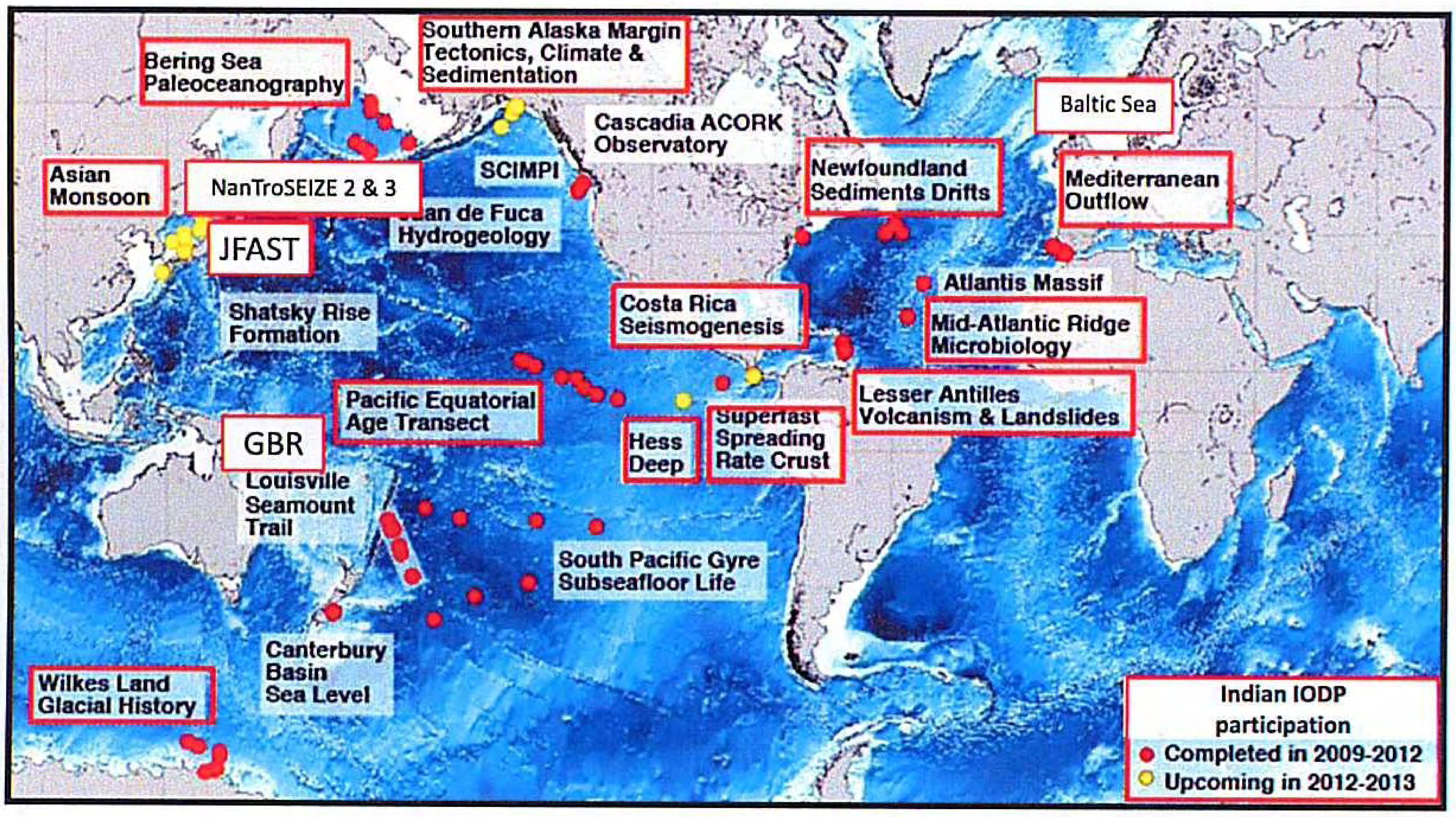
INDIAN SCIENTIFIC CONTRIBUTIONS TO THE INTEGRATED OCEAN DRILLING PROGRAM (IODP)

(2009-2013)



INDIAN IODP PARTICIPANTS MEET

14-15 JANUARY 2013

NATIONAL CENTRE FOR ANTARCTIC AND OCEAN RESEARCH
MINISTRY OF EARTH SCIENCES (GOVT OF INDIA)
HEADLAND SADA, VASCO, GOA-403804

राष्ट्रीय अंटार्कटिक एवं समुद्री अनुसंधान केन्द्र
पृथ्वी विज्ञान मंत्रालय
(भारत सरकार)
हेड लैण्ड सडा, वास्को-डा-गामा
गोवा- ४०३ ८०४, भारत

NATIONAL CENTRE FOR ANTARCTIC & OCEAN RESEARCH
Ministry of Earth Sciences
(Government of India)
Headland Sada, Vasco-da-Gama,
Goa - 403 804, INDIA.

Dr. S. Rajan
Director
Chairman (IODP-India)

Dated: 11/1/2013

Preface

The Integrated Ocean Drilling Program (IODP) is an international research consortium which carries out deep ocean drilling expeditions to study the history of the Earth recorded in sediments and rocks beneath the seafloor.

