Insignificant thicknesses of late Miocene to Pliocene age drift deposits were recovered during Expedition 342, but it is important to reiterate that the drilling strategy was to avoid thick accumulations of Neogene sediments in order to access and recover Paleogene sediments with the APC (Figure 2). Seismic reflection data indicate that many areas on the Southeast Newfoundland Ridge have Neogene drift accumulations that are several hundreds of meters in thickness.

We created high-quality spliced records of most of the sites on Southeast Newfoundland Ridge that penetrate sequences with carbonate-rich lithologies. As anticipated, the task of creating spliced records in the more clay-rich lithologies at some sites was not straightforward due to intervals of low-amplitude change in some physical properties data sets. All sites also proved to have differences in stratigraphy between adjacent holes showing that there is often considerable local variation within the drift sequences. Particularly expanded sedimentary sequences were drilled in Miocene–Oligocene, Eocene–Oligocene, and middle Eocene sequences (Figure 3).

3 Initial Findings and Highlights

Expedition 342 to the Newfoundland sediment drifts was a ground-breaking expedition that achieved both record IODP recovery in mid-Cretaceous to Miocene sediments as well as overall core recovery. In total, 5724 m of sediment was cored, of which 5413 m was recovered (average 94%) in 25 APC/XCB holes across 10 sites (U1402 to U1411). Sediment of Paleogene age, our main objective, makes up the majority of our recovery including particularly spectacular records of the Eocene together with Paleocene/Eocene, Eocene/Oligocene and Oligocene/Miocene boundaries.

Notable findings include the discovery of intermittent calcareous sediments in the Cretaceous, Paleocene, and early to middle Eocene at 4.5 km palaeo-water depth, suggesting that the Atlantic CCD was deeper than expected during these times. We find evidence of carbonate deposition events following the Cretaceous/Paleogene (K/Pg) boundary mass extinction, the Paleocene/Eocene thermal maximum, and the Eocene–Oligocene transition. These deposition events may reflect the rebalancing of ocean alkalinity after mass extinctions or abrupt global climate change. Intervals during which the CCD appears to have been markedly shallow in the North Atlantic include the Early Eocene climatic optimum, the late Eocene, and the middle Oligocene.

As anticipated, Expedition 342 recovered sequences with sedimentation rates up to >15 cm/k.y. - high enough to enable studies of the dynamics of past abrupt climate change, including both transitions into 'greenhouse' and 'ice-house' climate states, the full magnitudes of hyperthermal events, and rates of change in the CCD. We find that the thickest, central parts, of the various sediment drifts typically record similar depositional packages to those recovered in the thin 'noses' and 'tails' of these drifts, but these central parts are often greatly expanded with clay, especially near the CCD. Times of rapid accumulation of drift deposits include the early middle Eocene to late middle Eocene, the late Eocene to early Oligocene, the late Oligocene and early Miocene, the later Miocene to probable late Pliocene, and the Pleistocene.

An unexpected finding was the recovery of a number of Cretaceous 'critical boundaries'. These include the K/Pg boundary (Figure 4), the Campanian–Coniacian interval, the Cenomanian–Turonian boundary and oceanic anoxic event (OAE) 2, and the

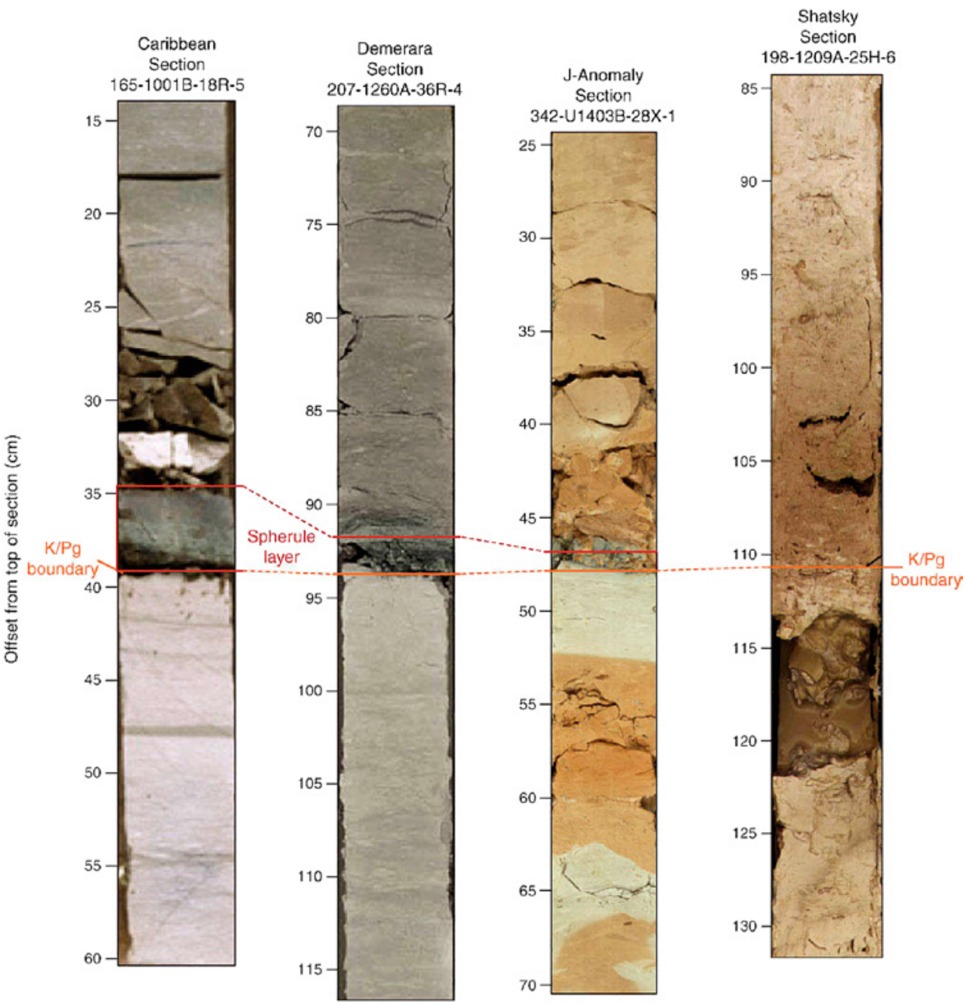


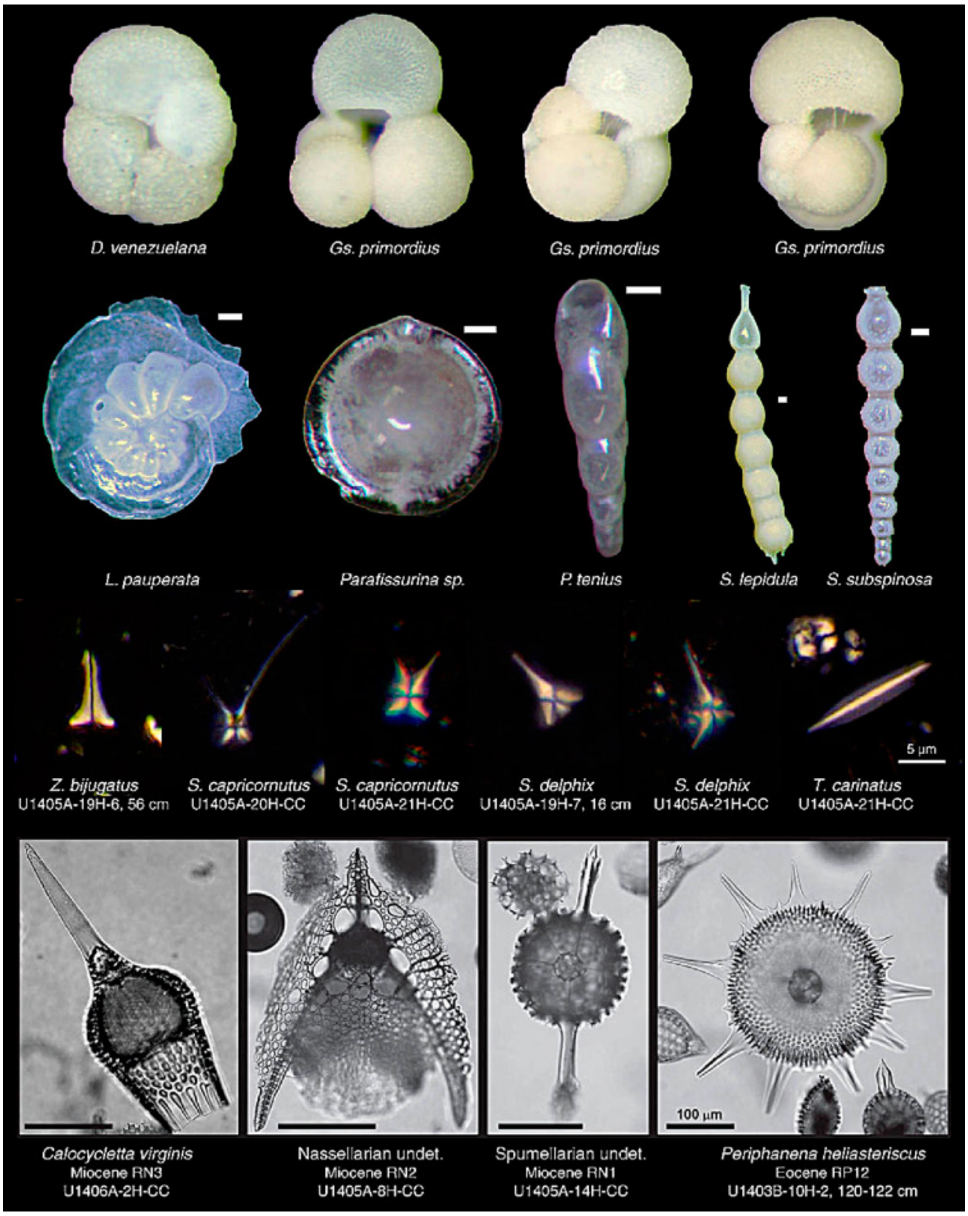
Figure 4.
Core images of Cretaceous/Paleogene (K/Pg) boundary sections showing a range of spherule bed thickness. Spherule bed thickness ranges from >8 cm thick at sites proximal to the impact (e.g. Caribbean ODP Site 1001) to not observed in very distal sites with bioturbation (Shatsky Rise ODP Site 1209).

Albian/Cenomanian boundary OAE 1d. These intervals were drilled opportunistically when they were encountered near or above our target depth for a given site.

A major objective of Expedition 342 was the recovery of high–accumulation rate, clay-rich sediments containing well-preserved microfossils. A major expedition highlight is the recovery of intervals and sites containing assemblages of calcareous and siliceous microfossils exhibiting exceptional preservation (Figure 5). These coincided with, in the case of calcareous flora and fauna, the intervals with the highest sedimentation rates, such as the Oligocene/Miocene boundary interval, the middle Eocene sequence and the Eocene/Oligocene transition. The presence of holococcoliths and minute coccoliths is an indicator of high quality preservation (Bown *et al.,* 2008), and the conspicuous occurrence of these is coincident with observations of 'glassy' (Sexton *et al.,* 2006) planktonic foraminifers at Sites U1403, U1405, U1408, U1410, and U1411 (Figure 5). The best-preserved calcareous microfossil assemblages recovered are virtually unprecedented in deep-sea sections (Sexton *et al.,* 2006) and have been previously found only in shelf environments with clay deposits (e.g. Tanzania, Gulf Coast) (Pearson *et al.,* 2001; Bown *et al.,* 2008). Expedition 342 material will allow shore-based studies of major expedition objectives (e.g. climate sensitivity to greenhouse gas forcing and floral and faunal turnover) to proceed effectively free of the usual concerns over taphonomic bias.

A further main objective of the expedition was to obtain records of the Eocene that can be used to link the astronomical timescale developed for the last ~40 m.y. (Pälike and Hilgen, 2008) to the floating timescale of the early Paleogene developed over a series of IODP and earlier drilling expeditions. Expedition 342 sites not only record well-developed cyclicity bundled into familiar orbital periods but also show promise for the development of magnetostratigraphy and refined biochronology.

Figure 5.
Images of exceptionally well preserved microfossils from J-Anomaly Ridge Sites U1403, U1405, and U1406. Examples include glassy planktonic and benthic foraminifers and fragile and dissolution-susceptible nannofossils. Top row: lower Miocene (Zone M1b) planktonic foraminifers revealing semi-glassy taphonomy and even the presence of relict spines within the umbilici (Samples 342-U1405A-13H-6, 100–102 cm; 15H-2, 100–102 cm; 15H-CC; and 16H-CC). Second row: benthic foraminifers (Samples 342-U1405A-15H-6, 100–102 cm; 19H-6, 100–102 cm; 15H-2, 100–102 cm; 14H-6, 70–72 cm; and 15H-6, 100–102 cm). Third row: calcareous nannofossils. Fourth row: radiolarians. All images are at the same magnification.



4 Post-Cruise Research Initiatives

The material that we have recovered makes it possible to address all of these scientific objectives as well as some unanticipated ones:

- The long-term history of change in the CCD in the North Atlantic Ocean over the past 100 m.y.
- The amplitude of rapid CCD change associated with extreme perturbations to the Earth system (e.g. the K/Pg mass extinction, the PETM, and the Eocene–Oligocene transition).
- The amplitude, frequency, and cause of Paleogene and Cretaceous hyperthermal and hypoxic events, and the related response of the hydrological and terrestrial system.
- Changes in deep-sea ventilation, vertical ocean structure, and circulation in the North Atlantic in the Eocene greenhouse.
- The timing of the initiation of sediment drift formation in the North Atlantic.
- Climate sensitivity to changes in atmospheric greenhouse gas concentrations under contrasting baseline climate conditions.
- The stability of climate, ice sheets, and biotic systems at orbital and millennial scales in the pre-Pliocene–Pleistocene North Atlantic.
- The stability of Cenozoic ice sheets and the pre-Pliocene history of glaciation in the northern hemisphere.

Finally, comparison of our drilling results with seismic stratigraphy from the Southeast Newfoundland Ridge indicates large-scale lateral changes in age and thickness of sediment drift packages, regionally, meaning that the area presents an attractive target for future expeditions aimed at recovering high deposition–rate records from many parts of the Cenozoic.

References

Bown, P.R., Dunkley Jones, T., Lees, J.A., Randell, R.D., Mizzi, J.A., Pearson, P.N., Coxall, H.K., Young, J.R., Nicholas, C.J., Karega, A., Singano, J., and Wade, B.S. 2008. A Paleogene calcareous microfossil Konservat-Lagerstätte from the Kilwa Group of coastal Tanzania: *Geol. Soc. Am. Bull.*, 120(1–2):3–12. doi:10.1130/B26261.1

Hohbein, M.W., Sexton, P.F., and Cartwright, J.A. 2012. Onset of North Atlantic Deep Water production coincident with inception of the Cenozoic global cooling trend. *Geology*, 40(3):255–258. doi:10.1130/G32461.1

Lourens, L.J., Sluijs, A., Kroon, D., Zachos, J.C., Thomas, E., Röhl, U., Bowles, J., and Raffi, I. 2005. Astronomical pacing of late Palaeocene to early Eocene global warming events. *Nature*, 435(7045):1083–1087. doi:10.1038/nature03814

Pälike, H., and IODP Expedition 320/321. 2012. A new Cenozoic record of equatorial Pacific carbonate accumulation rates and compensation depth. *Nature,* 488: 609–615. doi:10.1038/nature11360

Pälike, H., and Hilgen, F. 2008. Rock clock synchronization, *Nature Geoscience* 1, 282, doi:10.1038/ngeo197

Pearson, P.N., Ditchfield, P.W., Singano, J., Harcourt-Brown, K.G., Nicholas, C.J., Olsson, R.K., Shackleton, N.J., and Hall, M.A. 2001. Warm tropical sea surface temperatures in the Late Cretaceous and Eocene epochs. *Nature*, 413(6855):481–487. doi:10.1038/ 35097000

Sexton, P.F., Norris, R.D., Wilson, P.A., Pälike, H., Westerhold, T., Röhl, U., Bolton, C.T., and Gibbs, S. 2011. Eocene global warming events driven by ventilation of oceanic dissolved organic carbon. *Nature*, 471(7338):349–352. doi:10.1038/nature09826

Sexton, P.F., Wilson, P.A., and Pearson, P.N. 2006. Microstructural and geochemical perspectives on planktic foraminiferal preservation: 'glassy' versus 'frosty'. *Geochem., Geophys., Geosyst.*, 7:Q12P19. doi:10.1029/2006GC001291

Expedition 341: Southern Alaska margin: interactions of tectonic, climate and sedimentation

29 May 2013 – 29 July 2013

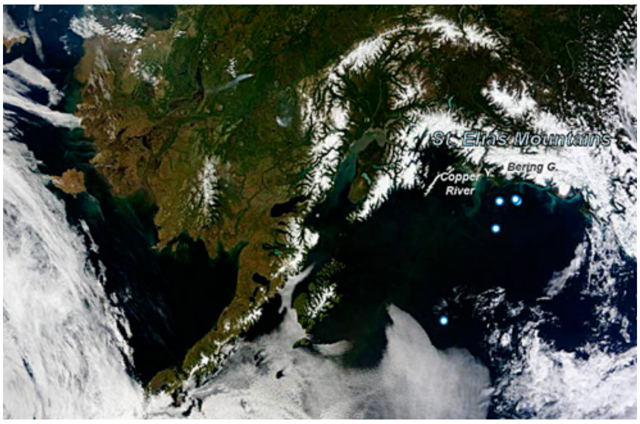
Erin McClymont (Durham University), Christian März
(Newcastle University) and the IODP Expedition 341 Science

Scientific motivation

Over the last 65 million years, the global climate has become colder and experienced increased variability on orbital timescales. This long-term trend culminated with the development and expansion of major Northern Hemisphere continental ice sheets associated with the transition into the Pleistocene epoch c. 2.6 million years ago (Ma). This same time window is associated with an increase in erosion rates and supply of sediment to basins. Recent research has demonstrated that there is a complex interplay between mountain building, erosion, and climate change. For example, local and regional climate change can be affected by tectonic processes, e.g. through enhancing orographic precipitation patterns and intensity. In addition, the development of the large Northern Hemisphere ice sheets over the last 3 million years has been linked to global and regional climate transitions including ocean circulation change. However, the links between mountain building, the development of more erosive glaciated regimes, and climate transitions have not been fully established.

The aim of Expedition 341, led by John Jaeger (University of Florida) and Sean Gulick (University of Texas at Austin), is to assess the linkages between global climate change, erosion and tectonics from the late Miocene to the present day, using the Gulf of Alaska as the

Figure 1a.
A rare clear satellite image of Alaska taken during the expedition, 17 June 2013. The glaciated St. Elias orogen is visible, as well as the plumes of sediment flowing from the Copper River into the Gulf of Alaska. Expedition 341 drill sites are marked (white circles). Figure adapted from NASA Earth Observatory (http://earthobservatory.nasa.gov/IOTD/view.php?id=81416&src=iotdrss), with original NASA image courtesy of Jeff Schmaltz, LANCE MODIS Rapid Response Team at NASA GSFC.