The sub-seafloor rocks contain a unique record of our planet's history and structure. Geoscientists study the sub-seafloor through IODP expeditions to better understand Earth's components, processes, and phenomena. This research helps us answer questions about fundamental aspects of our planet such as the environment, the biosphere, solid earth cycles, and geodynamics.

Considering the quantum jump in our fundamental knowledgebase through scientific deep ocean drilling, India joined the consortium as an Associate Member in 2009. NCAOR, Goa has been designated as the nodal agency by Ministry of Earth Sciences (MoES) to coordinate the Indian IODP activities. Indian scientists have been regularly participating in the IODP expeditions around the world. Till date, seventeen scientists from different national laboratories and universities have contributed to this international endeavour. Further, India has submitted a detailed proposal for scientific drilling in the Arabian Sea to understand the link between Himalayan Tectonics and Indian Monsoon.

IODP-India is organising a brainstorming session during January 14-15, 2013 at NCAOR, Goa to consolidate on Indian IODP participation till date. The primary goal of this meeting is to chalk out the future research plans by the Indian participants based on the deep sea sediment samples through IODP expeditions. Further, their role in Indian IODP proposal is also to be discussed during this meeting.

This abstract volume summarises the scientific contributions made by Indian researchers to various IODP expeditions between 2009 -2013. We look forward to hear detail deliberations on various IODP expeditions from the Indian IODP participants during this meeting.

(S. Rajan)

Phone:0832-2525503, 2525600, 2525601, 2520876 Fax:0832 - 2520877 Website: www.ncaor.gov.in

Contents

Exploring the Earth Beneath the Oceans:

India in Integrated Ocean Drilling Program (IODP)

Dhananjai K Pandey

National Centre for Antarctic and Ocean Research (NCAOR), Goa

Email: pandey@ncaor.org

Various components of the Earth system – the solid Earth, hydrosphere, atmosphere, cryosphere and biosphere - are closely connected through flows of mass, energy and life. Their mutual interactions have lead to the evolution of our planet and determined its suitability for life. Highly significant records of Earth's journey through time are buried beneath the seafloor. Scientific ocean drilling allows researchers to access records of such interactions through sub-seafloor samples, fluids, microbes and other scientific data, in order to understand how the Earth system works.

Integrated Ocean Drilling Program (IODP) is an international endeavour which brings together scientists from different countries and scientific disciplines to accomplish deep sea research by monitoring, drilling, sampling, and analyzing subseafloor environments. In 1961 scientific ocean drilling technology was successfully used to recover the first sample of oceanic crust and after that the well known Deep Sea Drilling Project (DSDP), began in 1966. Subsequently, Ocean Drilling Program (ODP) was initiated to explore and study the composition and structure of the Earth's sub-seafloor. On the basis of earlier successes of these two programs, Integrated Ocean Drilling Program (IODP) was envisioned in 2003 as a ten-year earth science and research program.

The IODP initiative was established by two lead agencies. In 2003, Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the U.S. National Science Foundation (NSF) signed a Memorandum of Understanding (MOU) in which they agreed to form and jointly operate the Integrated Ocean Drilling Program (IODP). For a successful implementation of this program a ten year roadmap was envisioned by group of scientists from around the world which is known as the Initial Science Plan (ISP). Execution of science objectives are achieved through the flagship drilling platforms JOIDES Resolution (JR) and CHIKYU. Another boost came to the IODP consortium when the European Consortium for Ocean Research Drilling (ECORD) was established in December 2003 with 17 European nations (Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and United Kingdom) and Canada.

Funding agencies:

1. National Science Foundation (NSF), USA
2. Ministry of Culture, Education, Sports, Science & Technology (MEXT), JAPAN;
3. European Consortium for Ocean Research Drilling (ECORD), Europe
4. Ministry of Science and Technology (MOST), CHINA
5. Korea Institute of Geoscience and Mineral Resources (KIGAM), KOREA
6. Australia-NewZealand IODP Consortium (ANZIC),
7. Ministry of Earth Sciences (MoES), INDIA
8. Ministry of Education (CAPES), BRAZIL.

Working along with Japan and the United States, ECORD has provided the Mission-Specific Platforms (MSPs). MSPs usually are deployed for drilling in the shallow seas and usually have limited space onboard for labs and scientists. Presently, IODP is supported by 26 countries viz. USA, Japan, ECORD, China, South Korea, ANZIC (Australia-New-Zealand IODP Consortium), India and Brazil. The IODP has its council which provides governmental oversight for all IODP activities and assures effective planning, management and operations of the scientific drilling. The program is managed by IODP Management International Inc. (IODP-MI). Working as a central management organization with the Science Advisory Structure (SAS), IODP-MI develops and manages the implementation plans for the IODP science program. The SAS comprises different standing committees and panels that conduct the IODP scientific planning such as the scientific evaluation, ranking and scheduling of the drilling proposals submitted to IODP-MI.