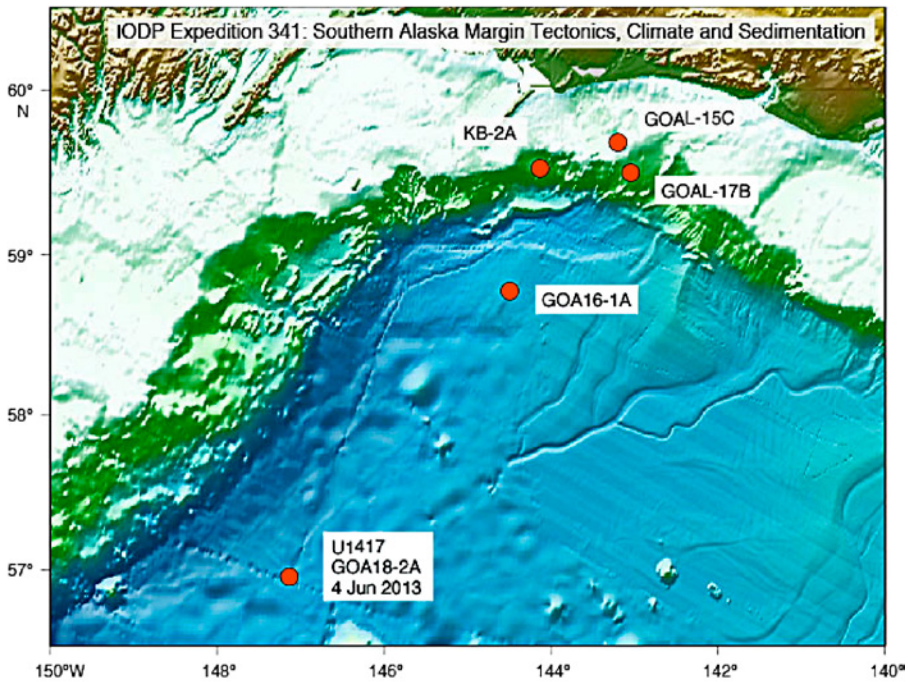


Figure 1b.
Proposed and ongoing coring sites for Expedition 341. Site GOA18-2A (U1417) is the most distal site and will provide the longer-term (Miocene-Pleistocene) perspective on climate and ice-sheet changes. Site KB-2A is a shallow and proximal site where there is potential for millennial-scale climate variability in ocean circulation and nutrient cycling to be obtained. The remaining sites will focus on understanding the signal of orogenesis, erosion, glaciation and the links with the climate signals obtained from GOA18-2A and KB-2A. Adapted from Jaeger et al. (2011).

study area. To the north and east lies the St. Elias orogen, less than 10 million years old but the highest coastal range globally (Figure 1a). It developed during a time of overall climate cooling and ice-sheet expansion, and the sediments eroded from the orogen have been deposited offshore but in a relatively confined area (the Surveyor Fan, Figure 1b). There is evidence that the northwest Cordilleran ice sheet (NCIS) may have developed in the St. Elias range as early as 6 Ma, several million years before the major expansion of the northern hemisphere ice-sheets c. 3 Ma. As a result, extensive sedimentary sequences have developed, with accumulation rates exceeding 1 km Ma^{-1} in some of the proximal sites. Some of these sedimentary sequences can also be traced onshore, and distinct geological units within the St. Elias orogen itself offer the opportunity to track the source regions of this sediment and how their contributions have changed through time.

A cross-margin transect is being drilled during Expedition 341 (Figure 1), which will provide detailed records of changes in the locus and magnitude of glacial erosion, degree of tectonic shortening, the timing of NCIS onset, its relationship to regional climate change, and sediment and freshwater delivery to the coastal ocean and their impact on oceanographic conditions in the Gulf of Alaska (Jaeger *et al.,* 2011). The major objectives of Expedition 341 are to:

1. Document the tectonic response of an active orogenic system to late Miocene to recent climate change.

2. Establish the timing of advance and retreat phases of the northwest Cordilleran ice sheet to test its relation to dynamics of other global ice sheets.

3. Implement an expanded source-to-sink study of the complex interactions between glacial, tectonic, and oceanographic processes responsible for creation of one of the thickest Neogene–Quaternary high-latitude continental margin sequences.

4. Understand the dynamics of productivity, nutrients, freshwater input to the ocean, and surface and subsurface circulation in the northeast Pacific and their role in the global carbon cycle.

5. Document the spatial and temporal behaviour during the Neogene of the geomagnetic field at extremely high temporal resolution in an under-sampled region of the globe.

Shipboard activities

At the time of writing, we are on board the JOIDES *Resolution*, drilling at Site U1417 in more than 4 km water depth (Figure 1). An international Science Party has been assembled, representing 11 countries and including recent IODP signatory, Brazil. We are both sailing as part of the shipboard geochemistry group (with Atsunori Nakamura, Japan, and Glaucia Berbel, Brazil), with duties including sampling the sediments for headspace gases, interstitial water chemistry, and bulk sediment geochemistry at all sites. After a short and smooth transit from Victoria, British Columbia, we started drilling Site U1417A on 5 June in calm seas, before our sea legs (and drilling operations) were briefly tested as we moved onto Hole U1417B.

The aim of this first site is to provide a continuous record of climate and tectonic history that extends into the Miocene. Site U1417 is a re-drill of DSDP Site 178 (drilled in 1973), which suffered from poor recovery in sediments older than c. 1 Ma due to the combination of rotary drilling and interval coring techniques used. So far, the expedition has successfully recovered five holes from Site U1417. This was achieved using hydraulic piston coring (APC), including a newly developed 'APC half corer' to allow for high quality APC core recovery from even deeper sediments. Drilling with both the extended core barrel (XCB) and rotary core barrel (RCB) was also successful beyond APC refusal. Despite some difficulties recovering full cores from the deeper, spatially heterogeneous glaciomarine units, the drilling strategy has already significantly improved upon the recovery of Pleistocene and Pliocene sediments from DSDP Site 178. Preliminary data indicates that we have sediments spanning the Pleistocene and Pliocene, and this site is slated to recover

Figure 2.
John Jaeger (Co-Chief), Sean Gulick (Co-Chief) and Chris Moy (Sedimentologist) investigating a sediment core recovered from Site U1417 (GOA18-2A). Credit: Erin McClymont.

Figure 3.
Co-Chief Sean Gulick is interviewed during a ship-to-shore broadcast, with Education and Outreach Officer Alison Mote. Credit: John Beck, IODP/TAMU.

Miocene sections and the oceanic basement. Sediments include both marine and terrigenous components (mud, dropstones, diatom oozes, thin ash beds, turbidites). A suite of palaeomagnetic and biostratigraphy data has provided a consistent chronology, and the stratigraphic correlators have been successful in creating a composite depth section. The site looks promising for recording evidence for long-term climate evolution and making links to ice sheet growth, orogenesis and erosion onshore. We will now move closer to shore and start drilling in shallower sites in the heart of the Surveyor Fan and on the continental slope and shelf (Figure 1).

Expedition 341 has also been busy with a range of Education and Outreach activities taking place on board. These have been led by Carol Larson (National Aquarium of New Zealand) and Alison Mote (The Ann Richards School for Young Women Leaders), and we've both been able to participate in events linking to both UK and international audiences. The Outreach activities have included ship-to-shore broadcasts with schools, question and answer sessions with school students, and regular blogs made by us and by the Education and Outreach officers (see www.joidesresolution.org). Christian will also participate in the 'I'm a scientist get me out of here' programme (and eagerly awaits to hear whether he won the competition), and we will speak with students from our home region in the North-east of England via the 'Big Bang' Science Fair held in Newcastle.

Specific objectives for our post-cruise research

In collaboration with the Expedition 341 Science Party, and depending on sediment recovery, our post-cruise research will focus on the following analyses:

To constrain the magnitude and timing of ocean circulation and primary productivity changes in the NE Pacific over the last 4 Ma associated with the mid-Pliocene warm period, onset of northern hemisphere glaciation, and the mid-Pleistocene transition. Higher temporal resolution (but shorter) records will be targeted in one of the proximal cores. Analyses will reconstruct sea surface temperatures, sea ice, marine production and marine production using both organic (biomarker) and inorganic geochemistry methods.

To identify sediment inputs with terrestrial origin, and constrain the timing and provenance of changes in these inputs. This approach will use both biomarkers specific to terrestrial organic compounds, and inorganic elements related to terrigenous input from various continental source areas.

To establish a long-term record of bottom water redox conditions in the Northeast Pacific since the Miocene, making use of trace metal and iron speciation analyses. This record will be linked to reconstructions of the cycling, burial, and diagenesis of key nutrients (Fe, P) that might have impacted redox conditions by controlling primary productivity and organic matter export to the sea floor.

*** IODP Expedition 341 Science Party**

J. Jaeger (University of Florida), S. Gulick (University of Texas), L. Schneider (Texas A&M University), A. Slagle (Columbia University), L. Drab (Columbia University), H. Asahi (Pusan National University), H. Bahlburg (Universität Münster), C. Belanger (South Dakota School of Mines and Technology), G. Berbel (Universidade de São Paulo), L. Childress (Northwestern University), E. Cowan (Appalachian State University), M. Davies (The Australian National University), Fabiana Ribeiro Dottori (Universidade de São Paulo), M. Forwick (Universitetet i Tromsø), A. Fukumura (Nagoya University), S. Ge (State Oceanic Administration), S. Gupta (National Institute of Oceanography, Goa), A. Kioka (University of Tokyo), S. Konno (Kyushu University), C. Larson (National Aquarium of New Zealand), C. März (Newcastle University), K. Matsuzaki (Tohoku University), E. McClymont (Durham University), A. Mix (Oregon State University), A. Mote (The Ann Richards School for Young Women Leaders), C. Moy (University of Otago), J. Müller (Alfred Wegener Institute), A. Nakamura (University of Tokyo), T. Ojima (University of Tokyo), K. Ridgway (Purdue University), O. Romero (Universidad de Granada), J. Stoner (Oregon State University), G. St-Onge (Université du Québec à Rimouski), I. Suto (Nagoya University), L. Worthington (University of New Mexico).

References

Jaeger, J., Gulick, S., Mix, A., and Petronotis, K. 2011. Southern Alaska margin: interactions of tectonics, climate, and sedimentation. *IODP Scientific Prospectus*, 341. doi:10.2204/iodp.sp.341.2011

Shipboard Scientific Party. 1973. Site 178. *In* Kulm, L.D., von Huene, R., *et al.,* (Eds.), Initial Reports of the Deep Sea Drilling Project, Volume 18, Washington (U.S. Government Printing Office), 287–376.

Expedition 343: Japan Fast Drilling Project (JFAST), Rapid Response to the Tohoku Earthquake

1 April 2012 – 24 May 2013

Becky Cook (University of Southampton)

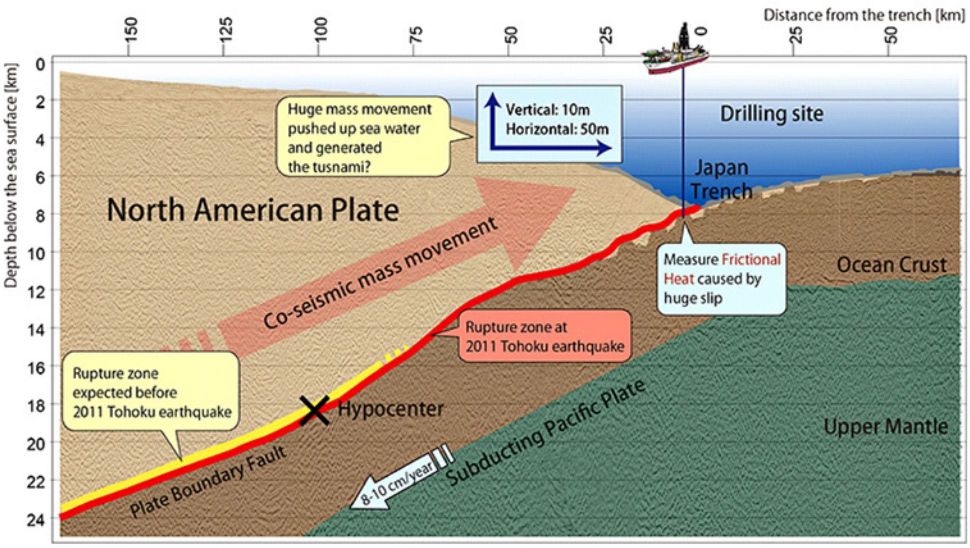
On 11 March 2011, a Mw=9.0 earthquake ruptured the Tohoku segment of the Japan Trench subduction zone. Earthquake slip models and repeat bathymetric surveys show strong evidence of large (up to 50 m) shallow coseismic slip which resulted in a devastating tsunami. Prior to the 2011 Tohoku earthquake, slip along the shallow subduction megathrust was thought to occur stably as aseismic, slow creep but the strong evidence for shallow coseismic slip has led to a re-evaluation of slip behaviour on shallow subduction zone plate boundary faults. The Japan Trench Fast Drilling Project (JFAST), IODP Exp. 343, was mobilised to aid in understanding the enigma of shallow slip, and to understand the frictional and physical properties of the plate boundary and microstructures resulting from such shallow slip. The main goals of JFAST were to understand the stress conditions, frictional and physical properties that allowed for such shallow slip, and the resultant microstructures. To accomplish these goals the expedition drilled three boreholes: a logging-while-drilling (LWD) hole, C0019b; a core hole, C0019e; and an observatory hole, C0019d.

The expedition set sail from Shimizu Port on 1 April 2012 with Mount Fuji standing proudly behind; there was a certain excitement in the air as everyone knew we were embarking on an expedition that would push the boundaries of ocean drilling. It soon became apparent that when you push the boundaries, it won't always go as you planned. The first 22 days of the expedition were plagued with bad weather and equipment troubles, but it did allow the science party to settle in to ship life. A daily science meeting and seminar series allowed the science party to share their research interests and included very useful talks on analogue fault drilling projects from Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE), San Andreas Fault Observatory at Depth (SAFOD), Taiwan Chelungpu-fault Drilling Project (TCDP) and Alpine Fault Deep Fault Drilling Project (DFDP). During the downtime we also had plenty of other activities to keep from going stir crazy including a ship tour, movie screenings, a ping pong tournament, calligraphy lessons and a tea ceremony.

Spudding of the second hole, C0019b, on day 23 marked the start of data collection. The record for deepest total length from the ocean surface for a research borehole (7049.5 m, set by DSDP Leg 60, Hole 461A in the Marianas Trench in 1978) was surpassed at 09:16 on 23 April and the following days were spent with the science party gathered around a monitor displaying the real-time gamma ray and resistivity logs. A total depth of 7740 metres below sea level (mbsl) was reached on 25 of April when the rate of penetration dropped to near zero, indicating we had likely reached the basal chert layer observed at the reference site (DSDP Leg 56, Hole 436). After retrieval of the tool string the logging team began analysis of the gamma ray, resistivity and resistivity-at-bit (RAB) image logs. Four logging units and two possible faults at ~720 and 820 metres below sea floor (mbsf) were identified in the borehole (see Chester *et al.*, 2012).

The next hole, C0019c, was planned as the observatory hole but had to be abandoned due to break in the pipe and a loss of the

Schematic cross-section through the 11 March 2011 earthquake rupture area and IODP Exp. 343 drill site (from http://www.jamstec.go.jp/chikyu/exp343/e/index.html).



Expedition scientists take in the view of Mt. Fuji from the helideck as Chikyu sets sail from Shimizu Port.

borehole assembly (BHA). With time running short, it seemed hopeless to set the observatory and retrieve core samples, but at the last minute an extra 4 days were allotted to the expedition. Spirits lifted, the visual core description (VCD) team finalised the core flow plan and conducted dry runs. At hole C0019d, casing was set but problems with the underwater TV umbilical meant we could not re-enter to set the observatory and, after a short wait on weather, coring operations at C0019e began on 13 May 2012 with only 10 days left for operations.

Core 1 targeted the shallow section (~175 mbsf) and with 90% recovery the science party were sure their luck had finally changed for the better. Then the weather deteriorated, halting operations again. The final days were action packed as we cored through the two target zones. At the ~720 mbsf a 15 mm thick, 60° dipping fault associated with a hydrogen gas anomaly was recovered but its structural features were not consistent with the significant (< 50 m) amount of slip noted during the Tohoku earthquake. The real excitement occurred on 21 May, three days before the science party disembarkation, when Core 17 was brought on deck. The 1 m of recovered material contained a scaly clay unit with variably sized phacoids defined by discrete slip surfaces. The features of Core 17 indicate accommodation of significant shear displacement within the zone, and the change to near horizontal, relatively undisturbed footwall strata led to the conclusion that we had successfully sampled the subduction plate boundary. The big question is

Logging team discuss the preliminary results of borehole breakout analysis of RAB image logs.

Upper 14 cm of the scaly clay unit (plate boundary fault zone) of Core 17.

have we recovered samples from the fault that slipped during the 11 March 2011 Tohoku earthquake? Sampling of Core 17 had to be done with care to preserve the structural features and was not completed on board but most samples have now been distributed and work is being done to answer this key question.

The unplanned JFAST Leg 2 or Exp. 343T lasted for 14 days, from 5–19 July 2012, and allowed for the emplacement of the temperature observatory in hole C0019d. By all accounts the second leg of the expedition ran much smoother and the record breaking (deepest borehole observatory) temperature sensor string was emplaced ahead of schedule on 16 July 2012. Successful recovery of the sensor string was completed on 26 April 2013. Initial results show a clear temperature anomaly near 820 mbsf, and work is being done to determine the frictional properties of the earthquake fault.

The main goals of JFAST were to understand the stress conditions, frictional and physical properties resulting in the large shallow slip, and the resultant microstructures. Work showing that the earthquake resulted in a near complete stress drop have already been published (Lin *et al.*, 2013), and frictional, geochemical and microstructural studies are underway. Despite the major challenges faced by the onboard management and scientists during IODP Exp. 343 the expedition was a success, and will provide answers to key questions regarding earthquake rupture behaviour.

For more information on the JFAST IODP Exp. 343 please refer to the expedition website http://www.jamstec.go.jp/chikyu/exp343/e/index.html

For more information on site specifics and initial results please refer to the Preliminary Report http://publications.iodp.org/preliminary_report/343343T/343343tpr_.htm

References

Chester, F.M., Mori, J.J., Toczko, S., Eguchi, N., and the Expedition 343/343T Scientists. 2012. Japan Trench Fast Drilling Project (JFAST). *IODP Prel. Rept.,*343/343T. doi:10.2204/iodp.pr.343343T.2012

Lin, W., Conin, M., Moore, J.C., Chester, F.M., Nakamura, Y., Mori, J.J., Anderson, L., Brodsky, E.E., Eguchi, N., and the Expedition 343 Scientists. 2013. Stress State in the Largest Displacement Area of the 2011 Tohoku-Oki Earthquake, *Science*, *339*(6120), 687–690.

IODP Expedition 343 (JFAST) on-board science party.

Expedition 338: NanTroSEIZE Stage 3: NanTroSEIZE plate boundary deep riser 2

1 October 2012 – 13 January 2013

Dean Wilson (University of Southampton), Jacob Geerson (University of Southampton), Kevin Pickering (University College London) and the Expedition 338 Science Party

In September 2007, D/V Chikyu embarked upon the first expedition of the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE), part of a multistage drilling project focussed on understanding the mechanics of seismogenesis and rupture propagation along subduction plate boundary faults (Tobin and Kinoshita, 2006). Since then, a total of nine IODP expeditions have been conducted within the NanTroSEIZE with >45 holes drilled at 13 sites situated in a variety of settings, ranging from the incoming plate to the forearc basin. The cores, logging and seismic data that have been acquired have enabled important elements of the subduction system to be examined. In addition, at one Site (C0002) a permanent long-term borehole observatory has been installed, providing in situ, time series measurements of temperature, pressure and fluid composition. A series of temporary, recoverable observatories (SmartPlug and GeniusPlug) measuring temperature and pressure at Site C0010 have also been installed.

The NanTroSEIZE transect is located in the Nankai Trough subduction zone and the Shikoku Basin, offshore Kii Peninsula, Japan (Figure 1). The Nankai Trough active margin represents one of the best-studied subduction zones in the world with an ~1300 year-long historical record of recurring and typically tsunamigenic great earthquakes, including the 1944 Tonankai (M = 8.1) and 1946 Nankaido (M = 8.3) earthquakes (Ando, 1975; Hori *et al.,* 2004). The geologic and tectonic framework of the Nankai Trough is controlled by the northwestward subduction of the Philippine Sea plate beneath the Eurasian plate at a rate of ~4.1-6.5 cm yr^{-1} (Seno *et al.,* 1993; Miyaziki and Heki, 2001).

IODP Expedition 338

The centrepiece of the NanTroSEIZE project is IODP Site C0002, located in 1939 m water depth over the Kumano Basin and the inner accretionary prism. This site is above the seismogenic zone and the presumed locked portion of the plate-boundary. The ultimate target depth at Site C0002 is >7000 metres below seafloor (mbsf), which is expected to penetrate: (a) the transition from Kumano Basin sediments to the inner accretionary prism at ~940 mbsf; (b) the megasplay fault at ~5200 mbsf, which is thought to be capable of seismogenic locking and slip, and to have accommodated slip during the recent 1944 Tonankai M 8.2 earthquake (e.g. Ichinose *et al.,* 2003); (c) the plate boundary fault at ~7000 mbsf, and (d) the upper part of the subducting oceanic basement.

As the target depth of ~7000 m is extremely deep for scientific drilling, this part of the overall project has been split into several stages involving successively narrower boreholes and casing to strengthen the borehole and preserve it between different legs. In 2010, Hole C0002F was drilled and cased to a depth of 856 mbsf during IODP Expedition 326 (Expedition 326 Scientists, 2011). The aim of Expedition 338 was to extend and case the hole from 856 to 3600 mbsf in preparation for a final step of NanTroSEIZE stage 3, reaching the seismically imaged megasplay and plate boundary faults.

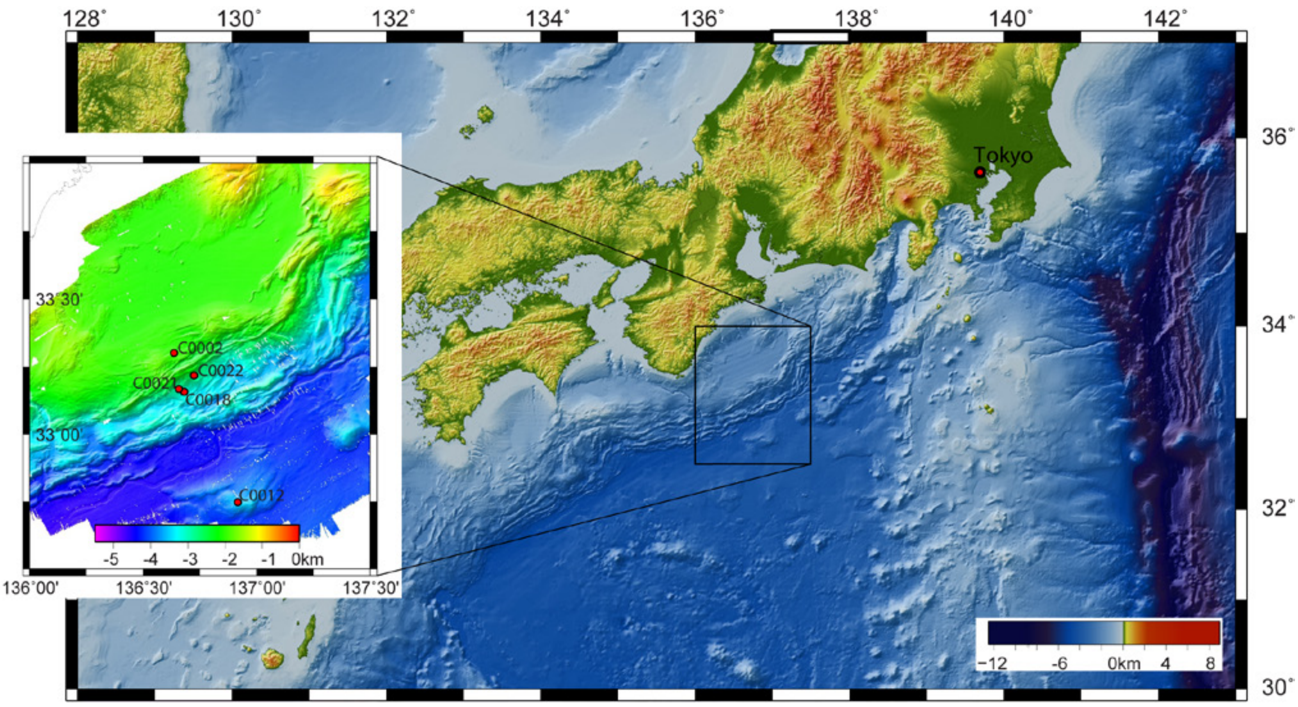
Due to the length of time required for riser operations, Expedition 338 continued the concept of a two-part science party, first experimented with during IODP Expedition 319. In order to maintain a sense of continuation and build collaborative links within the whole science party there was a one-week cross-over period in the middle of the expedition, when all shipboard scientists were present along with most speciality co-ordinators.

Science Party A — Challenges in scientific ocean drilling

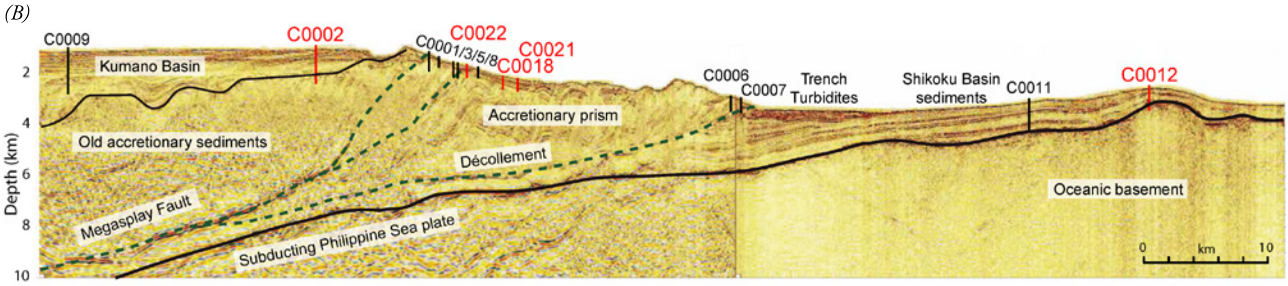
Chikyu departed from the port of Shimizu on 4 October and started sailing towards Site C0002. Unfortunately the preparations for re-occupation of Hole C0002F had to be interrupted on 9 October due to Typhoon Prapiroon. The blow-out preventer (BOP) and riser were successfully recovered over the following two days and the vessel moved into a low current area. After the typhoon had passed operations for site re-occupation restarted on 19 October. Following some troubleshooting on the auxiliary line, conduit line, hot line, and replacement of some buoyancy riser joints the BOP was successfully landed on the wellhead of Hole C0002F on 26 October and the cement plug left in place at the end of Expedition 336 was drilled out on 30 October. After a series of function and leak-off tests, drilling commenced on 4 November. Over the following 12 days, a full suite of logging-while-drilling (LWD), measurement-while-drilling (MWD), mud gas, and cuttings data were collected from ~875.5 — 2005.5 mbsf. Drilling was only interrupted for short periods to allow for the waste mud control system to cope with the large volume of cuttings, and also due to periods of rough weather (5, 12, and 16 November). However, when waiting for more favourable weather conditions on 17 November, the passing of a cold front and its associated storm caused abrupt changes in wind direction and speed which, together with the strong Kuroshio Current, made it difficult for *Chikyu* to maintain its position. In order to ensure the safety of the ship and drilling equipment, an emergency disconnect of the BOP and riser was conducted. The emergency disconnect left the lower part of the BOP on the seafloor, sealing off the borehole, whereas the riser and upper part of the BOP

Figure 1.
(A) Overview of the Nankai trough subduction zone. Inset shows the location of the holes drilled during Expedition 338. (B) Composite seismic line showing the situation of the holes in relation to the subduction system.

(A)



(B)



remained connected to the ship. Although at this point the riser pipe was disconnected from the borehole, the strong Kuroshio Current caused *Chikyu* to drift, creating torsional stresses on the riser pipe. The tilt in the riser pipe was accommodated primarily by the intermediate flex joint, which in turn suffered damage. Because of this damage, riser drilling was not possible during the remaining of Expedition 338.

The above described sequence of events during the first part of Expedition 338 underlines some of the difficulties and challenges in deep-ocean drilling. However, it also impressively highlights the value of the results that have been obtained under sometimes challenging circumstances in the NanTroSEIZE project to date.

First results from Hole C0002F, 875.5—2005.5 mbsf

Based on the analysis of LWD data, mud-gas monitoring and investigations of the retrieved cuttings, two major lithologic units were defined within the inner wedge of the accretionary prism that are separated by a prominent fault zone located at ~1640 mbsf. Variations in the style and amount of deformation structures in the cuttings, a downhole increase of thermogenically produced gas, and evidence for mechanical compaction and cementation, all attest to the complex structural evolution of the inner accretionary prism (Expedition 338 Scientists, 2013). In this context, the shipboard data, combined with post-cruise investigations that will be carried out over the next years, should provide unprecedented insights into the mechanical state and behaviour of the previously unsampled wedge.

An unexpected visitor

On 15 November Dr. Walter Munk, accompanied by JAMSTEC President Professor Asahiko Taira, visited *Chikyu* for a short, four hour long visit. In 1957 Walter Munk, one of the world's greatest acknowledged oceanographers, together with Harry Hess, proposed the revolutionary idea to drill through Earth's crust and into the upper mantle. Although the so-called 'Mohole' remains unrealised it may be feasible over the next years using the latest technology on *Chikyu* (Teagle and Ildefonse, 2011). During the visit Professor Taira announced that the shipboard library is to be renamed the Walter Munk Library.

Cross-over week

Both halves of the science party, as well as the specialty co-ordinators, were on board *Chikyu* for the middle week of the expedition. Scientists from Group A provided a thorough briefing on the outcomes of the first half of the cruise, enabling a smooth handover for each discipline. The presentations also included updates on scientific procedures and introduced the drawback of the underreamer, whereby surface cuttings represent a mixture within the borehole of cuttings taken from more than one depth, and the misleading drilling-induced cohesive aggregates (not to be confused with real cuttings). During the cross-over week, there was ample opportunity to discuss and formulate post-cruise research, especially with the potential contingency operations, thereby allowing individuals to identify possible openings for mutually beneficial collaborations.

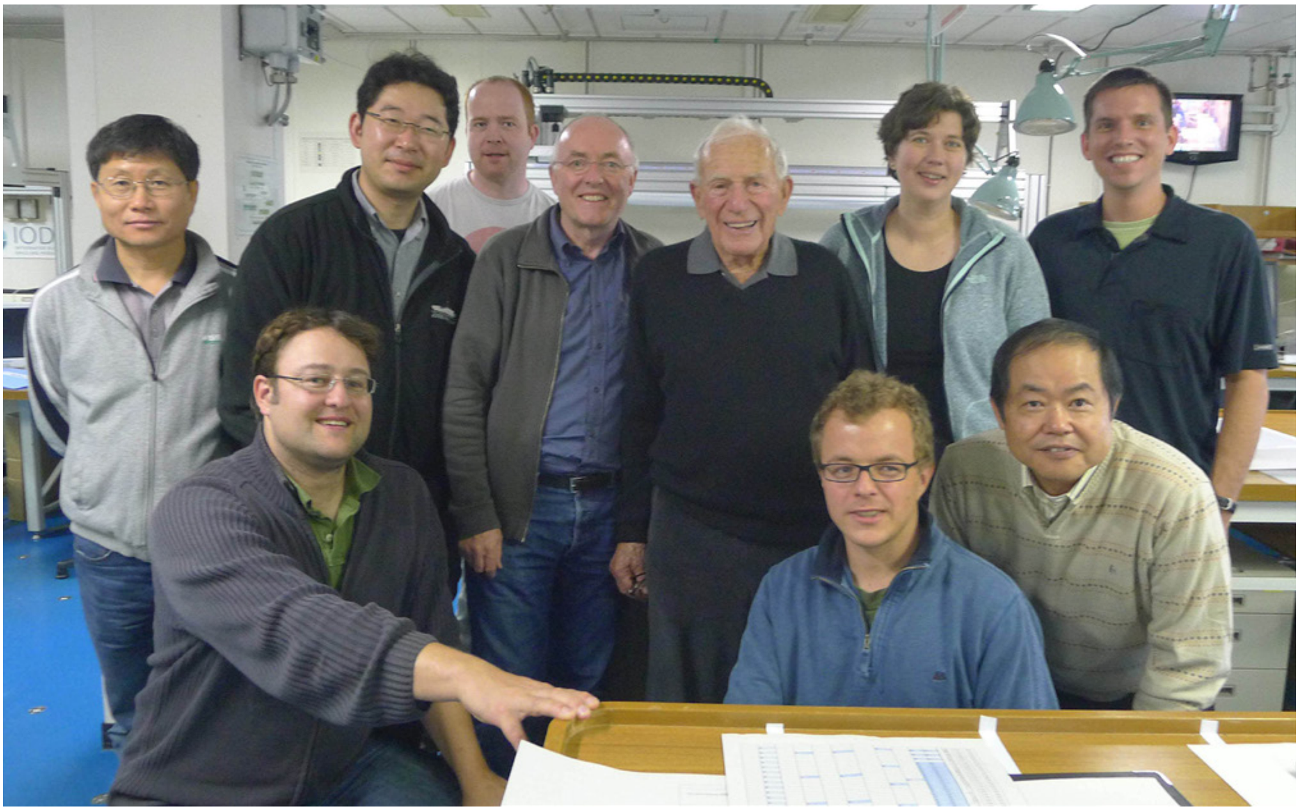
Science Party B — Contingency operations

Due to the damage caused to the riser pipe during unfavourable weather conditions (discussed above), the second half of the expedition was devoted to non-riser contingency operations designed to fill in knowledge gaps within the framework of the overall NanTroSEIZE objectives (Expedition 338 Scientists, 2013). The science party discussed the potential targets within the depth range of the non-riser capabilities of *Chikyu*. Following operational advice from the drilling engineers a list of priorities for coring or LWD data acquisition was created.

Geophysical characterisation of the incoming section at Site C0012 using LWD tools was the first contingency operation to be conducted. Hole C0012H successfully reached 709 mbsf, including ~180 m of penetration into the igneous basement. Resistivity images revealed a wide variety of textures as well as significant variability in the degree of fracturing, which may be related to hydrothermal alteration (Figure 3).

Coring at Site C0002 focussed on intervals not previously cored: the gas hydrate zone, including the bottom-simulating reflector (BSR) 200–505 mbsf; the lower part of the Kumano forearc basin, 902–940 mbsf; and the uppermost part of the upper accretionary prism, 1100–1120 mbsf. The lack of riser capability

Figure 2.
A flying visit — Walter Munk drops by the Chikyu.



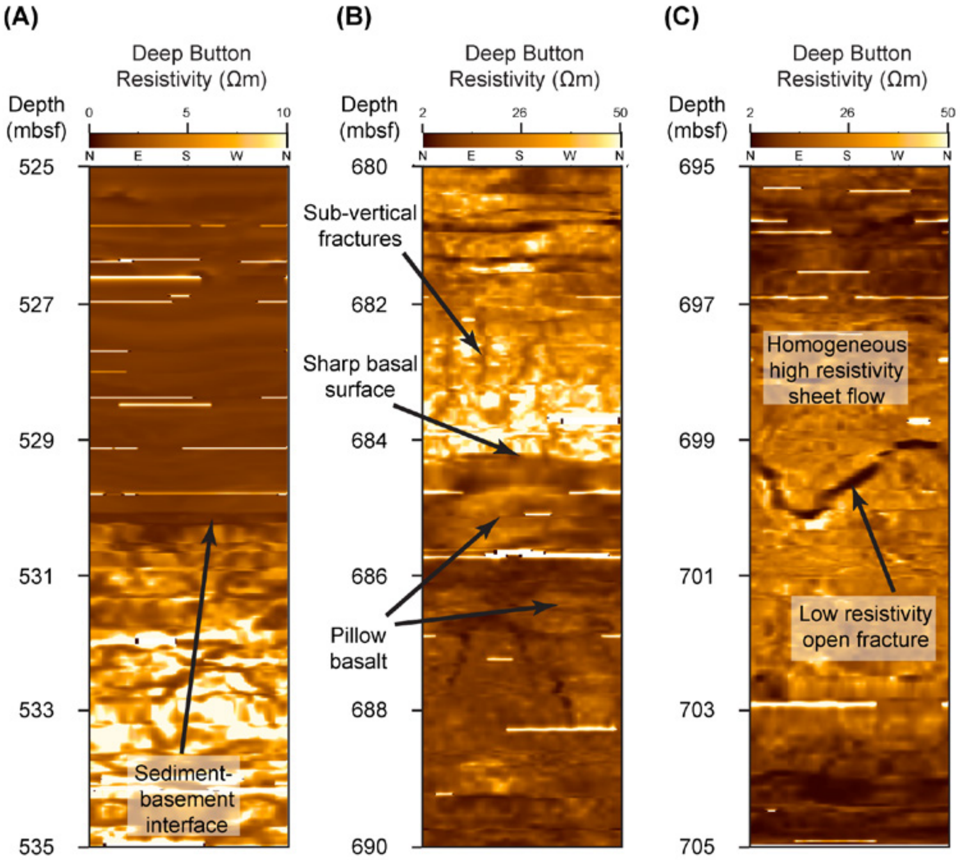


Figure 3.
Resistivity images acquired at Hole C0012, showing: (A) the irregular sediment-basement interface, (B) contrasting lava flow morphologies, and (C) low resistivity fractures observed in the high-resistivity basement rocks.

meant that the condition of the borehole could not be controlled or monitored. Unpredictable hole stability meant that target depth and downhole time limitations had to be considered due to known instability problems, especially within the accretionary prism (below ~940 mbsf). In total, four riserless holes yielded successful penetrations and core recovery (Holes C0002H, J, K and L). A low-velocity zone, targeted between ~1290 and 1350 mbsf and identified from C0002F LWD sonic velocity data, had to be abandoned after the drill string became stuck due to choking of the borehole by re-circulated caving material.

There was a considerable focus of effort on the scientific objectives of the Nankai Trough Submarine Landslide History (NanTroSLIDE) Ancillary Project Letter, targeting stacked mass-transport deposits (MTDs) located in the slope basin seaward of the megasplay and identified from the 3-D seismic data (Strasser *et al.,* 2011). Site C0018 was cored during Expedition 333 and the cores revealed a succession of six MTDs including one >50 m thick (Expedition 333 Scientists, 2012). In order to complement the information gained from coring and to fill in gaps of poor core recovery, LWD data were acquired at Site C0018 and an additional NanTroSLIDE Site, C0021, located ~2 km to the northwest upslope from the seismically interpreted mass transport direction (Strasser *et al.,* 2011). Additionally, two intervals were cored at Site C0021, from 0 to 5.9 and 80.0 to 194.5 mbsf. LWD resistivity images reveal clear differences between planar bedding horizons and heavily disturbed zones, which match the intervals of chaotic mixing identified from both the cores and the Kumano 3-D seismic volume (Moore *et al.,* 2009).

As the expedition drew to a close, there was sufficient time to gather LWD data and cores to settle the debate of whether or not the megasplay fault propagated up through the shallow slope sediments. This question arose because it is unclear if there is an offset of reflectors in the seismic volume. At Site C0022, a prominent fault zone ~30 m thick was identified based on the high concentration of high-angle fractures picked from the LWD resistivity images, centred about as a low-resistivity horizon at ~100 mbsf. Although the fault was not directly observed in the cores, there was significant evidence of a broad zone of deformation from microstructures.

References

Ando, M. 1975. Source mechanisms and tectonic significance of historical earthquakes along the Nankai Trough, Japan. *Tectonophysics*, **27(2)**:119–140. doi:10.1016/0040-1951(75)90102-X.

Hori, T., Kato, N., Hirahara, K., Baba, T., and Kaneda, Y. 2004. A numerical simulation of earthquake cycles along the Nankai Trough in southwest Japan: lateral variation in frictional property due to the slab geometry controls the nucleation position. *Earth Planet. Sci. Lett.*, **228(3–4)**:215–226. doi:10.1016/j.epsl.2004.09.033.

Expedition 326 Scientists. 2011. NanTroSEIZE Stage 3: plate boundary deep riser: top hole engineering. *IODP Prel. Rept.,* 326. doi:10.2204/iodp.pr.326.2011.

Expedition 333 Scientists. 2012. Site C0018. *In* Henry, P., Kanamatsu, T., Moe, K., and the Expedition 333 Scientists. *Proc. IODP*, **333**: Tokyo (Integrated Ocean Drilling Program Management International, Inc.). doi:10.2204/iodp.proc.333.103.2012.

Expedition 338 Scientists. 2013. NanTroSEIZE Stage 3: NanTroSEIZE plate boundary deep riser 2. *IODP Prel. Rept.*, **338**. doi:10.2204/iodp.pr.338.2013.