The first phase of IODP campaign is scheduled for completion by Sept 2013. The focus of IODP's deep-water efforts during present phase has been a brand new riser-equipped, dynamically positioned drill-ship *Chikyu*. It is designed to ultimately drill upto the seven kilometers beneath the seabed, in areas where the Earth's crust is much thinner, and into the Earth's mantle, deeper than any other hole drilled in the ocean thus far. *Chikyu* is operated by the Centre for Deep Earth Research (CDEX), a subdivision of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). D/V *Chikyu* is 210 meters long, 38 meters wide, 16.2 meters high, and has an approximate gross tonnage of about 57,087 tons. Its complement of150 crew is divided between 100 operators and 50 science personnel, with at seas crew changes handled by helicopter transfer. The main modern facilities available for studying in this vessel are a GPS system and six adjustable computer controlled azimuth thrusters (3.8 meters in diameter) that enable precise positioning to maintain a stable platform during deep water drilling. The maximum drilling water depth for riser drilling is 2,500 meters and can support a drill string up to 10,000 meters long. This vessel is partnered with a modern, non-riser, dynamically positioned drill-ship, a successor to the Ocean Drilling Program's JOIDES Resolution (JR), supplied and operated by the US National Science Foundation. JR is about 143 m long and has breadth of 21 m with gross tonnage of ~70 tons. JR has typical endurance at sea of ~75 days in one stretch. In addition, the European and circum-Pacific nations have taken the initiative to provide "Mission-Specific Platforms (MSP)" for small-scale ocean drilling.

India @ IODP

India joined the present phase of IODP in 2009 as an Associate Member through an MOU among National Science Foundation (NSF), USA, Japanese MEXT and Ministry of Earth Science (MoES). The MoU includes provisions for Indian scientists and researchers to participate in the regular IODP expeditions around the world and get involved in the active research pertaining for the deep sea drilling.

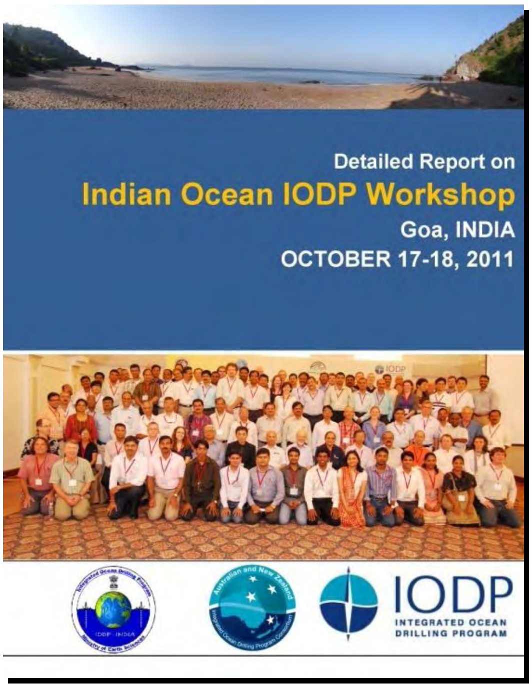
India is a member of Science Advisory Structure (SAS) and the Science Planning and Implementation Committee (SIPCom) of this multi-national endeavour. India joined this consortium till 30th Sep. 2013. Ever since joining, MoES has designated the National Centre for Antarctic and Ocean Research (NCAOR), Goa as the nodal agency for all the IODP related activities in India (IODP-India: www.ncaor.gov.in). India, being an Associate Member, has been actively participating in various scientific and administrative panels of the IODP. This include Science Advisory Structure Executive Council (SASEC), International Working Group plus (IWG+), Proposal Evaluation Panel (PEP), Site Characterization Panel (SCP) and Technology Panel (TP).

A detailed Science Plan has been developed by IODP-India which highlights prominent issues from the northern Indian Ocean which require attention of the Ocean Drilling Program. In order to emphasize the need for a long term scientific ocean drilling program for the northern Indian Ocean sector, India presented a white paper during the INVEST meeting (September 2009), at the University of Bremen, Germany. Through this white paper crucial geo-scientific issues that could be addressed using ocean drilling were also highlighted.

Subsequent to the above, two parallel sessions exclusively for IODP activities were organized by IODP-India at the Asia Oceania Geosciences (AOGS) Meeting, Hyderabad in 2010. The main objective of these independent sessions was to facilitate ample discussions among Indian scientific fraternity and concretize a fully fledged Indian deep sea drilling proposal. As a result, a scientific proposal for drilling in the Arabian Sea was formulated and developed at NCAOR, Goa which was submitted to IODP-MI in October 1, 2010. The Indian proposal entitled "*Deep sea drilling in the Arabian Sea: Discovering the tectono-climatic unknowns*" primarily aims at recovering deep sea cores from five different sites from the Arabian sea to obtain high resolution climate records and to reconstruct the erosion response of the Western Himalaya. The proposal is under consideration with IODP and it is expected that drilling to meet its scientific objectives may take place by 2014-15.

First international IODP workshop for drilling in the Indian Ocean:

Indian Ocean plays a crucial role in exerting a fundamental control on the Earth's climate and it hosts a variety of complex tectonic features. It influences the Indian Monsoon and hosts a major part of the thermohaline conveyor. Considering that it has been more than a decade since scientific drilling in the Indian Ocean has taken place, an international workshop during October 17-18, 2011 on scientific drilling in the Indian Ocean sector was organized by IODP-India in Goa jointly with Australia and New Zealand IODP Consortium (ANZIC) and IODP-MI.



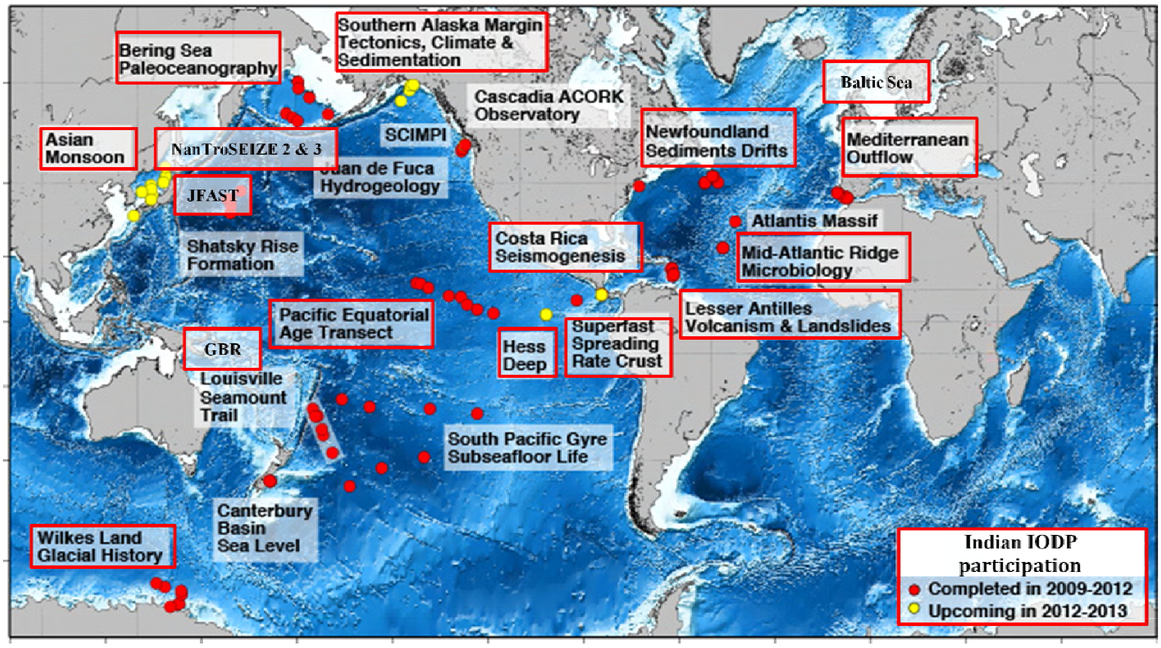
The workshop provided a unique platform for scientists from countries like USA, Japan, Europe, Australia, New Zealand, Indonesia, etc to interact and prioritize existing ideas as well as explore new research frontiers having larger societal relevance such as climate change, earthquake hazards, biotechnology and natural resource potential etc. The workshop was attended by several distinguished scientists from various laboratories such as NCAOR, NIO, NGRI, Delhi University, IIT, Mumbai, IISC Bangalore, Andhra University and Goa University etc. In total, more than 100 scientists (60-Indian; 40 international) attended the workshop to deliberate on different aspects of the scientific drilling in the Indian Ocean. There workshop focussed around four principal scientific themes:

1. Cenozoic oceanography, climate change, gateways and reef development.
2. The history of the monsoons.
3. Tectonics and volcanism.
4. The deep biosphere.

Indian participation in the IODP expeditions since 2009

Soon after joining the IODP consortium, Indian scientists have been participating on various IODP expeditions around the world. Nominations of these scientists are invited from across the country and selected based on their field of expertise in tandem with the scientific objectives of each expedition. The Indian scientific participation onboard IODP platforms has been one of the most significant aspects of the IODP membership as scientists from various disciplines and expertise have been able to get hands-on experience of scientific drilling in the ocean. So far, all the Indian scientists participated in the IODP expeditions have been very young who with their first hand experience would be a great potential for the capacity building in the years to come. All of the scientists participated so far have initiated research programs based on the exclusive sediment cores obtained through respective IODP expeditions.

In summary, the participation of Indian scientists from various disciplines and institutes in the IODP expeditions around the world has so far been one of the most noteworthy aspects of our association with IODP consortium. This has enabled our scientists to acquire first hand concrete knowledge about the cutting edge science through scientific drilling in the ocean.



IODP Expedition 338: Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE)

Ravi Mishra
National Centre for Antarctic and Ocean Research
Headland Sada, Vasco, Goa-403804
Email: drravimishra@gmail.com

Nankai Trough is located beneath the ocean off the southwest coast of Japan. It is one of the most active earthquake zones on the planet. The Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) is a complex ocean drilling project that will be conducted over several years with multiple expedition teams of scientists from all around the world. The NanTroSEIZE project consists of four stages in all, with drilling operations planned at several sites along a line orthogonal to the Nankai Trough in the Kumano Basin, offshore of the Kii Peninsula. The Expedition 338 is planned in stage 3 for ultra-deep drilling to reach the seismogenic zone. Operations include direct core sampling and analysis from the fault on which great earthquakes have repeatedly occurred to understand the geologic characteristics of the seismogenic zone.