Ichinose, G.A., Thio, H.K., Somerville, P.G., Sato, T., and Ishii, T. 2003. Rupture process of the 1944 Tonankai earthquake (Ms 8.1) from the inversion of teleseismic and regional seismograms. *J. Geophys. Res., [Solid Earth]*, **108(B10)**:2497. doi:10.1029/2003JB002393.

Miyazaki, S., and Heki, K. 2001. Crustal velocity field of southwest Japan: subduction and arc-arc collision. J. Geophys. Res., [Solid Earth], 106(B3):4305–4326. doi:10.1029/2000JB900312

Moore, G.F., Park, J.-O., Bangs, N.L., Gulick, S.P., Tobin, H.J., Nakamura, Y., Sato, S., Tsuji, T., Yoro, T., Tanaka, H., Uraki, S., Kido, Y., Sanada, Y., Kuramoto, S., and Taira, A. 2009. Structural and seismic stratigraphic framework of the NanTroSEIZE Stage 1 transect. InKinoshita, M., Tobin, H., Ashi, J., Kimura, G., Lallemant, S., Screaton, E.J., Curewitz, D., Masago, H., Moe, K.T., and the Expedition 314/315/316 Scientists, *Proc. IODP*, **314/315/316**: Washington, DC (Integrated Ocean Drilling Program Management International, Inc.). doi:10.2204/iodp.proc.314315316.102.2009.

Seno, T., Stein, S., and Gripp, A.E. 1993. A model for the motion of the Philippine Sea plate consistent with NUVEL-1 and geological data. *J. Geophys. Res., [Solid Earth]*, **98(B10)**:17941–17948. doi:10.1029/93JB00782.

Strasser, M., Moore, G.F., Kimura, G., Kopf, A.J., Underwood, M.B., Guo, J., and Screaton, E.J. 2011. Slumping and mass-transport deposition in the Nankai forearc: evidence from IODP drilling and 3-D reflection seismic data. *Geochem., Geophys., Geosyst.*, **12**:Q0AD13. doi:10.1029/2010GC003431.

Teagle, D., and Ildefonse, B. 2011. Journey to the mantle of the Earth. *Nature*, **471**, 437-439.

Tobin, H.J., and Kinoshita, M. 2006. NanTroSEIZE: the IODP Nankai Trough Seismogenic Zone Experiment. Sci. Drill., 2:23–27. doi:10.2204/iodp.sd.2.06.2006.

Results from Expedition 320/321 Site Survey: Evidence of a widespread current crossing the equatorial Pacific Implications for paleoceanographic and tectonic studies

Neil C. Mitchell (School of Earth, Atmospheric and Planetary Sciences, University of Manchester)

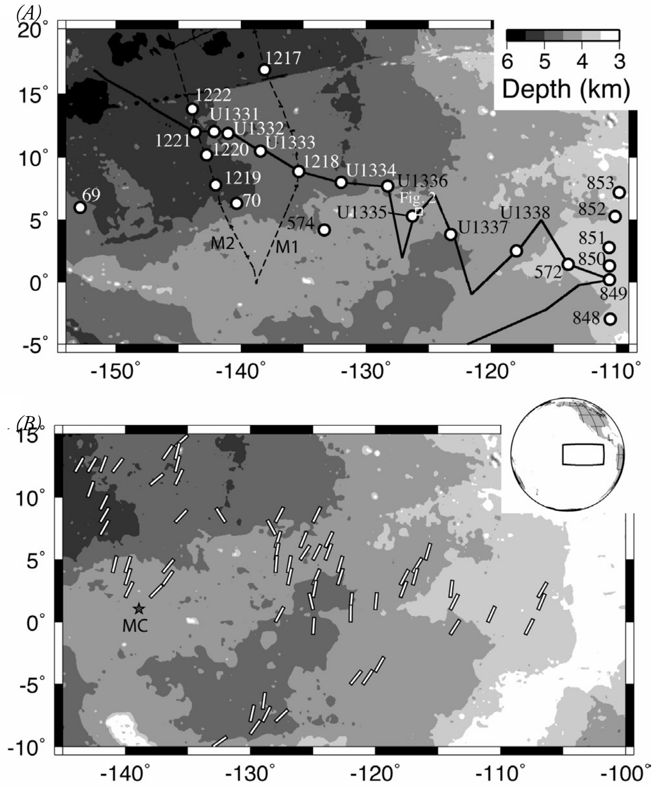
Geophysical site surveys can potentially be much more useful than merely checking site conditions for drilling. As preparation for IODP expedition 320/321, data were collected at the proposed sites and in transits between them aboard the Scripps *RV Roger Revelle* (bold line in Figure 1a). The data from the ship's Simrad EM120 multibeam echo-sounder have turned out to reveal an intriguing pattern of sedimentary bedforms (Mitchell and Huthnance, 2013). In the example swath plotted as a shaded-relief image in Figure 2, a series of low-relief ridges can be observed running slightly west of north (parallel to the white dashed line shown). These represent the oceanic abyssal hills originally formed at the East Pacific Rise, their topography preserved by the pelagic sediments here partly draping them (Tominaga *et al.,* 2011).

Crossing those hills, a series of shallow elongate ridges and troughs run NNE–SSW. Similar sedimentary bedforms to these have been interpreted to be caused by a secondary circulation in the benthic boundary layer (Flood, 1983; Viekman *et al.,* 1992). Some elongate troughs apparently emanating from small depressions (marked by arrows in Figure 2) suggest flow to the SSW in this image.

These linear bedforms are shallow (<10 m peak to trough) and only revealed in data collected with the new generation multibeam sonar systems, such as on the *Revelle*. In this study, individual lineaments were digitized and their orientations binned to produce the pattern in Figure 1b. They occur across the entire carbonate ooze province of the central Pacific where high-quality sonar data exist, covering a huge area (compare with North America in upper-right inset to Figure 1b). The pattern is curious as lineaments cross bathymetry contours in Figure 1b, so the current responsible for them is not obviously the mean current, which is also expected to turn east near the equator (Roussenov *et al.,* 2004).

Reliable long-term measurements with current meters close to the equator and close to the seabed have been made only at the site located by the star symbol in Figure 1b (MANOP-C). However, those data reveal an interesting oscillating current, with periods from several weeks to annual or longer, and which is aligned with the bedforms. The origins of the current are unclear. We have speculated that it may be produced by an indirect coupling of ocean surface movements with the lower ocean, for example, from pressure gradients generated by migrating meso-scale eddies and other sea surface disturbances (Mitchell and Huthnance, 2013).

Figure 1.
(A) Bathymetry of the central Pacific, with the equatorial Pacific IODP (U1331–U1338) and other drill sites and tracks of RVs Roger Revelle (solid line) and Ewing (dashed line). (b) Orientations of geomorphological current indicators marked by white bars. Star symbol locates the MANOP current meter site C.



The implications of this current for paleoceanographic work on cores depend on the extent to which the current redistributes particles before they deposit, potentially affecting studies involving location (spatial patterns) and those involving accumulation rates. There is relatively little mixing of microfossil ages in this area so the current probably does not significantly erode the sediment, rather it may carry particles some distance from where they settle from the overlying water column to their final sites of deposition. Progressive vector diagrams computed from the MANOP-C suggest that fine particles, if persistently

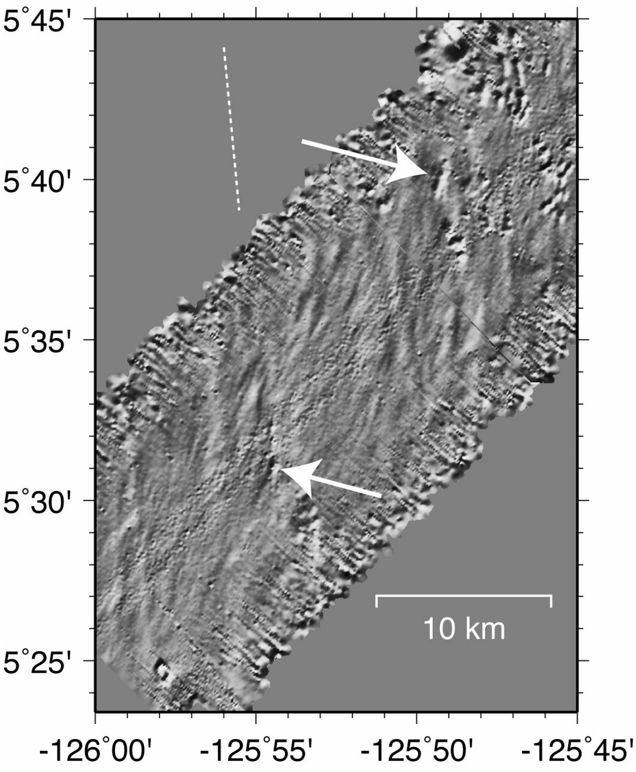


Figure 2.
Example of multibeam echo-sounder swath bathymetry collected on RV Revelle displayed as a shaded-relief image (artificial illumination from N330°E). Dashed line marks the local orientation of the abyssal hills underlying the sediment. Overlying these and trending oblique to the abyssal hills can be observed elongated troughs and ridges (sediment drifts). Arrows mark depressions with troughs emanating to SW, suggesting mainly southwest flow of bottom water.

suspended, could potentially migrate hundreds of km with the long-period oscillation.

Equatorially enhanced accumulation rates of ^{230}Th hint that some transport of sedimentary particles can occur (Marcantonio *et al.,* 2001). ^{230}Th is produced uniformly in the water column by radioactive decay of dissolved ^{234}U and stripped efficiently from the water by adsorption onto sinking particles. Accumulation rates of ^{230}Th measured in sediment cores are up to several times its production in the immediately overlying water column in a narrow latitude band, only 1°–2° wide about the central Pacific equator (Kienast *et al.,* 2007). This simple interpretation has been controversial, with several potential complications aired in the literature (Broecker, 2008; Lyle *et al.,* 2005; Lyle *et al.,* 2007; Siddall *et al.,* 2008; Thomas *et al.,* 2000). In Mitchell and Huthnance (2013), we evaluated these complications and concluded that most can be dismissed, although one uncertainty remains, that the particles most responsible for transport of ^{230}Th may be fine-grained (clays, for example) so the high ^{230}Th accumulation rates may not necessarily indicate transport of bulk sediment.

On RV Revelle, we also ran a seismic reflection system but, unfortunately, the lines had to be cut back at sea due to other priorities and the data have turned out to be noisy. However, seismic data previously collected on RV Ewing along the two dashed lines in Figure 1a (Knappenberger, 2000; Mitchell and Lyle, 2005; Mitchell *et al.,* 2003) are useful for the issue of sediment particle displacements. Mapping out the stratigraphy is helped here by abrupt changes in dry bulk density linked to carbonate variations of paleoceanographic origin (Mayer, 1979; Mayer *et al.,* 1986). Figure 3 shows the interval thickness (expressed in seismic two-way travel time) for two age intervals. The interval data have been filtered to attenuate the short-wavelength variability described by Mitchell and Lyle (2005). For the younger 10.05–14.25 Ma interval, there is a region of enhanced deposition only 1°–2° of latitude across. The feature is similar to the 230Th anomaly (Kienast *et al.,* 2007) in terms of both latitude range and magnitude. It is much narrower than the ~10° region of enhanced particle flux in sediment traps (Honjo *et al.,* 2008), so it is unlikely to be a productivity effect. This seems to be the result of transport of particles to the equator, where they have deposited, possibly because of an abrupt effect of Coriolis on currents crossing the equator (Mitchell and Huthnance, 2013).

In contrast, the interval 14.25–16.35 Ma does not show a clear anomaly. The transition between these two intervals coincides with a major strengthening of the westerly boundary current off New Zealand (Hall *et al.,* 2003) so it may represent a change in the mean current. Alternatively, a coincident change in meteorologically-driven upper ocean variability may have caused a change in oscillating currents near the bed.

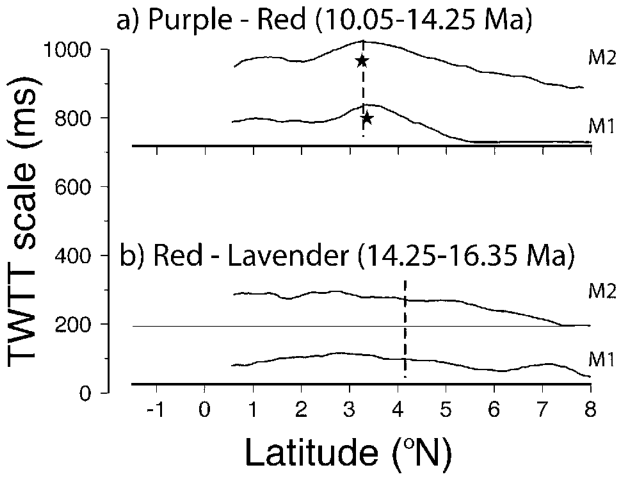
A number of studies have interpreted spatial or temporal variations in accumulation rates of various types of particles or bulk sediment (Beaufort *et al.,* 2001; Chugh and Bhattacharji; Griffith *et al.,* 2010; Hovan, 1995; Lyle, 2003; Mitchell *et al.,* 2003; Pälike *et al.,* 2012), which will almost certainly have been variably affected by bottom current shear (McCave and Swift, 1976). Unfortunately, the geophysical data of the site survey cruise were not fully processed until much later so our results were not available to the participants of IODP 320/321. From the drilling results, Pälike *et al.,* (2012) derived a carbonate compensation depth (CCD) curve for the equatorial Pacific by regressing carbonate accumulation rates on depth. Such depths will have been distorted by bottom current shear in ways that are difficult to assess. Some sites were located in depressions so accumulation rates may have been distorted by the well-known basin-filling effect (Tominaga *et al.,* 2011). Where sites lay at the equator and equatorial focusing occurred, accumulation rates were enhanced while those away from the equator were reduced. Hence, some of the abrupt variation in apparent CCD (Pälike *et al.,* 2012) could have been caused by particle transport rather than the chemical variations inferred.

If our interpretation of the equatorial anomaly as a result of the Coriolis effect is correct, the locations of anomalies such as those in Figure 3a are potentially useful for constraining the northward movement of the Pacific tectonic plate. The narrow 1°–2° widths of the sediment anomalies in Figure 3 and in the ^{230}Th data suggest that we can do much better than the few degrees achieved in previous attempts using the broader pattern of accumulation (Mitchell, 1998; Moore *et al.,* 2004; Parés and Moore, 2005; Suarez and Molnar, 1980). Coincidentally, increasing numbers of dates available for the Pacific seamounts and improved reconstruction methods mean that plate motion relative to the hotspots is becoming accurately constrained (Wessel and Kroenke, 2008). Combined with the sediment paleo-equator data, we may be able to resolve some motion of the hotspots (true polar wander) over the late Cenozoic. Such a result would be interesting as it has only really been possible to tackle hotspot motion (using paleomagnetic data) for the Emperor Seamounts for ages older than the Hawaiian-Emperor bend (Tarduno, 2007).

Acknowledgements

Thanks to the captain and crew of *RV Roger Revelle*, Mitch Lyle and the shipboard scientists for their help in collecting the AMAT03RR cruise data. Cruise costs were supported by grants from the NERC (NE/C508985/2) and NSF (OCE-9634141 to Lyle).

Figure 3.
Sediment interval thicknesses for two RV Ewing lines of seismic reflection data located by the dashed lines in Figure 1a. Reflector dates are from Mitchell et al. (2003) and correspond with the bio-stratigraphic levels of Mayer et al. (1985) who assigned the reflectors names based on colours shown here. Vertical dashed lines are rough estimates of the paleoequator deduced using the rotation poles of Sager and Pringle (1988).



References

Beaufort, L., de Garidel-Thoron, T., Mix, A.C. and Pisias, N.G. 2001. ENSO-like forcing on oceanic primary production during the Late Pleistocene. Science, 293: 2440–2444.

Broecker, W. 2008. Excess sediment ^{230}Th: Transport along the sea floor or enhanced water column scavenging? Global Biogeochem. Cycles, 22: Paper GB1006, doi:1010.1029/2007GB003057.

Chugh, R.S. and Bhattacharji, J.C. Study of isostasy in the Himalayan Region.

Flood, R.D. 1983. Classification of sedimentary furrows and a model for furrow initiation and evolution. Geol. Soc. Am. Bull., 94: 630–639.

Griffith, E., Calhoun, M., Thomas, E., Avery, K., Erhardt, A., Bralower, T., Lyle, M., Olivarez-Lyle, A., and Paytan, A. 2010. Export productivity and carbonate accumulation in the Pacific Basin at the transition from a greenhouse to icehouse climate (late Eocene to early Oligocene). Paleocean., 25: Paper PA3212, doi:3210.1029/2010PA001932.

Hall, I.R., McCave, I.N., Zahn, R., Carter, L., Knutz, P.C., and Weedon, G.P. 2003. Paleocurrent reconstruction of the deep Pacific inflow during the middle Miocene: Reflections of East Antarctic Ice Sheet growth. Paleocean., 18: Paper 1040, doi:1010.1029/2002PA000817.

Honjo, S., Manganini, S.J., Krishfield, R.A., and Francois, R. 2008. Particulate organic carbon fluxes to the ocean interior and factors controlling the biological pump: A synthesis of global sediment trap programs since 1983. Progr. Oceanogr., 76: 217–285.

Hovan, S.A. 1995. Late Cenozoic atmospheric circulation intensity and climatic history recorded by eolian deposition in the Eastern Equatorial Pacific Ocean. *In* N.G. Pisias, L.A. Mayer, T.R. Janecek, A. Palmer-Julson and T.H. van Andel (Editors), Proceedings of the Ocean Drilling Program, Scientific Results. Ocean Drilling Program, College Station, TX, pp. 615–625.

Kienast, S.S., Kienast, M., Mix, A.C., Calvert, S.E., and Francois, R. 2007. Thorium-230 normalized particle flux and sediment focusing in the Panama Basin region during the last 30 000 years. Paleocean., 22: Paper PA2213, doi:2210.1029/2006PA001357.

Knappenberger, M.B. 2000. Sedimentation rates and Pacific plate motion calculated using seismic cross sections of the Neogene equatorial sediment bulge. MSc Thesis, Boise State University, Boise, 95 pp.

Lyle, M. 2003. Neogene carbonate burial in the Pacific Ocean. Paleoceanography, 18: DOI: 10.1029/2002PA000777.

Lyle, M., Mitchell, N.C., Pisias, N., Mix, A., Ignacio Martinez, J., and Paytan, A. 2005. Do geochemical estimates of sediment focusing in the equatorial Pacific pass the sediment test? Paleoceanography, 20: PA1005, doi:1010.1029/2004PA001019.

Lyle, M., Pisias, N., Paytan, A., Ignacio Martinez, J., and Mix, A. 2007. Reply to comment by R. Francois *et al.,* on 'Do geochemical estimates of sediment focusing pass the sediment test in the equatorial Pacific?': Further explorations of 230Th normalization. Paleocean., 22: Paper PA1217, doi:1210.1029/2006PA001373.

Marcantonio, F., Anderson, R.F., Higgins, S., Stute, M., Schlosser, P., and Kubik, P. 2001. Sediment focusing in the central equatorial Pacific Ocean. Paleoceanography, 16: 260–267.

Mayer, L.A. 1979. Deep-sea carbonates: acoustic, physical, and stratigraphic properties. J. Sed. Petrol., 49: 819–836.

Mayer, L.A., Shipley, T.H., Theyer, F., Wilkens, R.H., and Winterer, E.L. 1985. Seismic modeling and paleoceanography at deep sea drilling project site 574. *In* L. Mayer, F. Theyer and *et. al.,* (Editors), Init. Repts. DSDP. U. S. Govt. Printing Office, Washington, DC, pp. 947–970.

Mayer, L.A., Shipley, T.H., and Winterer, E.L. 1986. Equatorial Pacific seismic reflectors as indicators of global oceanographic events. Science, 233: 761–764.

McCave, I.N., and Swift, S.A. 1976. A physical model for the rate of deposition of fine-grained sediments in the deep sea. Geol. Soc. Am. Bull., 87: 541-546.

Mitchell, N.C. 1998. Modeling Cenozoic sedimentation in the central equatorial Pacific and implications for true polar wander. J. Geophys. Res., 103: 17749–17766.

Mitchell, N.C., and Huthnance, J.M. 2013. Geomorphological and geochemical evidence (^{230}Th anomalies) for cross-equatorial currents in the central Pacific. Deep-Sea Res. I., 78: 24–41.

Mitchell, N.C., and Lyle, M.W. 2005. Patchy deposits of Cenozoic pelagic sediments in the central Pacific. Geology, 33: 49–52.

Mitchell, N.C., Lyle, M.W., Knappenberger, M.B., and Liberty, L.M. 2003. The Lower Miocene to Present stratigraphy of the equatorial Pacific sediment bulge and carbonate dissolution anomalies. Paleoceanography, 18: DOI: 10.1029/2002PA000828.

Moore, T.C., Backman, J., Raffi, I., Nigrini, C., Sanfilippo, A., Palike, H., and Lyle, M. 2004. Paleogene tropical Pacific: Clues to circulation, productivity, and plate motion. Paleocean., 19: Paper PA3013, doi:3010.1029/2003PA000998.

Pälike, H., Lyle, M.W., Nishi, H., Raffi, I., Ridgwell, A., Gamage, K., Klaus, A., Acton, G., Anderson, L., Backman, J., Baldauf, J., Beltran, C., Bohaty, S.M., Bown, P., Busch, W., Channell, J.E.T., Chun, C.O.J., Delaney, M., Dewangan, P., Jones, T.D., Edgar, K.M., Evans, H., Fitch, P., Foster, G.L., Gussone, N., Hasegawa, H., Hathorne, E.C., Hayashi, H., Herrle, J.O., Holbourn, A., Hovan, S., Hyeong, K., Iijima, K., Ito, T., Kamikuri, S., Kimoto, K., Kuroda, J., Leon-Rodriguez, L., Malinverno, A., Moore, T.C., Murphy, B.H., Murphy, D.P., Nakamura, H., Ogane, K., Ohneiser, C., Richter, C., Robinson, R., Rohling, E.J., Romero, O., Sawada, K., Scher, H., Schneider, L., Sluijs, A., Takata, H., Tian, J., Tsujimoto, A., Wade, B.S., Westerhold, T., Wilkens, R., Williams, T., Wilson, P.A., Yamamoto, Y., Yamamoto, S., Yamazaki, T., and Zeebe, R.E. 2012. A Cenozoic record of the equatorial Pacific carbonate compensation depth. Nature, 488: 609–615.

Parés, J.M., and Moore, T.C. 2005. New evidence for the Hawaiian hotspot plume motion since the Eocene. Earth Planet. Sci. Lett., 237: 951–959.

Roussenov, V., Williams, R.G., Follows, M.J., and Key, R.M. 2004. Role of bottom water transport and diapycnic mixing in determining the radiocarbon distribution in the Pacific. J. Geophs. Res., 109: Paper C06015, doi:06010.01029/02003JC002188.

Sager, W.W., and Pringle, M.S. 1988. Mid-Cretaceous to Early Tertiary apparent polar wander path of the Pacific plate. J. Geophys. Res., 93: 11753–11771.

Siddall, M., Anderson, R.F., Winckler, G., Henderson, G.M., Bradtmiller, L.I., McGee, D., Franzese, A., Stoker, T.F., and Müller, S.A. 2008. Modeling the particle flux effect on distribution of ^{230}Th in the equatorial Pacific. Paleocean., 23: Paper PA2208, doi:2210.1029/2007PA001556.

Suarez, G., and Molnar, P. 1980. Paleomagnetic data and pelagic sediment facies and the motion of the Pacific plate relative to the spin axis since the Late Cretaceous. J. Geophys. Res., 85: 5257–5280.

Tarduno, J.A. 2007. On the motion of Hawaii and other mantle plumes. Chemical Geology, 241: 234–247.

Thomas, E., Turekian, K.K., and Wei, K.Y. 2000. Productivity control of fine particle transport to equatorial Pacific sediment. Global Biogeochem. Cycles, 14: 945–955, doi:910.1029/1998GB001102.

Tominaga, M., Lyle, M., and Mitchell, N.C. 2011. Seismic interpretation of pelagic sedimentation regimes in the 18–53 Ma eastern equatorial Pacific: Basin?scale sedimentation and infilling of abyssal valleys. Geochem. Geophys. Geosys., 12: Paper Q03004, doi:03010.01029/02010GC003347.

Viekman, B.E., Flood, R.D., Wimbush, M., Faghri, M., Asaka, Y., and Van Leer, J.C. 1992. Sedimentary furrows and organized flow structure: A study of Lake Superior. Limnol. Oceanogr., 37: 797–812.

Wessel, P., and Kroenke, L.W. 2008. Pacific absolute plate motion since 145 Ma: An assessment of the fixed hot spot hypothesis. J. Geophys. Res., 113: Paper B06101, doi:06110.01029/02007JB005499.

Expedition 344: Costa Rica Seismogenesis Project (Program A, Stage 2)

23 October 2011 – 11 December 2012

Christopher Smith-Duque (University of Southampton), Paola Vannucchi (Royal Holloway, University of London), and the IODP Expedition 344 Shipboard Science Party.

Understanding the physical processes that generate earthquakes, one of the most destructive natural forces on Earth, remains a long-standing aim within geoscience.

The world's most powerful earthquakes occur as a result of nucleation and seismic rupture within subduction zones. The 2011 Tohoku earthquake and its resulting Tsunami represents a terrifying example of the kind of devastation such earthquakes cause. Despite the pressing need to understand seismogenesis at erosive convergent margins, the depth at which these earthquakes occur has prohibited direct sampling. However, over 30 years of offshore scientific drilling of the Middle America convergent margin, where active subduction erosion is taking place, has made great strides towards understanding seismogenesis within subduction-erosion settings. In utilizing the great wealth of

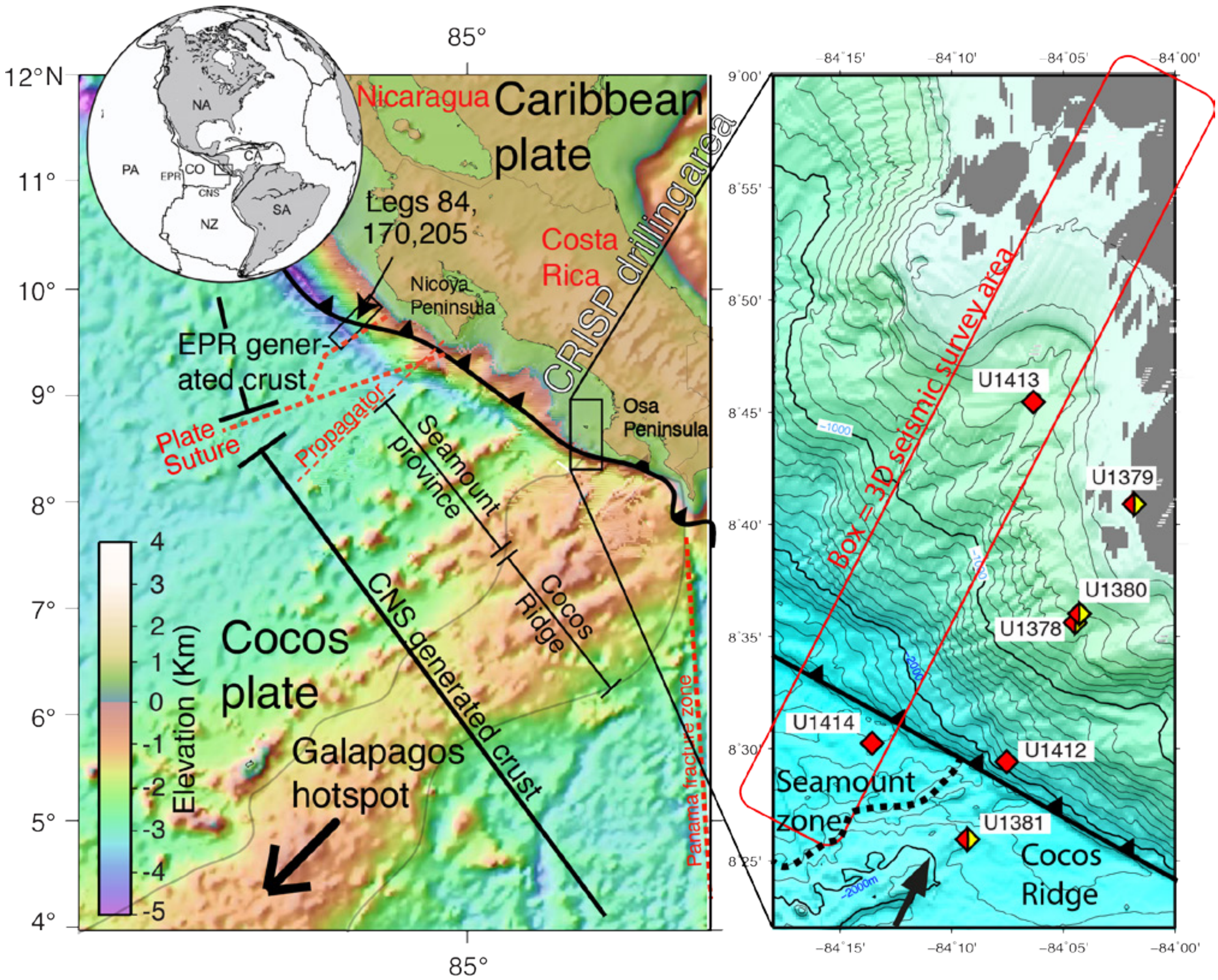


Figure 1.
Topographic and bathymetric map showing Location of Exp. 344 and Exp 334 Drill site locations, and major tectonic features. Red diamonds = Exp 344, Yellow and red = Exp 334 and Exp 344 (Modified from Harris et al., 2010b, 2012).

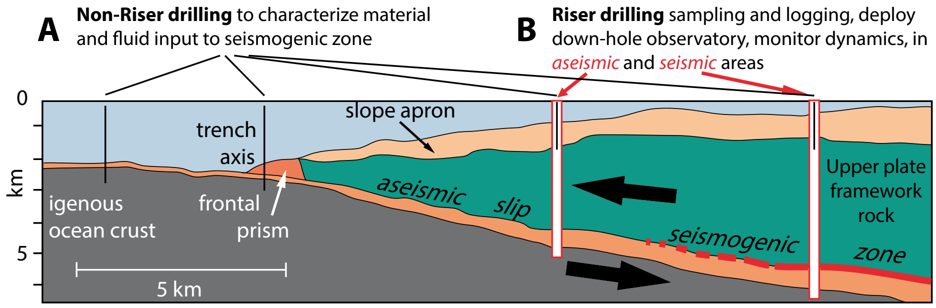


Figure 2.
Proposed drilling plan for the CRISP program and key hypotheses to be tested. Expedition 344 completes the non-riser drilling phase (CRISP-A). Proposed Riser drilling (CRISP-B) highlighted in red (After Vannucchi, et al., 2006)

The CRISP program is designed to test the following key hypotheses:

1) Subduction zone megathrust evolution from stable to unstable slip corresponds to a transition from a broad fluid rich fault zone to a narrow, fluid poor fault zone.
2) Fluid pressure gradient and fluid advection directly influence the spatial and temporal characteristics of localized faulting and erosional plate locking.
3) The composition, physical properties, and structure of incoming plate material directly influences the process from stable slip to unstable slip and seismogenesis.
4) Hydrothermal activcity affects the physical and chemical properties of eroded upper plate framework rock thus affects the transition from stable slip to unstable slip.
5) Along strike heterogeneity in plate releif, subduction channel thickness, compostitopn and phycial properites affects seismogenesis and rupture propegation.

scientific achievement and experience of those previous studies in conjunction with improved IODP drilling capabilities, the Costa Rica Seismogenesis Project (CRISP) represents a coordinated multi-expedition effort to fully characterize, sample, and monitor an active erosive convergent margin, including, for the first time in an erosive setting, the seismogenic zone.

Study area: Central American Margin offshore Costa Rica

The Central American Margin offshore the Osa Peninsula (Figure 1) was chosen for the CRISP project (Figure 2) since: (1) it is a seismically active erosive margin; (2) based on earthquake hypocenter locations, It has a shallow up-dip limit for seismogenesis. In addition, modeling of heatflow and temperature suggest that the up-dip limit of seismicity is coincident with the intersection of the 100-150°C isotherm with the subduction thrust (Harris *et al.,* 2010a, b). Critical for the next phase of the CRISP project (CRISP B), both the depth and temperature regime of the seismogenic zone place it within the drilling capabilities of the riser drillship D/V *Chikyu*; (3) there is an abundance of onshore and offshore data (Drilling and ROV), spanning over 30 years of geophysical research; (4) there is widespread hydrothermal activity (Forearc venting, fluid flow) which increases the chance of direct fluid sampling' (5) exhibits variable along-strike topographic variation; and 6) the study area is close to uplifted forearc exposure on land (Osa Peninsula), for relatively easy set up of monitoring stations.

CRISP A: Expeditions 334 and 344

IODP Expedition 334 initiated the CRISP program with recovery of sediment at 3 sites (U1378–U1380) across the upper slope of the Caribbean plate and basement at Site U1381, from the incoming Cocos plate. Highlights of Exp. 334 include: 1) Recovery of a potential mélange material and upper plate framework and the presence of a fault zone, 2) The first penetration of basement and sediment of the Cocos Ridge by scientific drilling 3) Discovery of unusually high sedimentary accumulation rates (up to 1035 m/m.y) for the Costa Rican Margin, 4) Identification of deep sourced fluids within two zones of the Upper plate and the inference of lateral flow of modified seawater within the incoming Igneous basement, 5) The first determination of the stress state of the CRISP transect through measurements of bore hole breakouts that suggest historical change from compression (middle-slope) to extension (upper-slope) as a result of subduction erosion.

Led by Prof. Robert Harris and Prof. Arito Sakaguchi, IODP Expedition (Exp.) 344, a continuation of Exp. 334, aimed to provide critical characterization of the inputs and outputs of the Costa Rican erosive margin while laying the foundation for future riser drilling into the seismogenic zone (CRISP-B).

Expedition 344 sailed from Balboa (Panama) on the 23rd October 2012 with a complement of 34 scientists representing 13 nationalities (Fig 3). Dena Rosenberger (Teacher at sea) conducted live conference calls to US classrooms and videographer, Thanos Faturos produced an exceptional series of mini-documentaries about the science conducted during Exp. 344. A link to the Exp. 344 introductory video can be found here: http://www.youtube.com/watch?v=SLreP3TuwBg.

Following a 3 day transit from Balboa, The JOIDES Resolution began drilling/coring operations along the CRISP transect (Figure 1). Throughout the 6 ½ weeks of operations 5 sites were drilled and cored spanning the incoming Cocos Ridge, toe of the margin, mid-slope and the upper slope of the Costa Rican Margin. Exp. 344 took place entirely within sight of Cano Island and the Osa Peninsula, uplifted forarc exposure, in water depths that ranged from 503 m closest to shore to 2458 m near

Figure 3.
Expedition 344 Science Party photo: Second from left: Christopher Smith-Duque, 1st on right within middle seated row: Paola Vannucchi (Photo: John Beck)

the trench. A total of 1471.1 m of core was recovered with 73% average recovery rate.

Scientific achievements of Expedition 344

Exp. 344 has greatly enhanced our understanding of the processes related to subduction erosion and has provided important new insights into seismogenesis at erosive convergent margins. Our achievements in relation to the scientific objectives of Exp. 344 are outlined below:

1) Recover upper plate and décollement material and characterize its composition, structure, physical properties, and texture.
Slope sediments, consisting of silty clay and fine sand stones (Unit I) and variably calcite-lithified clayey siltstone (Unit II) recovered at Site U1380 and U1413 were found to unconformably overlie upper plate basement sediments. Upper plate framework rock at Site U1380 includes silty claystone with well calcite-lithified, intercalated massive coarse-grained sandstones (Unit III). At Site U1413 basement comprised fine to medium grained sandstone and siltstone. A major outcome of Exp. 344 drilling at Sites U1380 and U1413 is that upper plate basement is composed of lithified forearc basin sediments that comprise terrestrially sourced upper slope sequences (Units I and III of Site U1380, and Site U1413) and a terrestrially sourced shelf sequence (Unit II, Site U1380). Previously it had been suggested that upper plate basement might be an offshore extension of igneous rocks that consist of the Carribbean Large Igenous Complex (CLIP) and the Quepos and Osa terranes (Ye *et al.,* 1996; Kimura *et al.,* 1997; Vannucchi *et al.,* 2001);

2) Provide further insight into sedimentary burial rates and the subsidence/uplift history in slope sediment.
During Exp. 344, sediment accumulation rates were acquired based on shipboard biostratigraphy and paleomagnetic data for all drilled sites. One of the most important observations is that slope sediment accumulation rates at Sites U1380 (~290 to 590 m/m.y) and U1413 (380 to 432 m/m.y) are very high compared to offshore Nicoya Peninsula sedimentation rates (Kimura, Silver, Blum, *et al.,* 1997), but similar to the rates calculated during Expedition 334 (Exp. 334 Scientists, 2012a, 2012b). An initial interpretation by Exp. 344 scientists (2013) is that either upper plate erosion is being actively enhanced by subduction of the Cocos Ridge or subducting bathymetry creates topographic lows that are quickly filled;

3) Characterize the hydrogeological regime within the upper plate.
Within sediment above the incoming Cocos plate at Sites U1381 and U1414, and within a shear-zone at the lower slope site (Site U1380), pore fluids compositions indicative of fluid flow were observed. In addition, alteration of basement at Site U1414 was described in detail, yielding clues as to how the hydrogeological regime of incoming basement has evolved. Fluid compositions observed at Input sites U1381 and U1414 indicate contrasting hydrogeological regimes despite their proximity to each other (<13 km).