The Expedition 338 is being done to extend the bore hole drilled during Expedition 326 in 2010. Expedition was carried out from 13th October 2012 to 10th Jan 2013 and 105 days long expedition was planned in two Group A from 13th October to 1st December and Group B from 1st Dec to 10th Jan 2013. Scientific party drilled the extended hole C0002F upto 2009 meter below the sea floor, While few more drilling and coring has been done by the onboard expedition party B.

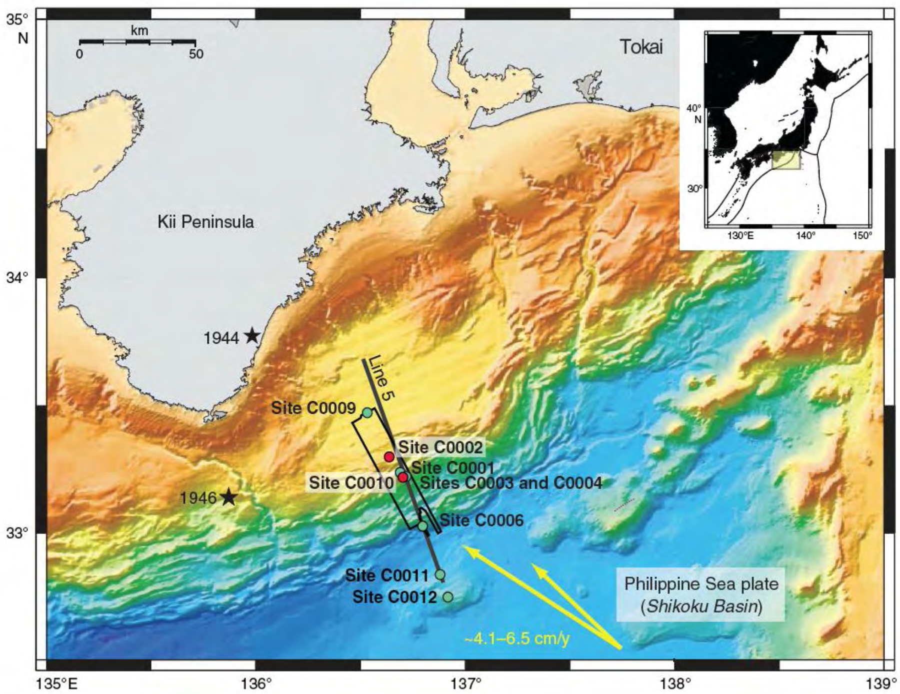


Figure: Location map of the NanTroSEIZE

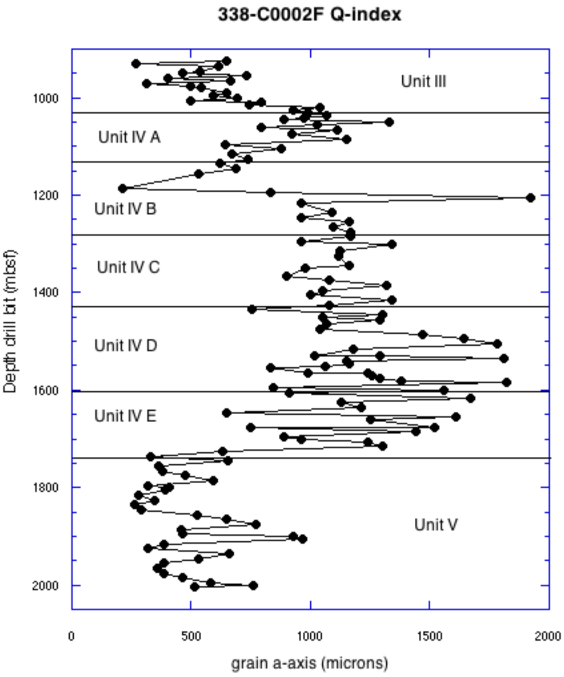
The various sedimentological studies have been carried out onboard D/V Chikyu during the party A of the expedition from 13th October to 1st Dec 2012. The observation includes

- Macroscopic observations of percent silty claystone *versus* percent sandstone;
- Microscopic observations including smear slides and thin sections;

- Mineralogical observations by X-ray diffraction (XRD) and X-ray fluorescence (XRF); and
- LWD data (GR, resistivity, sonic P-wave velocity, resistivity borehole images, see C0002-B-F2).

Based on integration of data available from cuttings and logging while drilling (LWD), three lithologic units and five lithologic subunits were recognize. The boundaries of the lithologic units and subunits are defined primarily using the percent sandstone *versus* percent silty claystone supplemented by the quartz-index .