Profiles of fluid Ca, SO_4, Li, Mn, and Si with depth and anomalously high heat flow at Site U1381 indicate diffusion of fluids with seawater-like chemistry from igneous basement. In contrast low sulfate and calcium at ~330 mbsf imply lateral flow of sulfate depleted fluids at Site U1414, possibly sourced downdip landward of Site U1414 where oxidation of methane and/or other organic carbon took place. In addition the presence of cemented sandstone near the basement may cap upwelling of seawater-like fluids from basement. A series of massive relatively impermeable flows that make up igneous basement at Site U1414, coupled with a limited, oxygen-starved alteration assemblage attests to restricted fluid flow within Site U1414 basement. Large polymineralic veins suggest repeated

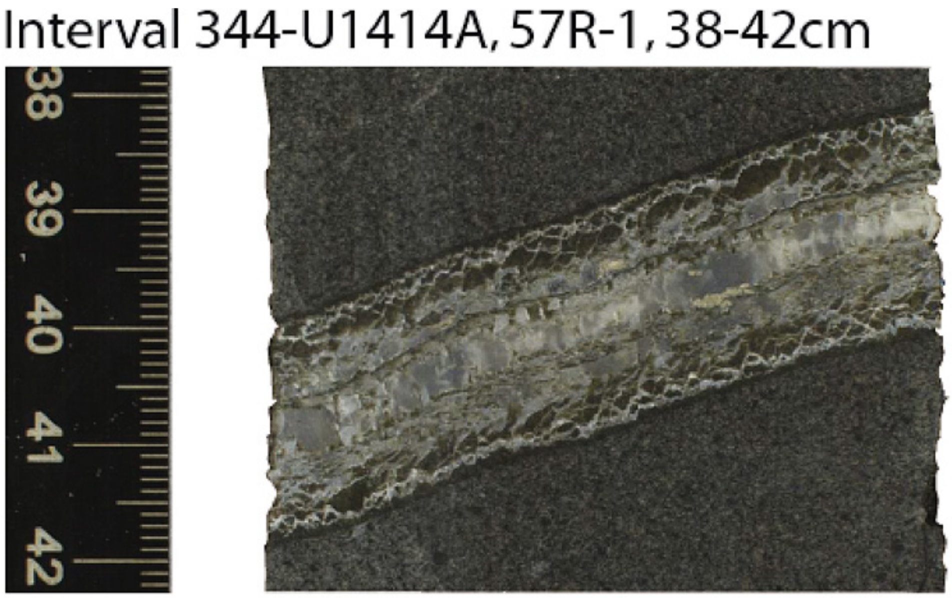


Figure 4.
Example of a large polymineralic vein within Site U1414 igneous basement.

re-opening and precipitation of secondary minerals within incoming basement (Figure 4);

4) Measure the stress field across the up-dip limit of the seismogenic zone.
Structural measurements of faults, borehole breakout data, and strain recovery measurements on whole round core samples allowed Exp. 344 scientists to estimate palaeostress and present-day in-situ stress. Principal results include the observation of both normal and reverse faults at Site U1413, which suggests multiple faulting generations. Borehole breakouts at Site U1413 are indicative of north-south orientated minimum compressive stress, which corresponds to an extensional stress regime on the upper slope. Extension on the upper slope is consistent with similarly obtained results from Site U1379 during Exp. 334;

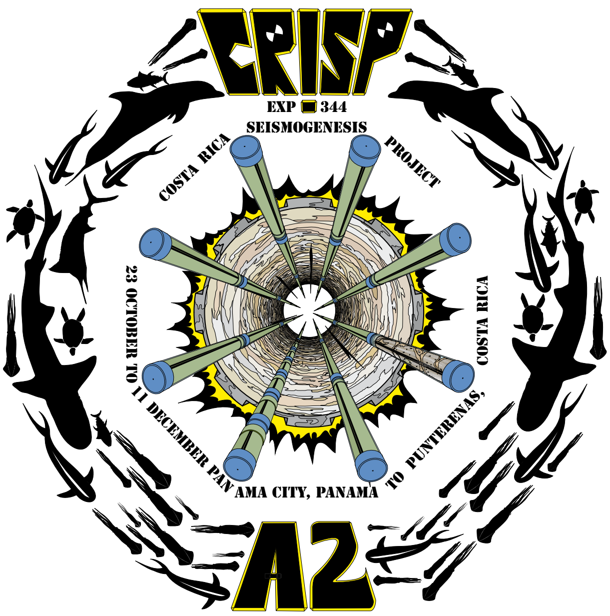
5) Elucidate the nature of Cocos Ridge subduction and the evolution of the Central American volcanic arc.
Two major advances made during Exp. 344 that help address this objective include: 1) Recovery of previously unavailable time slices of tephra layers between the mid-to late Pleistocene and middle Miocene will yield the most complete story of how Central American volcanism has evolved, and 2) Basement and sediment recovered during Exp. 344 at Site U1414 can now be directly compared to sediment and basement recovered from site U1381. This will yield a much more complete understanding of the nature of subducting material within the CRISP area.

UK participation and post cruise work.

Christopher Smith-Duque (Southampton) sailed as an igneous petrologist and sole UK scientific participant on Exp. 344. Shipboard activity that Christopher Smith-Duque oversaw included 1) Description and characterization of the volcanostratigraphy and igneous petrology of incoming igneous basement and 2) detailed description and characterization of low temperature hydrothermal alteration of all basaltic materials recovered during Exp. 344, and 3) production of the expedition logo (Figure 5).

In terms of post cruise research activity shipboard data will be combined with shore-based petrography, whole rock major and trace element data, Sr-isotope, and stable isotope ($\delta^{18}O$, $\delta^{13}C$)

Figure 5.
Expedition logo, created by Christopher Smith-Duque, that reflects just some of our experiences we shared while at sea.



data from secondary minerals to: 1) constrain primary magmatic origins of Site U1414 basement, testing whether Cocos/Nazca Spread Site U1414 has been influenced by Galapagos plume activity, and 2) determine how the hydrogeological regime of incoming basement has evolved to the present day, providing new insights into the fluid regime of imminently subducting CNS-formed basement.

Paola Vannucchi (Royal Holloway) moved to the UK right before the expedition, where she sailed as CDEX scientist. She is PI of the riserless CRISP A project. Paola was structural geology specialist on board Exp. 344, following her involvement as co-chief scientist during Exp. 334 CRISP A1.

Her post-cruise activity, which is spanning over both CRISP A expeditions, is focused on 1) quantifying the effects of Cocos Ridge subduction on the structure of the forearc, such as the subduction erosion rate or the sedimentary balance (Vannucchi et al., 2013), 2) determining the paleo strain characteristics and compare it with the modern stress characteristics across the forearc, and 3) measure frictional properties of the recovered material through laboratory tests.

References

Expedition 344 Scientists. 2013. Costa Rica Seismogenesis Project, Program A Stage 2 (CRISP-A2): sampling and quantifying lithologic inputs and fluid inputs and outputs of the seismogenic zone. *IODP Prel. Rept.,* 344.

Expedition 334 Scientists. 2012a. Site U1378. *In* Vannucchi, P., Ujiie, K., Stroncik, N., Malinverno, A., and the Expedition 334 Scientists, *Proc. IODP,*334: Tokyo (Integrated Ocean Drilling Program Management International, Inc.).

Expedition 334 Scientists. 2012b. Site U1379. *In* Vannucchi, P., Ujiie, K., Stroncik, N., Malinverno, A., and the Expedition 334 Scientists. *Proc. IODP,*334: Tokyo (Integrated Ocean Drilling Program Management International, Inc.).

Harris, R.N., Grevemeyer, I., Ranero, C.R., Villinger, H., Barckhausen, U., Henke, T., Mueller, C., and Neben, S. 2010a. Thermal regime of the Costa Rican convergent margin, 1. Along-strike variations in heat flow from probe measurements and estimated from bottom-simulating reflectors. *Geochem., Geophys., Geosyst.*, 11(12):Q12S28.

Harris, R.N., Spinelli, G., Ranero, C.R., Grevemeyer, I., Villinger, H., and Barckhausen, U. 2010b. Thermal regime of the Costa Rican convergent margin, 2. Thermal models of the shallow Middle America subduction zone offshore Costa Rica. *Geochem., Geophys., Geosyst.*, 11(12):Q12S29.

Harris, R., Sakaguchi, A., and Petronotis, K. 2012. Costa Rica Seismogenesis Project, Program A Stage 2 (CRISP-A2): sampling and quantifying lithologic inputs and fluid inputs and outputs of the seismogenic zone. *IODP Sci. Prosp.,* 344.

Kimura, G., Silver, E.A., Blum, P., *et al.,* 1997. *Proc. ODP, Init. Repts.,* 170: College Station, TX (Ocean Drilling Program).

Vannucchi, P., Scholl, D.W., Meschede, M., and McDougall-Reid, K. 2001. Tectonic erosion and consequent collapse of the Pacific margin of Costa Rica: combined implications from ODP Leg 170, seismic offshore data, and regional geology of the Nicoya Peninsula. *Tectonics,* 20(5):649–668.

Vannucchi, P., Dixon, T., Kastner, M., Villinger, H., *et al.,* 2006. Costa Rica Seismogenesis Project CRISP Program A. *IODP Proposal*: 537A-Full5.

Vannucchi, P., Sak, P.B., Morgan J.P., Ohkushi, K., Ujiie, K., and IODP Exp. 334 Shipboard Scientists. 2013. Rapid pulses of uplift, subsidence, and subduction erosion offshore Central America: Implications for building the rock record of convergent margins. Geology, doi:10.1130/G34355.1

Ye, S., Bialas, J., Flueh, E.R., Stavenhagen, A., von Huene, R., Leandro, G., and Hinz, K. 1996. Crustal structure of the Middle America Trench off Costa Rica from wide-angle seismic data. *Tectonics,* 15(5):1006–1021.

Expedition 340: Drilling offshore Monserrat (U1393 to U1396)

3 March 2012 – 17 April 2012

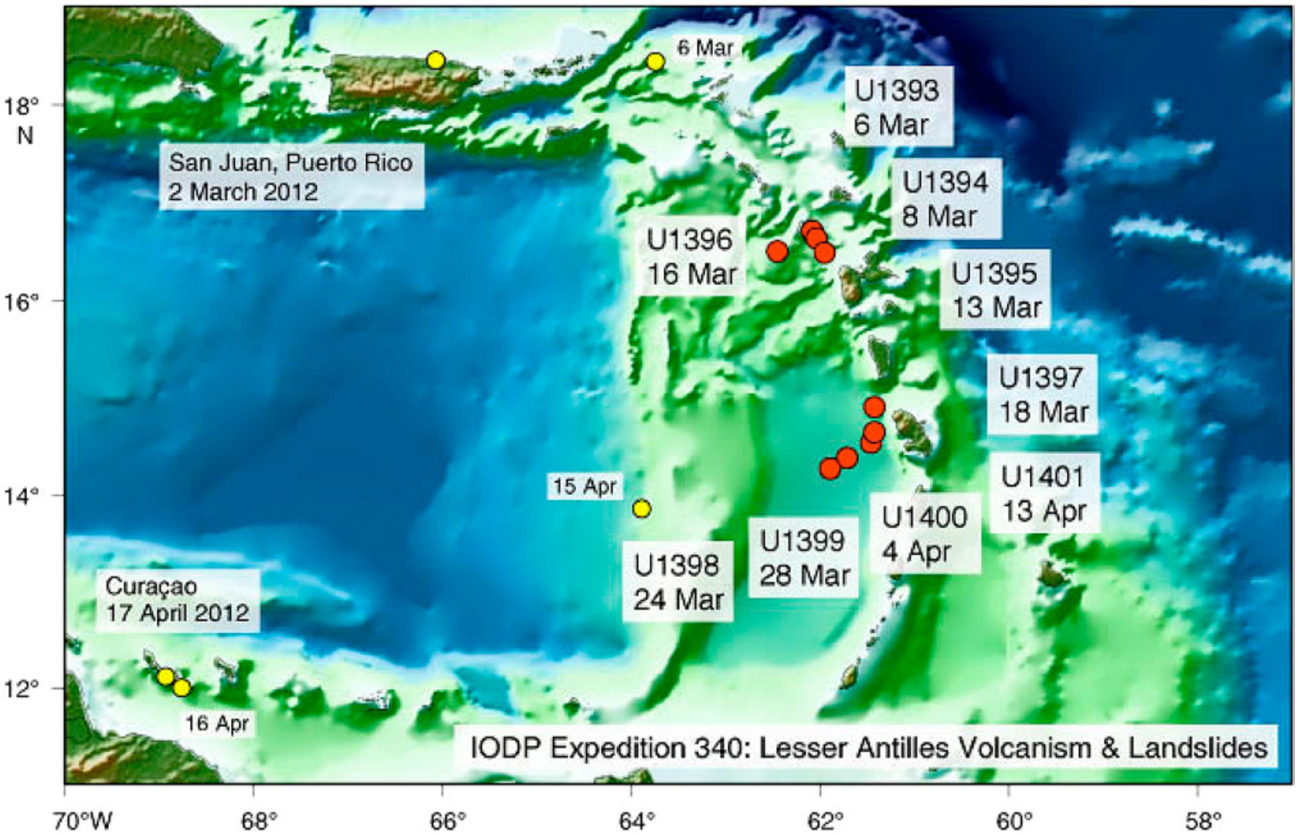
Deborah Wall-Palmer (University of Plymouth), Peter Talling (National Oceanography Centre, Southampton), Martin Palmer (University of Southampton), and Expedition 340 scientists

In 1995, the Soufriere Hills volcano, Montserrat, began it's most recent eruptive episode, initiating a wave of research into offshore processes and volcanic history. Marine sediments in this area contain a detailed record of volcanic events and collapse deposits, providing an ideal natural laboratory in which to study their timing and emplacement dynamics. Numerous short cores collected offshore and on land, as well as seismic and bathymetric surveys of the surrounding marine sediments, have lead to Montserrat becoming the centre of countless international multidisciplinary research projects (e.g. Trofimovs *et al.,* 2006; Le Friant *et al.,* 2008; Trofimovs *et al.,* 2010; Jones *et al.,* 2011; Wall-Palmer *et al.,* 2011).

An important outcome from this research was the recognition that large volumes of material were entering the ocean from island flank collapses during eruptive activity and that these had the potential to cause dangerous tsunami waves. Detailed seismic surveys (Lebas *et al.,* 2011) revealed a single deposit offshore Montserrat with a volume of ~20 km^3 and an area (277 km^2) larger than that of Montserrat (100 km^2). Recent research has further investigated these deposits (Watt *et al.,* 2012a, 2012b; Crutchley *et al.,* 2013), however, until recently, available sedimentary records spanned, at most, 250 ka (Le Friant *et al.,* 2008), making it difficult to fully appreciate the timing and emplacement dynamics of these large submarine collapse deposits.

In 2012, Integrated Ocean Drilling Program (IODP) Expedition 340: Lesser Antilles volcanism and landslides, set out to drill several sites in the Lesser Antilles (Figure 1), including four

Figure 1.
Bathymetric map of the Lesser Antilles showing all sites drilled during IODP Expedition 340.



offshore Montserrat (Figure 2). The aims of the expedition were to investigate the magmatic evolution and eruptive activity in space and time along the Lesser Antilles arc and to identify triggering, transport and deposition mechanisms for volcanic debris avalanches and submarine landslides.

To achieve these aims, three of the Montserrat sites were situated to the south east of the island, within the path of debris avalanches and submarine landslides which generally travel down the Bouillante-Montserrat graben (Figure 2), towards Guadeloupe. Coring through these blocky volcanic deposits proved to be very challenging, especially at site U1393, less than 7 km from land, where only 5.42 m of material was recovered, despite drilling 47.55 mbsf. However, sites U1394 and U1395 were very successful, drilling through two main deposits (Figure 3) previously identified by seismic surveys (Watt *et al.,* 2012a) and recovering exciting new records from the Bouillante-Montserrat graben. At site U1396, situated away from the path of submarine landslides, a sedimentary sequence spanning around 4.5 Ma was recovered, extending our current record of this area by 4.25 Ma. A total of eight cores were collected offshore Montserrat, recovering over 780 m of sediment and drilling to a maximum depth of 235 mbsf (U1394).

Material from these cores is currently being used in a variety of research by the international group of Expedition 340 ship board scientists. The short-term goal of our research is to produce a detailed stratigraphy for the upper sections of cores U1394, U1395 and U1396, spanning around 250 ka. This will involve oxygen isotope stratigraphy of planktonic foraminifera (*Globigerinoides ruber*) within hemipelagic sediment, as well as biostratigraphy of planktonic foraminifera and calcareous nannofossils. Once the stratigraphy is in place for site U1396, which has not been deformed by submarine landslides, correlation to sites U1394 and U1395 can be made. This will allow us to calculate the timing, scale and emplacement dynamics of volcanic and landslide events during the Pleistocene.

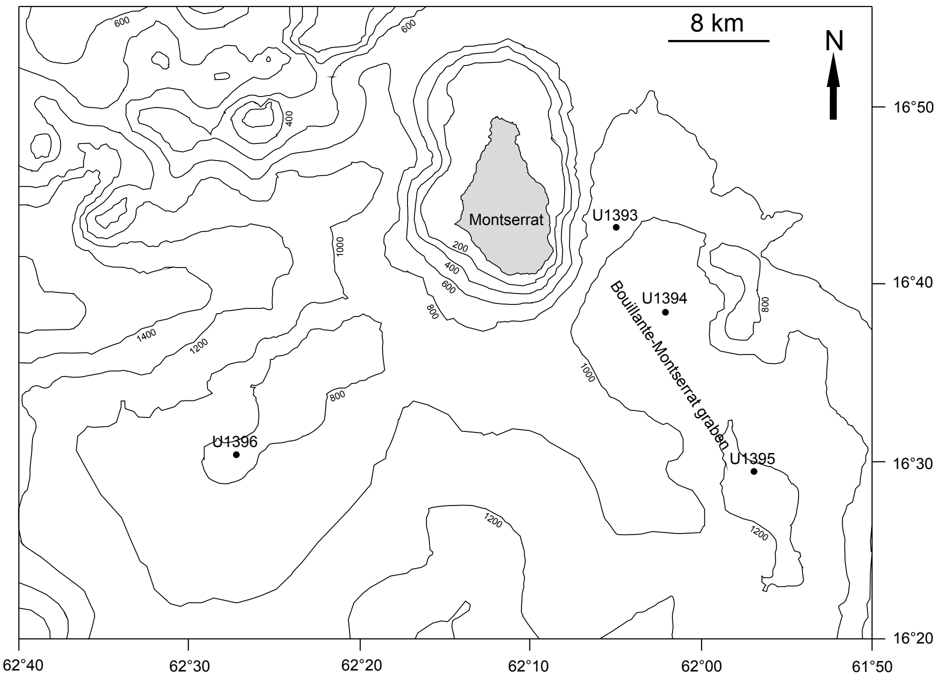
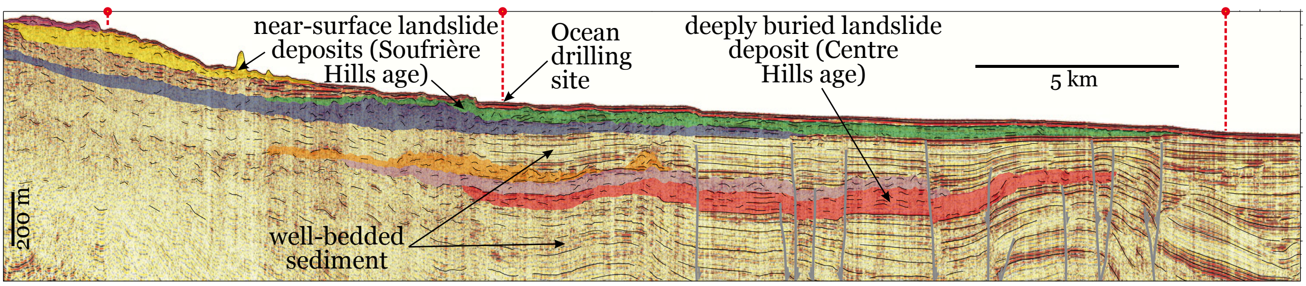


Figure 2.
The four IODP Expedition 340 sites situated offshore Montserrat with bathymetry. Three sites (U1393, U1394, U1395) are positioned within the path of submarine landslides and one (U1396) is positioned away from the path of landslides. Lines represent 200m intervals.

Figure 3.
Seismic profile collected in a north to south line to the east of Montserrat. The profile cuts across a number of landslide deposits. Image courtesy of Sebastian Watt, National Oceanography Centre, Southampton, UK.



References

Crutchley, G.J., Karstens, J., Berndt, C., Talling, P.J., Watt, S.F.L., Vardy, M.E., Hühnerbach, V., Urlaub, M., Sarkar, S., Klaeschen, D., Paulatto, M., Le Friant, A., Lebas, E., and Maeno, F. 2013. Insights into the emplacement dynamics of volcanic landslides from high-resolution 3D seismic data acquired offshore Montserrat, Lesser Antilles. *Marine Geology,* **335,** 1–15.

Jones, M.T., Hembury, D.J., Palmer, M.R., Tonge, B., Darling, W.G., and Loughlin, S.C. 2011. The weathering and element fluxes from active volcanoes to the oceans: a Montserrat case study. *Bulletin of Volcanology,* **73,** 207–222.

Le Friant, A., Lock, E.J., Hart, M.B., Boudon, G., Sparks, R.S.J., Leng, M.J., Smart, C.W., Komorowski, J.C., Deplus, C., and Fisher, J.K. 2008. Late Pleistocene tephrochronology of marine sediments adjacent to Montserrat, Lesser Antilles volcanic arc. *Journal of the Geological Society, London,* **165,** 279–290.

Lebas, E., Le Friant, A., Boudon, G., Watt, S.F.L., Talling, P.J., Feuillet, N., Deplus, N., Berndt, C., and Vardy, M.E. 2011. Multiple widespread landslides during the long-term evolution of a volcanic island: Insights from high-resolution seismic data, Montserrat, Lesser Antilles. *Geochemistry, Geophysics, Geosystems*, **12,** Q05006.

Trofimovs, J., Amy, L., Boudon, G., Deplus, C., Doyle, E., Fournier, N., Hart, M.B., Komorowski, J.C., Le Friant, A., and Lock, E.J. 2006. Submarine pyroclastic deposits formed at the Soufrière Hills volcano, Montserrat (1995–2003): What happens when pyroclastic flows enter the ocean? *Geology*, **34,** 549–552.

Trofimovs, J., Fisher, J.K., Macdonald, H.A., Talling, P.J., Sparks, R.S.J., Hart, M.B., Smart, C.W., Boudon, G., Deplus, C., Komorowski, J.C., Le Friant, A., Moreton, S.G., and Leng, M.J. 2010. Evidence for carbonate platform failure during rapid sea-level rise; ca 14 000 year old bioclastic flow deposits in the Lesser Antilles. *Sedimentology*, **57,** 735–759.

Wall-Palmer, D., Jones, M.T., Hart, M.B., Fisher, J.K., Smart, C.W., Hembury, D.J., Palmer, M.R., and Fones, G.R. 2011. Explosive volcanism as a cause for mass mortality of pteropods. *Marine Geology,* **282,** 231–239.

Watt, S.F.L., Talling, P.J., Vardy, M.E., Masson, D.G., Henstock, T.J., Hühnerbach, V., Minshull, T.A., Urlaub, M., Lebas, E., Le Friant, A. Berndt, C. Crutchley, G.J., and Karstens, J. 2012a. Widespread and progressive seafloor-sediment failure following volcanic debris avalanche emplacement: Landslide dynamics and timing offshore Montserrat, Lesser Antilles. *Marine Geology*, **323–325,** 69–94.

Watt, S.F.L., Talling, P.J., Vardy, M.E., Heller, V., Hühnerbach, V., Urlaub, M., Sarkar, S., Masson, D.G., Henstock, T.J., Minshull, T.A., Paulatto, M., Le Friant, A., Lebas, E., Berndt, C., Crutchley, G.J., Karstens, J., Stinton, A.J., and Maeno, F. 2012b. Combinations of volcanic-flank and seafloor-sediment failure offshore Montserrat, and their implications for tsunami generation. *Earth and Planetary Science Letters,* **319–320,** 228–240.

Scientific Workshops

UK-IODP support for Scientific Conferences and Workshops

Through direct funding, and/or by providing travel and subsistence funding for participating scientists, UK-IODP has recently provided support for the workshops described in this section. UK-IODP is also providing funding for the upcoming meeting 'Micropalaeontology and the IODP, Past, Present and Future Applications' hosted by The Micropalaeontological Society (TMS) http://www.tmsoc.org/agm2013.htm. Hosting and/or participating in IODP-related meetings is an important factor in maintaining UK scientist's success within the programme. If you would like to attend an IODP conference, or better yet host an event in the UK, please contact the Science Coordinator for further information (ukiodp@bgs.ac.uk).

ECORD Summer Schools

In 2013, UK-IODP has funded the participation (€1000) of five UK students in the always excellent ECORD summer schools in Bremen and Urbino. A further five students received funding directly from ECORD (http://www.essac.ecord.org/index.php?mod=education&page=summer-school).

- The Urbino Summer School in Paleoclimatology, Italy.
- ECORD Summer School on Deep Sea Sediments: From Stratigraphy to Age Models (MARUM), University of Bremen, Germany.

UK Participants	University	Programme
Adele Cameron	Open University	Urbino
Matt Carmichael	Bristol	Urbino
Max Holloway,	BAS	Urbino
Jamie Lorna Lakin	Leeds	Urbino
Cherry Newsam	UCL	Urbino
Rhian Ress Owen	Leeds	Urbino
Charlotte Spencer Jones	Newcastle	Urbino
Matthew Dumoth		Bremen
Chris Poole	Leeds	Bremen
Rosie Sheward	NOCS	Bremen

2012 UK-IODP Student and Early-Career Scientist Conference

9–11 September 2012

Dayton Dove (UK-IODP Science Coordinator; BGS)

Approximately 50 students, early-career scientists, and mentoring senior scientists participated in this three-day event of research presentations and workshop activities. The conference was held at the Royal Society's Kavli Centre at Chicheley Hall (http://www.chicheleyhall.co.uk/academic-events/. http://www.chicheleyhall.co.uk/academic-events/). On the opening evening and first full day we had a combination of talks by students/early-career scientists describing their research and IODP experiences, talks by senior scientists describing the future of ocean research drilling, and practical information on how best to interact with the programme. Prof. Joe Cann gave a fantastic keynote lecture on the history of ocean drilling. The final day was given to an exercise where breakout groups put together and presented a mock IODP drilling proposal. This turned out to be an excellent tool in which to introduce many aspects of the programme, from working with an inter-disciplinary group of scientists to coming up with complimentary scientific objectives, to planning a logistically practical operation. Senior scientists were on hand to mentor groups, and provide constructive feedback. We have had a lot of positive feedback on the event generally, so all in all it was a great success. This was the first UK event of its kind, and consensus is to hold the event every three years (tentatively next Student Conference in 2015).

Break-out group discussion.

Conference Abstracts and Programme: http://www.bgs.ac.uk/iodp/docs/Student%20UK%20IODP%202012%20Prog.pdf

Conference Participants in front of Chicheley Hall.

2012 UK-IODP General Conference

12 September 2012

Dayton Dove (UK-IODP Science Coordinator; BGS)

Held at the University of Oxford, the one day conference included a series of excellent talks covering the diversity of research conducted within IODP, a poster session, and discussions about the future of the international and domestic programmes with the current phase ending September of 2013. The talks were organised into short (15 min) and long (45 min) addresses. Most participants of the preceding Student Conference also travelled to join the audience in Oxford. The next General Conference is tentatively planned for summer 2014.

Speakers:

45 min: *Professor Gideon Henderson*, University of Oxford, 'Sea-level changes of the Pleistocene and the mechanisms of climate change'
Dr Sasha Turchyn, University of Cambridge, 'The Microbial Deep Biosphere: Insights from the geochemistry of pore fluids and sediments'
Dr Matt O'Regan, University of Stockholm, 'Arctic Drilling in the new phase of IODP—Opportunities, challenges and emerging proposals',
Professor Godfrey Fitton, University of Edinburgh, 'Testing the mantle plume hypothesis through ocean drilling'
Dr Dan Faulkner, University of Liverpool, 'The strength of faults through the seismic cycle'

15min: *Professor Paul Wilson*, University of Southampton, 'IODP Exp. 342 Newfoundland Sediment Drifts: Scientific rationale and initial drilling results'
Dr Rob Larter, British Antarctic Survey, 'Antarctic and Southern Ocean drilling in the new phase of IODP',
Professor David Hodell, University of Cambridge, 'Significance of the 'Shackleton Site' (IODP Site U1385) on the Iberian Margin for Global Stratigraphy and Climate Change Research'
Professor Julian Pearce, Cardiff University, 'Understanding Subduction Initiation and Ophiolite Formation through Forearc Drilling'
Professor Martin Palmer, National Oceanography Centre, Southampton,'Update for IODP leg 340 to the Lesser Antilles'.

Conference Abstracts and Programme: http://www.bgs.ac.uk/iodp/docs/UK%20IODP2012%20Main%20Prog.pdf

Hollywell Music Room, Wadham College, University of Oxford.

Advancing our Understanding of Cretaceous Ocean Dynamics by Scientific Drilling

15–17 April 2013, University College London

Stuart A Robinson (University College London; now at University of Oxford)

**The 'Exploring the Cretaceous Greenhouse through Scientific Drilling' workshop was funded by the ECORD Magellan+ workshop series, UK-IODP, USSSP and IODP-MI.*

Understanding the response of Earth's climate and ocean system to elevated levels of atmospheric CO_2 is a key theme for the next phase of scientific ocean drilling. Marine environmental conditions during the middle Cretaceous (Barremian through Turonian; ~130–88 Ma) provide insights into the possible state of future oceans influenced by globally increasing temperature and major changes in ocean chemistry. This preview includes ocean dynamics driven by reduced thermal gradients and episodic ocean acidification together with hypoxia, anoxia and euxinia. High profile and novel research has demonstrated that the middle Cretaceous oceans record the 'end-member' conditions of an ocean–atmosphere system forced by rapid and extreme climate change (e.g. Erba *et al.,* 2010, Jenkyns 2010). Studying the environmental conditions of the Cretaceous provides complementary, yet contrasting, views of greenhouse climates compared to the much better-studied Paleogene. However, over the last decade only one ODP leg had specific mid-Cretaceous palaeoceanographic objectives (Leg 207, Demerara Rise).

Considerable progress in our understanding of Cretaceous oceans was derived during the early stages of ocean drilling, especially the DSDP (e.g. Ryan and Cita, 1977; Schlanger and Jenkyns, 1976;

Workshop participants assembled on the steps of the portico at University College London.

Arthur and Fischer, 1977; Jenkyns, 1980; Bralower and Thierstein, 1984). However, advancing further the state of knowledge of Cretaceous oceanic environments is severely limited by a lack of material to which new proxies and techniques can be applied. The limitations are both geographic and stratigraphic in scope. For example, there are few oceanic records from the high latitudes, particularly in the Northern Hemisphere, and the Pacific Ocean is under-represented, especially given its significant geographical area, essentially half the planet, in the Cretaceous (even though only a proportion of ocean crust present during the Cretaceous still exists). Many 'classic' Cretaceous sites drilled during the early DSDP expeditions were only spot-cored with poor recovery. Furthermore, early DSDP drilling was largely exploratory and so sites were not located with specific paleoceanographic hypotheses to test. Consequently, there are very few well-designed depth transects through the Cretaceous ocean from the shelf to the deep sea.

This paucity of material from all oceans has limited our understanding of rapid paleoceanographic change such as expansion of the oxygen-minimum zone (OMZ) during Oceanic Anoxic Events (OAEs), injection of isotopically light carbon into the ocean–atmosphere system, movement of the Calcite Compensation Depth (CCD), fluctuations in nutrient loads and composition of planktonic biota — and hence prevented the high-resolution studies that have led to significant breakthroughs in studies of the Paleogene (e.g. Thomas *et al.,* 2002; Zachos *et al.,* 2003; Nunes and Norris, 2006).

In order to address the deficiencies in our understanding of Cretaceous climate and ocean dynamics, new drilling projects, both on land and at sea, are required. With support from IODP-MI, USSSP, Magellan+ and UKIODP, a workshop was held at University College London in April 2013, with the specific goal of instigating new drilling project designed to further our understanding of Cretaceous ocean circulation and climate, acidification and deoxygenation, and the impact of these conditions on life at the surface of the ocean and at depth.

In organising the workshop our approach was to limit the size to encourage dynamic and focused discussions in breakout groups that would lead, over three days, to preliminary drafts of drilling proposals. The workshop was attended by 47 participants (including 12 from the UK, 4 of which were funded by UKIODP), that were selected from over 70 applicants. We were keen to encapsulate the full breadth of expertise and disciplines interested in the Cretaceous. Consequently, representatives from the modelling, geochemical, geophysical and palaeontological communities were present, including everyone from PhD students just embarking on IODP careers to senior professors, with memories of life aboard GLOMAR Challenger!

As convenors, our aim was to have short written documents produced by the end of the three days that would lay the foundations for future proposals. In order to achieve this aim, we allocated very little time to presentation of science and instead devoted most of the time to discussion in breakout groups. Nonetheless, on the first day the convenors laid out an introduction to the science themes, proposal requirements and vision for the workshop. Stuart Robinson (UCL) provided an overview of Cretaceous climate and ocean circulation, and highlighted the critical need for depth transects in order to reconstruct chemical profiles (of, for example, d^{13}C, eNd). Hugh Jenkyns (Oxford) discussed the story of OAEs from the early days of DSDP to the latest geochemical proxies being applied to understand redox, climatic and physical oceanographic change during the events. Elisabetta Erba (Milan) and Paul Bown (UCL) introduced the implications for planktontic and benthic life of carbon cycle and climatic change during the Cretaceous. Proposal Evaluation Panel (PEP) sub-Chair, Tim Bralower (Penn State), presented the current proposal options and guidelines for IODP, which was followed by an introduction to site survey requirements by Site Characterisation Panel (SCP) member, Gabi Uenzelmann-Neben (AWI, Bremerhaven). It was felt that the inclusion of the latter talks was vital to ensure proponents were aware of the requirements of the IODP proposal process and that, by highlighting such critical issues now, future delays in the progression of the proposals might be avoided. At the end of the first day, a poster session gave participants the opportunity to discuss their ideas for future drilling targets, new proxy records and the outstanding questions regarding the Cretaceous marine environment.

Prior to the workshop, invited participants had completed a questionairre describing their areas of scientific interest and where they would like to drill. On the basis of this information, four breakout groups of approximately equal size were organised along geographical lines — Arctic, North and South Atlantic, Southern Ocean, Indian and Pacific Ocean. These groups met first to discuss science questions pertinent to their area, and then, from the beginning of the second day, to start discussing potential drilling targets. By the plenary session on the third day, each group had identified key objectives and had drafted documents describing the aims, justification, and drilling strategies for their region. Within these documents, detailed descriptions of specific target areas were given, which range from re-drilling of areas explored by DSDP to new drilling in places for which seismic data have only recently becoming available. Furthermore, the projects outlined during the workshop require a range of platforms both for onshore and offshore drilling. We hope that the information drafted in London will form the basis of many pre-proposals that will be submitted in Autumn 2013 to PEP and that eventually these will lead to exciting new opportunities to reveal the secrets of the Cretaceous world.

Convenors:

Stuart A. Robinson (University College London, UK, now at University of Oxford, UK)

Timothy J. Bralower (Penn State University, USA)

Paul R. Bown (University College London, UK)

Elisabetta Erba (University of Milan, Italy)

Hugh C. Jenkyns (University of Oxford, UK)

R. Mark Leckie (University of Massachusetts, Amhurst, USA)

References

Arthur M.A., and Fischer A.G. 1977. Upper Cretaceous-Paleocene magnetic stratigraphy at Gubbio, Italy. I. Lithostratigraphy and sedimentology. *Geol. Soc. Am. Bull.*, 88:367–371.

Bralower, T.J., and Thierstein, H.R. 1984. Low productivity and slow deep-water circulation in mid-Cretaceous oceans: *Geology*, v. 12, p. 614–618.

Erba, E., *et al.,* 2010. Calcareous Nannoplankton Response to Surface-Water Acidification Around Oceanic Anoxic Event 1a. *Science, 329*, 428–432. DOI: 10.1126/science.1188886

Jenkyns, H.C. 1980. Cretaceous anoxic events: from continents to oceans. *Geol. Soc. Lond.* 137:171–188.

Jenkyns, H.C. 2010. Geochemistry of oceanic anoxic events, *Geochem. Geophys. Geosyst.*, 11, Q03004, doi:10.1029/2009GC002788

Nunes, F., and Norris, R. 2006. Abrupt reversal in ocean overturning during the Palaeocene/Eocene warm period. *Nature*, 439, 60-63, doi:10.1038/nature04386

Ryan, W.B.F., and Cita, M.B. 1977. Ignorance concerning episodes of ocean-wide stagnation. *Marine Geology*, 23:197–215.

Schlanger, S.O., and H. C. Jenkyns. 1976. Cretaceous oceanic anoxic events: Causes and consequences, *Geol. Mijnbouw*, 55, 179–184.

Thomas, D.J., *et al.,* 2002. Warming the Fuel for the Fire: Evidence for the thermal dissociation of methane hydrate during the Paleocene-Eocene thermal maximum, *Geology,* v. 30, p. 1067–1070.

Zachos, J.C., *et al.,* 2003. A Transient Rise in Tropical Sea Surface Temperature During the Paleocene-Eocene thermal maximum, *Science* v. 302, p. 1551–155.

CHIKYU+10

21–23 April 2013, Tokyo

Lisa McNeill (University of Southampton)

In April, 2013, nearly 400 international participants from over 20 countries (including 160 from outside Japan) gathered at Hitosubashi University in Tokyo for the CHIKYU+10 planning meeting, in order to discuss potential riser and ultra deepwater drilling projects for the next 10 years of Deep Sea Drilling Vessel *Chikyu* operations. Presentations and discussions were arranged around 5 themes that link directly to IODP's 2013–2023 science plan: Dynamic Faults; Ocean Crust and Earth's Mantle; Deep Life and Hydrothermal Systems; Continent Formation; and Sediment Secrets. 127 White Papers were submitted in support of projects within these themes and 53 Project Proposal outlines were submitted at the end of the meeting. Presentations were also provided explaining D/V *Chikyu's* operational and technical capabilities, particularly for drilling deep riser holes. Currently the ship can drill to a total depth of 9000 m including a maximum water depth of 2500 m. There are plans for technological development in order to increase water depth capability to 4000 m and total depth to 12000 m.

A number of specific science projects addressing high priority Earth science problems were discussed and will be highlighted within the summary report (see below). These include: Styles of fault slip behaviour, continental margin evolution and seismogenic hazards from subduction zone margins; Composition of the mantle and crust and evolving crustal properties and hydrogeology during the life cycle of the oceanic lithosphere; Island arc formation and the building of continents; Limits of sub-seafloor life in contrasting environments; and Episodes of extreme climate change.

A report summarizing the meeting discussions and future directions has been compiled by the Steering Committee (which includes two members from the UK: Dick Kroon and Lisa McNeill) and will be released this summer. An EOS-AGU article summarizing the meeting will also be published imminently. The newly formed Chikyu IODP Board (CIB) will meet for the first time in July, 2013 in order to take forward discussions from the meeting, as summarized in the CHIKYU+10 meeting report.

**Apart from those receiving local support, four UK scientists were supported by UK-IODP to attend CHIKYU+10: Jason P. Morgan (Royal Holloway); David R. Tappin (British Geological Survey); Dean J. Wilson (University of Southampton); Paola Vannucchi (Royal Holloway)*

GeoPRISMS Planning Workshop for the New Zealand Primary Site

15–17 April 2013, Tokyo

Lisa McNeill (University of Southampton)

The NSF-funded GeoPRISMS program (the successor to MARGINS) includes two broad scientific themes: Subduction Cycles and Deformation (SCD); and Rift Initiation and Evolution (RIE). MARGINS and now GeoPRISMS play an extremely important role in bringing together the international Earth Science community focused on tectonics, continental margins and plate boundaries. Within SCD, three primary sites have been selected: Alaska; Cascadia; and New Zealand. In support of the New Zealand Primary Site an implementation planning workshop was held in Wellington, New Zealand in April, 2013. 170 international participants from 10 different countries (including the UK) attended the meeting and 30 high-quality white papers were submitted by individuals and groups of participants.

The meeting was based around the following themes:

- Geological, geochemical, and geophysical responses to subduction initiation and early arc evolution;
- Pathways and sources of magma and volatiles emerging in the arc and forearc and interactions with upper plate extension;
- Controls on subduction thrust slip behaviour;
- Feedbacks between climate, sedimentation and forearc deformation.

These themes were discussed in the context of four specific New Zealand geographic regions: the Puysegur Trench (a site of subduction initiation); the Hikurangi Subduction Zone (subduction of the thickened Hikurangi Plateau, and variable slip behaviour (including slow slip) and coupling along the margin); the Taupo Volcanic Zone (the most productive rhyolitic system on Earth and coincident with active extensional faulting); and the Kermadec Arc (a well developed volcanic arc).

The GeoPRISMS initiative in New Zealand is strongly linked to ocean drilling: a Multiphase Drilling Project and daughter proposals to target slow slip events at the Hikurangi subduction zone including both riserless and riser boreholes are already within the IODP system; and proposals to target the Brothers volcano within the Kermadec arc, and to analyse subduction initiation in the Tasman Sea region have recently been submitted.

A now regular feature of GeoPRISMS meetings, the student symposium, also took place in Wellington. This initiative provides students with a much more significant role at each meeting, an opportunity to meet prior to the meeting and to present their own perspective on the way forward. This is invariably the most succinct and insightful presentation at the meeting!

The results of scientific discussions and implementation approaches based around the primary themes and geographic regions are being compiled within the New Zealand Implementation Plan which will be available at the GeoPRISMS website in late summer (http://www.geoprisms.org/). This will then act as a guide for both NSF and international collaborative grant proposals and integrated projects.