An additional means of characterizing the sediments is the introduction of a new parameter called the "Q-index" ("quartz-index"). Whilst the overall sandiness is measured by the percent of silty claystone *versus* percent sandstone, the Q-index is a measure of the bulk sand fraction or caliber, i.e., the bulk mean grain size of the sand fraction.



Lithologic Unit III (lower part of Kumano forearc basin): ~875.5 - 1025.5 mbsf depth and dominated by greenish-gray silty claystone

Lithologic Unit IV (upper accretionary prism): 1025.5-1740.5 mbsf depth and dominant lithology of greenish-gray silty claystone with sandstone as a minor lithology.

Within Unit IV, five subunits are defined on the basis of the first occurrence of sandstone . These subunits, characterized by increasing and decreasing sand content, are:

- Subunit IVA: 1025.5 mbsf -1140.5 mbsf

- Subunit IVB: 1140.5 mbsf - 1270.5 mbsf

- Subunit IVC: 1270.5 mbsf - 1420.5 mbsf

- Subunit IVD: 1420.5 mbsf - 1600.5 mbsf

- Subunit IVE: 1600.5 mbsf - 1740.5 mbsf

The dominant lithology in the subunits is greenish-gray silty claystone with sandstone as a minor lithology . The silty claystone is semi-indurated, and the cuttings shape is subangular to angular . Sandstone cuttings are generally loose or very weakly indurated (i.e., soft). Their typical shape is rounded. Loose quartz grains are the dominant component in the dispersed > 63 µ sand-size fraction.

Lithologic Unit V (trench or Shikoku Basin hemipelagic deposits): 1740.5 - 2004.5 mbsf depth and dominant lithology is greenish-gray silty claystone, with sandstone as a minor lithology.

Mineralogical and geochemical analyses

X-ray diffraction mineralogy

Bulk powder X-ray diffraction (XRD) results show the relative abundance of total clay minerals, quartz, plagioclase, and calcite. As a measure of how accurate the XRD estimates are relative to absolute percentages, a regression analysis of percent calcite from XRD *versus* percent calcium carbonate from coulometric analysis and linear regression coefficient (R^2) shows a very good correlation of 0.97. The comparison also shows a slight shift in the coulometric data above values of ~10 wt%, which is to be expected if the concentration of $CaCO_3$ is expressed as a percentage of the total solid mass (weight percent), and calcite measured by XRD is normalized to 100 wt%.

X-ray fluorescence (XRF)

In order to characterize compositional trends with depth and/or lithologic characteristics of the sediments from Site C0002F, X-ray fluorescence (XRF) analysis was undertaken for ~150 samples. Major and minor element contents (SiO_2, Al_2O_3, TiO_2, Na_2O, MgO, CaO, K_2O, Fe_2O_3, MnO, and P_2O_5) were analyzed by XRF and complemented by loss on ignition (LOI) measurements. In order to compare the composition of cutting sizes, initially both 1 - 4 mm cuttings and > 4 mm cuttings size fractions were analyzed. A comparison shows no significant differences for both cutting size fractions; therefore, further analysis only involved the 1 - 4 mm cuttings size fraction.

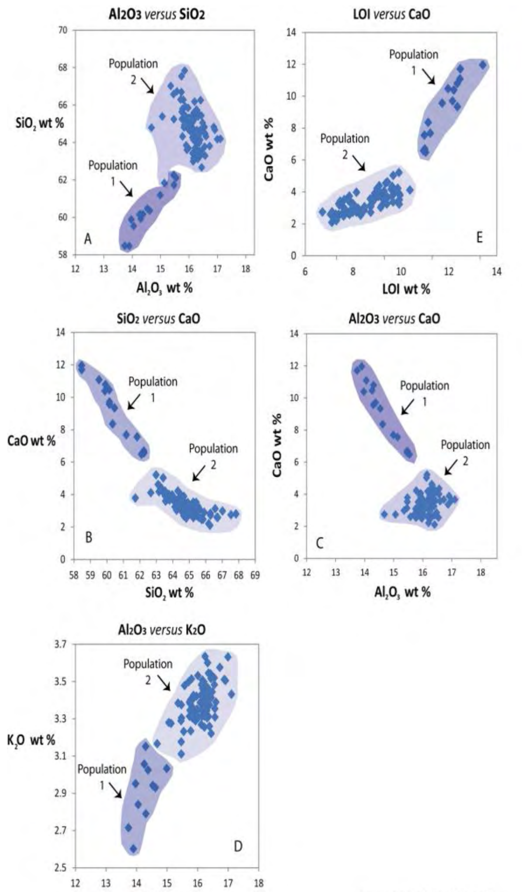


Figure 338-C0002F-C-F14

The cross-plots for various element oxides indicate two distinct, non-overlapping, populations of data. Population 1 consists of the data from 920.5 to 990.5 mbsf and population 2 containing all data from the 995.5 to 1990.5 mbsf.

Post Cruise Research Plan: The basic plan is to understand the sediment geochemistry of the Nankai Trough. The onboard pore water chemistry data will be interpreted and detailed geochemical analysis including minor and trace elemental will be carried out to understand the geochemistry and geochemical process of sediment–sediment and sediment-water interface.

IODP Expedition 339: Mediterranean Outflow

A. D. Singh
Centre of Advanced Study in Geology
Banaras Hindu University, Varanasi-221005
Email: arundeosingh@yahoo.com

High salinity, dense Mediterranean Sea Water (MOW) that cascades down into the Atlantic Ocean through the Gibraltar Strait, entrains upper Atlantic waters before it descends and spreads out into the Atlantic at depth between 500 and 1600 m. Thus, MOW represents an intermediate water mass that flows above the NADW (North Atlantic Deep Water) and under the cool water mass of the NE Atlantic (Fig. 1). The heat and salt export from the Mediterranean Sea into the intermediate Atlantic waters substantially affects the atmosphere-ocean coupling, the Thermohaline Circulation (THC) and the northern Hemisphere climate. In the present scenario of rapid climate change, the potential for the MOW in contributing to abrupt changes is being realized. Therefore, it is essential to understand better the environmental significance of the MOW and its global implications.

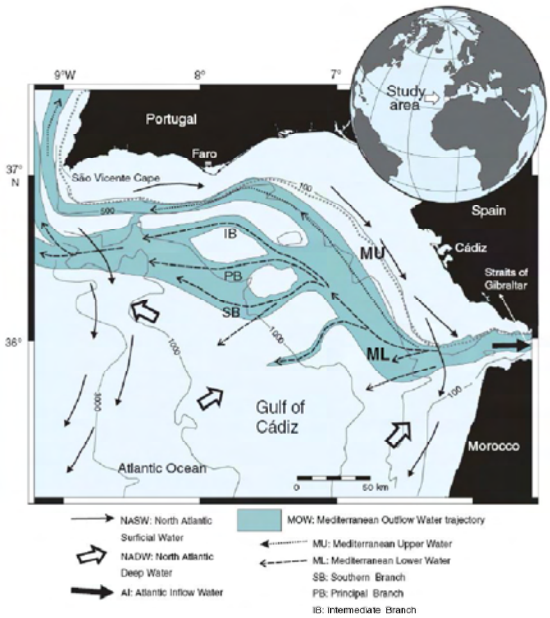


Fig. 1. Location sketch with main water-mass circulation in the Gulf of Cadiz and along the West Iberian margin. (modified from Hernández-Molina et al., 2006[3]).

The Mediterranean sector of the Atlantic Ocean is a region critical to the understanding of the development and evolution of the THC, the MOW and the interaction between them as well as with the global climate on various time scales. The contourite depositional system (CDS) with high rate of accumulation, developed in the Gulf of Cadiz and along the West Iberian margin under the direct influence of MOW since the opening of the Gibraltar Gateway, provides sedimentary records ideal for the reconstruction of paleoceanographic and paleoclimatic history on high resolution time scale. This is also a prime area for understanding the effects of tectonic activity on evolution of the Gibraltar Gateway. IODP Expedition 339 was the first to retrieve sediment core samples from deep below the seafloor here. This expedition drilled five sites in the Gulf of Cadiz (U1386, U1387, U1388, U1389 and U 1390) and two off the west Iberian margin (U 1386 and U1391) and recovered nearly 5.5 km of sediment with an average recovery of 86.4 %

(Fig. 2). The prime target of this expedition was to carry out multifaceted investigations that address many fundamental questions pertaining to tectonic evolution of Gibraltar Gateway, MOW paleocirculation and its influence on North Atlantic circulation and global climate. The other major objective was to recover and establish Marine Reference Section (MRS) of Pleistocene climate variability that preserves a signal of millennial scale changes throughout, and which can be correlated confidently to polar ice cores in both hemispheres and terrestrial archives.

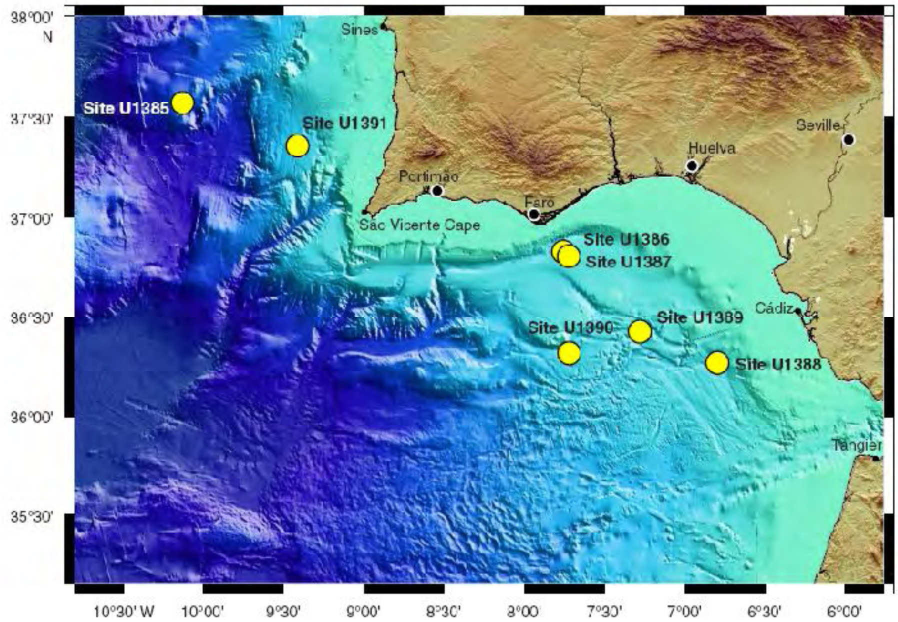


Fig. 2. Expedition 339 sites in the Gulf of Cádiz and West Iberian margin.