Outreach

Expedition 345: Post Cruise Education and Outreach Activities

12 December 2012 – 12 February 2013

Dr. Susan Gebbels (School of Marine Science and Technology, Newcastle University)

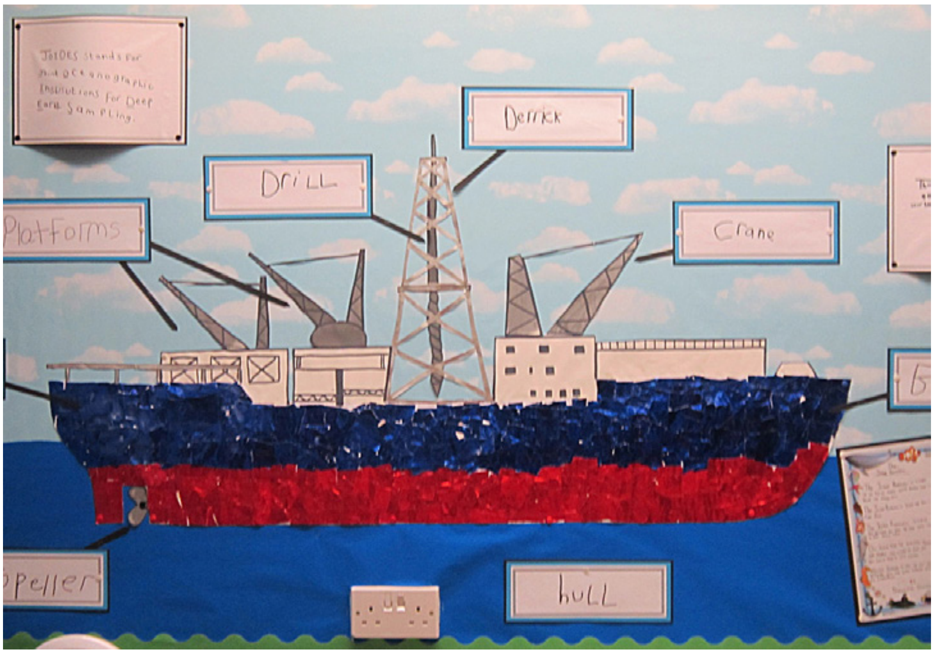
On 12 December the JOIDES Resolution left Costa Rica to travel to the Hess Deep Rift in the Pacific Ocean, just north of the equator. Expedition 345's mission was to drill into the lower oceanic crust to try to retrieve samples of gabbro from the rift which is within the triple junction of the Cocos, Nazca and Pacific plates. A secondary aim was to disseminate the daily challenges and findings of the cruise to the wider public via social media and to use to Skype to broadcast live from the ship to schools around the world. As one of the three education officers on board the later objectives were my responsibly. Prior to sailing, my French colleague, Jean-Luc Berenguer, and I, contacted schools and community groups from within our networks all over the world and invited them to take part in the broadcasts. The result was a very full calendar of 93 broadcasts. Each day we spoke with at least one school and on our busiest days 4/5 organisations. After 8 weeks at sea, 4000 young people from 16 countries had had a tour of the ship, seen the geologists at work and viewed the samples. This was an IODP record. The education and outreach activities also received the highest scores from every category in the post cruise evaluation report.

Left to right: Susan Gebbels, Nicole Kurtz, Jean-Luc Berenguer.

My other role was to develop educational resources that reflected all aspects of the mission: the geology of the seabed, the species in the water column and shipboard life. Working with closely with Jean-Luc and an American artist, Nicole Kurtz, we produced several, original work-packages that contained all the resources needed for teachers to run sessions on topics such as marine snow, deep sea animals, how ships work and the magnetic susceptibility of rocks. These can be downloaded at the JOIDES website. My shipboard colleagues and I were very keen that the educational aspects of the cruise continued beyond our 2 months at sea. To facilitate this we devised a post-cruise plan. Immediately upon my return to the UK I revisited over 20 NE schools that I had made contact with before sailing, I told them about my adventures and took in samples of rocks and other artefacts. Many of the schools had built the expedition into their half terms work and it was rewarding to see expedition 345 woven into many curriculums and displayed prominently on notice boards.

During National Science and Engineering Week in March I ran a week of workshops for secondary school pupils that focused on the expedition and utilised the work packages that we had developed. The activities aimed to teach geosciences and marine biology in a fun and novel way. For example, the animals of the deep session looked at the biodiversity of life that one could find down the length of the drill pipe as it was lowered from the ship to the seabed 4000 m below. The workshop session also included a mini research challenge; an adaptation game and an art session were pupils had to make a deep sea animal out of recycled materials. I am fortunate that the Dove Marine Laboratory in which I work is based in a bay that has been designated as a Site of Special Scientific Interest for its geological interest. The geology workshop was therefore based outside and involved a 'treasure hunt' and cave exploration. This was followed up with a poster session in the classroom and a game that showed the difficulties of sampling in deep water. Feedback from the schools has been very positive and the work-packages continue to be utilised by teachers. During the week I also delivered a public lecture about my experiences on board the JOIDES to a family audience in one of the main university auditoriums.

Brandling Primary School, Gateshead; Ages 9/10.



Citizen science, the use of non-scientists to help in scientific research, is a subject that has become very topical over the last decade. Many successful projects have shown the value of using lay people to gather data under the guidance of experts. The next phase of our post cruise agenda is an ambitious, collaborative project to involve 16–18 year old pupils from France and UK in a sampling experiment. As Exp. 345 was a hard rock expedition, the sediments are not being analysed by the geologists. Starting from September 2013, Jean-Luc and I will be working with 12–15 schools to analysis the nannofossils and radiolarians from some of the samples from the cruise. Schools will apply to get a sample of sediments, and to study fossils following a precise process. A database will be developed and the students will be able to upload their results. A publication an Education and Outreach Journal is expected. Another innovative hands-on activity that we will be starting in September is to make thin sections with sand drilled in the Hess Deep to study the minerals of the ocean crust, and to compare it with thin sections of sand taken from granite (continental crust). This practical activity will be offered to an additional cohort of young people to make the post cruise activities available to as many pupils as possible. Alongside these studies the students will have the opportunity to examine some of the actual cruise samples of olivine gabbro and troctolite, which will allow them to practise their visual description skills, and measure physical properties such as velocity and thermal conductivity.

My two months on-board the JOIDES provided me with amazing opportunity to learn new skills, travel to exciting destinations and meet with a diverse and interesting group of people. I would like to thank UKIOPD for all the assistance that they gave me during every phase of the expedition.

Susan Gebbels is a marine biologist in the School of Marine Science and Technology, Newcastle University. She works within the outreach and engagement group as a research associate.

Jean-Luc Berenguer is a science teacher at the International School of Valbonne.

Nicole Kurtz is a freelance artist from the USA.

UKIODP News

Dayton Dove (Science Coordinator-BGS), Jessica Surma (Programme Manager-NERC)

Websites:
http://www.bgs.ac.uk/iodp/ (Coordinator's website: Programme activities, guidance, and scientific highlights)

http://www.nerc.ac.uk/research/programmes/ukiodp/ (Formal website: programme announcements and information)

International Ocean Discovery Program (IODP) (2013–2023)

The next phase of IODP commences October 2013. While the management structure has evolved, all implementing organizations have agreed to administer programmes under the governing goals laid out in the new Science Plan 'Iluminated Earth's Past, Present and Future' (http://www.iodp.org/science-plan-for-2013-2023). UK scientists played a central role in developing the Science Plan which is organized around four themes:

1. Climate and Ocean Change: Reading the Past, Informing the Future

2. Biosphere Frontiers: Deep Life, Biodiversity, and Environmental Forcing of Ecosystems

3. Earth Connections: Deep Processes and Their Impact on Earth's Surface Environment

4. Earth in Motion: Processes and Hazards on Human Time Scales

Structure
The European Consortium for Ocean Research Drilling (ECORD) members are in the process of signing the MoU concerning national contributions to ECORD (NERC has recently signed). Draft MoU's between the three platform providers, ECORD (Europe), NSF (US), and MEXT (Japan), are at an advanced stage, and it is anticipated these will be finalised and signed in the near future.

Under the new IODP programme, it has been agreed by all the lead funding agencies that there will be a simplified funding model (no 'co-mingled funds'), with lighter management. While maintaining the overarching international umbrella of the programme, platform providers will have greater independence. Details of these agreements are stated in the following letter issued by ECORD:

http://www.ecord.org/Letter_to_ECORD_Science_Community.pdf

ECORD berths
The result of this restructuring is that in comparison with the past 10 year phase, there will be more ECORD (and by extension, UK) berths on JOIDES *Resolution* (JR) and Mission Specific Platform (MSP) expeditions, and fewer on *Chikyu*. It is anticipated that there will be up to 400 ECORD berths on JR over the next 10 years. ECORD is planning to run and average of one MSP per year, with a minimum of 10 ECORD berths per expedition (i.e. ~100 berths over the 10 year programme). While not yet finalised, as details of the MoU are still being finalised, it is anticipated that approximately six berths will be available for ECORD scientists on *Chikyu* per year, (i.e. ~60 over the 10 year programme).

Co-chief scientists will not count against berth quotas in the new programme. All told, it is expected there will be between 500 and 600 ECORD berths over the next 10 years, a 25–50% increase on the concluding programme.

UK-IODP (2013–2018); Next phase for NERC's directed research programme.

Following the evidence gathering exercise of 2010-2011, the Review in 2011 (http://www.nerc.ac.uk/research/programmes/ukiodp/findings.asp), and the presentation to NERC over the last year, the UK-IODP research programme has been successfully renewed for five years (2013–2018), after which time the programme will be subject to review. Earlier in 2013, the UK-IODP Programme Advisory Group and Management Office revised the Theme Action Plan (TAP) that was presented by Prof. Harry Elderfield (temporary Theme Leader for Earth System Science (ESS)) to the NERC Science and Innovation Strategy Board (SISB). With SISB's recommendation the TAP was funded by NERC Council in June with a budget of £5.5 m for the first 5 years of the new programme (see announcement at: http://www.nerc.ac.uk/research/themes/tap/tap-phase4.asp#ukiodp).

Taking recommendations from the NERC 2011 Review of UK-IODP, and knowing early on it would be untenable to maintain the pot of 'ring fenced' grant funding as allocated for 2003–2013 phase, the structure for the new programme was defined by the NERC ESS Theme Leader (Prof. Tim Jickells up until October 2012, followed by Prof. Harry Elderfield) with input from the UK-IODP Programme Advisory Group. Notable elements of the new programme include:

- Moratorium Awards (new) — incorporates participation costs for IODP expeditions (continued) and post-cruise funding (continued) (~£2.7 mil over 5 years)
- Site Survey Grants (continued) (~£2.2 mil)
- Knowledge Exchange Function (new) (~£0.2 mil)

The British Geological Survey will continue to provide the UK-IODP Science Coordination function, and NERC will continue to administer the programme (~0.5 mil).

Moratorium Awards
These awards will combine salary support for expedition participants and funding for post cruise research. Moratorium awards are available to all IODP expedition participants, however available funding for post cruise research will depend on career stage:

PhD student — £25,000

Post-doctoral researcher — £50,000

Tenured scientist — £25,000

Applications for Moratorium Awards will be made through JeS prior to joining expedition. Further detail and guidance will be posted on the NERC UK-IODP webpages and through the UK-IODP mailing list.

Knowledge Exchange Programme
The NERC Ocean Drilling Review highlighted that more could be done to engage more widely in Knowledge Exchange activities. In response we will employ a Knowledge Exchange Fellow, on a part-time basis for up to 3 years, who will act as an interface between the UK community and business. They will facilitate effective communication; advance the uptake of relevant IODP research outputs and appropriate knowledge transfer mechanisms; and work towards creating a legacy of strong relationships between business and the research community.

Further news on the Knowledge Exchange post will be forthcoming through the UK-IODP mailing list.

Site Survey Grant Rounds
A key requirement of the IODP proposal evaluation process is that potential drill sites have adequate site surveys to justify selection of safe drill sites. UK-IODP will continue to make available resources to allow the UK community to acquire such site surveys, since they are essential for UK-lead expedition applications. These grants in the past have been important for establishing UK's leadership in UK-IODP.

It is anticipated that there will be two calls for Site Survey Grants over the next five years, the first of which in 2014/15.

Science Coordination
- Continue to communicate programme news and opportunities to network of over 500 UK scientists who engage in IODP-related research.
- Support UK scientists participating in IODP expeditions as well as those engaged in the IODP Science Advisory Structure (SAS).
- Organise, facilitate, and sponsor science meetings/workshops
- Establish programme research priorities with NERC managers and the Programme Advisory Group.
- Support student opportunities and outreach (e.g. Summer schools, and Teachers at Sea)
- Regularly publish programme literature through newsletters, website, advocacy reports, etc . . .

UK-IODP Programme Advisory Group
Following a recent call, a new chair will soon be in place for the Programme Advisory Group (PAG) (previously called the Science Advisory Panel (SAP). The PAG comprises delegates to IODP's Science Advisory Structure (SAS) international panels, and several invited members. A new 3+1 rotation policy has been implemented on the PAG, which entails three years commensurate with SAS membership, then one further year on PAG. When the new Chair is in place, we will determine whether there are gaps in expertise within the group, and fill them accordingly.

UKIODP Programme Advisory Group (PAG) Membership			
All IODP Science Advisory Structure (SAS) panel members plus chair, invited members			
****SAS Panel recently disbanded**			
SAS Panel	**Member**	**Alternate**	**PAG membership ends (3+1)**
***SIPCom (Science Implementation and Policy Committee)*	Paul Wilson (Southampton)		January 14
PEP (Proposal Evaluation Panel)	Dick Kroon (Chair; Edinburgh)		December 15
PEP (Proposal Evaluation Panel)	Lisa McNeill (Southampton)		November 16
PEP (Proposal Evaluation Panel)	Stuart Robinson (UCL)		May 16
***TP (Technology Panel)*	Cedric John (Imperial)		September 13
EPSP (Environmental Protection and Safety Panel)	Bramley Murton (NOC)		September 14
SCP (Site Characterization Panel)	Mads Huuse (Manchester)		January 17
ESSAC	Bridget Wade (Leeds)	Anthony Morris (Plymouth)	October 16
All above Panel members plus			
Chair	*New Chair decided Aug 2013		
Former Chair	Mike Bickle (Cambridge) (Former SASEC member)		September 13
Invited representative	Mike Lovell (Leicester) (Former STP member and chair)		September 13
Invited representative	John Maclennan (Cambridge) (Former PEP member)		September 13
Invited representative	Damon Teagle (Southampton) (Former SASEC member)		September 13
***Engineering Developement Panel (EDP)*	John Thorogood (Consultant)		September 13
ESO representative	David McInroy (BGS) (Previously Dan Evans)		Ongoing

Grants:
There were no dedicated UK-IODP grant rounds in the last year.

Recent Rapid Response Grants
Rapid Response Grants have supported small-scale, shore research activities relating to IODP leg objectives. While this objective be largely accommodated by the new Moratorium Grants, rapid-response grants will likely be continued into the new programme, available to science party members (including onshore), and possible for broader community aiming to work with legacy core. Further news will be forthcoming through the UK-IODP mailing list.

Recently Awarded:
Christopher Smith Duque (Southampton): Constraints on magma origin and alteration from lava emplacement to subduction: IODP Site U1414, Cocos plate.

Paul Wilson (Southampton): A North Atlantic record of the Eocene-Oligocene transition (EOT): A pilot study at IODP Expedition 342 Site U1411, Newfoundland margin

Paola Vanucchi (Royal Holloway): MICROSTRUCTURAL STUDY OF SAMPLES FROM IODP EXP.344—CRISP A2

Get Involved—Mailing list

Would you like to hear more about research opportunities with IODP? From announcements to join IODP expeditions, to meeting announcements, to funding opportunities, the UK-IODP Announcements bimonthly email is the first point of contact for UK scientists participating in the programme. Email the Science Coordinator (ukiodp@bgs.ac.uk) to have your name added to the mailing list. Also see the websites listed at the top of this section.

UKIODP Contacts

UK IODP Science Coordinator
Dayton Dove
British Geological Survey
Murchison House
West Mains Road
Edinburgh, EH9 3LA
Tel: +44 (0)131 6500355
ukiodp@bgs.ac.uk

UK IODP Programme Manager
Jessica Surma
Natural Environment Research Council
Polaris House
North Star Avenue
Swindon, SN2 1EU
jetc@nerc.ac.uk

UK IODP Programme Administrator
David Roberts
Natural Environment Research Council
Polaris House
North Star Avenue
Swindon, SN2 1EU
davber51.nerc.ac.uk

UK IODP Executive Officer
Mike Webb
Natural Environment Research Council
Polaris House
North Star Avenue
Swindon, SN2 1EU
mweb@nerc.ac.uk

UK ESSAC Representative
Bridget Wade
University of Leeds
B.Wade@leeds.ac.uk

ESSAC Science Coordinator
Julia Gutierrez Pastor
Instituto Andaluz de Ciencias de la Tierra, IACT (CSIC-UGR)
Avda. de Las Palmeras nº 4
18100, Armilla, Granada
SPAIN
tel: +34 958 23 00 00 + 190130
+34 958 23 00 00 + 190219
fax: +34 958 55 26 20
iact_essac.office@iact.ugr-csic.es

ESO External Communication and Scientific Liaison
Alan Stevenson
British Geological Survey
Murchison House
West Mains Road
Edinburgh, EH9 3LA
Tel: +44 (0)131 6500376
agst@bgs.ac.uk

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

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

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

IODP Science Advisory Structure
www.iodp.org/sas

IODP Implementing Organisations

Centre for Deep Earth Exploration (CDEX)
www.jamstec.go.jp/chikyu/eng/index.html

ECORD Science Operator
www.eso.ecord.org

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

IODP Core Repositories

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

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.kiodp.re.kr
IODP Australia and New Zealand http://iodp.org.au/

IODP Related Sites

Consortium for Ocean Leadership
http://www.oceanleadership.org/; and
http://www.oceanleadership.org/scientific-programs/scientific-ocean-drilling/

European Science Foundation (ESF)
www.esf.org

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

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

Lamont Doherty Earth Observatory
www.ldeo.columbia.edu

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

National Science Foundation
www.nsf.gov

Natural Environment Research Council
www.nerc.ac.uk

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

ODP Legacy Sites

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

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

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

Acronym List

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 (old)	Engineering Development Panel (SAS)
EMA	ECORD Management Agency
EPC	European Petrophysical Consortium
EPSP	Environmental Protection and Safety Panel (SAS)
ESO	ECORD Science Operator
ESSAC	ECORD Science Support and Advisory Committee
ETF (old)	Engineering Task Force
FB	Facility Board (e.g. ECORD and JOIDES *Resolution* FB's; Chikyu IODP board (CIB)
GCR	Gulf Coast Repository
ICDP	International Continental Scientific Drilling Program
IIS-PPG	Industry-IODP Science Program Planning Group
ILP	Industry Liaison Panel (ECORD)
IO(s)	Implementing Organization(s)
IODP	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.
JR	JOIDES *Resolution*
KCC	Kochi Core Center Repository
LUBR	Leicester University Borehole Group
MEXT	Ministry of Education, Culture, Sports, Science, and Technology (Japan)
MOST	Ministry of Science and Technology (People's Rep. of China)
MSP	Mission Specific Platform
NanTroSEIZE	Nankai Trough Seismogenic Zone Experiment
NERC	Natural Environment Research Council (UK)
NSF	National Science Foundation (USA)
ODP	Ocean Drilling Program
OTF (old)	Operations Task Force (SAS)
PEP	Proposal Evaluation Panel (SAS)
PI	Primary Investigator
POC	Platform Operations Costs
SAS	Science Advisory Structure
SASEC (old)	Science Advisory Executive Committee (SAS)
SIPCom	Science Implementation and Planning Committee (SAS)
SOC	Science Operating Costs
SCP	Site Characterization Panel (SAS)
SPC (old)	Science Planning Committee (SAS)
SSEP (old)	Science Steering and Evaluation Panel (SAS)
SSP (old)	Site Survey Panel (SAS)
STP (old)	Scientific Technology Panel
TAP (old)	Technology Advice Panel
TP	Technology Panel (SAS)
USAC	United States Advisory Committee for Scientific Ocean Drilling
USIO	United States Implementing Organization
USSAC	United States Science Advisory Committee
USSSP	United States Science Support Program

UK newsletter 38
August 2013

IODP
INTEGRATED OCEAN DRILLING PROGRAM

NATURAL ENVIRONMENT RESEARCH COUNCIL