Highlights of Ship-board research findings: Two months ship-board studies carried out by a group of 35 scientists having expertise in various earth science disciplines enabled to decode signals of the past changes from the cores of mud and sand recovered and brought out both anticipated and unexpected scientific results (Fig. 3). These findings have been presented by Expedition scientists in several international conferences.

Out of seven, two sites drilled in the Gulf of Cadiz enabled to recover sediment record up to the Miocene. A strong signal of MOW following the opening of the Gibraltar Gateway was discovered[2]. The Pliocene successions penetrated at four sites, show a general weak MOW. Significant widespread unconformities (hiatuses), present at all sites, but with variable duration, are interpreted as a signal of intensified MOW.[2] The Quaternary succession shows a dominant phase of contourite drift development with two major periods of MOW intensification separated by a widespread unconformity. Preliminary work has also shown a remarkable record of orbital scale variation in bulk sediment properties and a good correlation between all sites. Studies suggest a deep, powerful Mediterranean Outflow through the Gibraltar gateway began over 4.5 million years ago[2]. A tectonic pulse – heartbeat of the Earth, at the junction between the African and European tectonic plates was also discovered. The site on the west Portuguese margin (U1385) was dedicated entirely to providing the most complete marine sediment record of climate change through the past 1.5 million years of Earth history. This would track back through at least four major ice ages in recent Earth history, and provide a new marine archive through undisturbed oceanic sediments for comparison with ice core records from Greenland and Antarctic ice sheets, and with numerous land-based records. Shipboard analyses have already revealed the first tantalizing evidence of climate cycles. Yet, it will take many months and even years of painstaking research in the scientists' shore-based laboratories to properly decode the signals of climate change in the past, to document periods of very rapid change comparable to rapid global warming today.

Post Cruise Research (in progress) : It has been planned to carry out post-cruise studies on core samples of selected sites employing multi-proxy approach in order to accomplish scientific objectives of the IODP expedition 339, relating to its broad themes "Ocean Gateways, Paleoceanography and Rapid Climate Change". Micropaleontological studies on the sediment cores retrieved at three key sites U1385, U1387 and U1391, are in progress at the Banaras Hindu University. These cores were sub-sampled at high resolution during Post-Cruise sampling party at Bremen Core Repository (BCR), Germany. The ongoing research aims to reconstruct paleoceanographic and paleoclimatic history of the last 600 kyr on centennial to millennial scales. Study envisages multiple microfaunal (planktic and benthic foraminifera) proxy approach for reconstruction of past changes. Additionally, it is also planned to study long term surface water paleoceanographic variability in the region since the late Pliocene based on core samples from a site (U 1391) taken at low-resolution interval. An integration of multiple microfaunal proxy records being generated at BHU, with geochemical, isotope and sedimentological records constructed by the collaborators (within India and abroad) will enable to better interpret the paleo-records and to unravel the paleoceanographic and paleoclimatic history on the tectonic and orbital to sub-orbital scales. Our ongoing study will address some important scientific issues such as (1) temporal variability of deep water mass and its phase relationship with surface ocean changes on orbital to millennial scales (2) sensitivity of MOW to the rapid climate change, (3) linkages among MOW variability, NAO (North Atlantic Oscillation), ENSO (El-Nino Southern Oscillation) and low-latitude monsoonal climate.

Expedition 341: Southern Alaska Margin Tectonics, Climate & Sedimentation

Shyam M Gupta
National Institute of Oceanography (CSIR), Dona Paula, Goa – 403 004, India
Email: smgupta@nio.org

Jaeger et al. proposed to drill the high-resolution sedimentary record of late-Cenozoic continental margin in southern Alaska to study ties between tectonically driven orogenic, volcanic, glacial and climatic changes in the north Pacific. Objective of their expedition is to relate terrestrial glacial and tectonic processes in Alaska to similar marine events preserved in the Continental Margin seas. The age and stratigraphic controls of drilled cores is a vital issue for a source-to-sink loop of the depositional history. As north pacific is a very complex area in terms of the plankton diversity, the radiolarians and diatoms occasionally outnumber the planktonic forams, and often becomes very important index fossils for identifying the bio-datum levels for the stratigraphic control. I proposed to identify radiolarian index fossils ranging from late Quaternary to Late Miocene (0.2-12 Ma) in IODP drill cores which are likely to be recovered during IODP-341 expedition. Along with other 3 diatom and one foraminifer expert on board JOIDES resolution, I expect that we would be able to work out a reasonable biostratigraphy, which may enable us to link with paleo-magnetic, grey-scale, and stratigraphic markers.

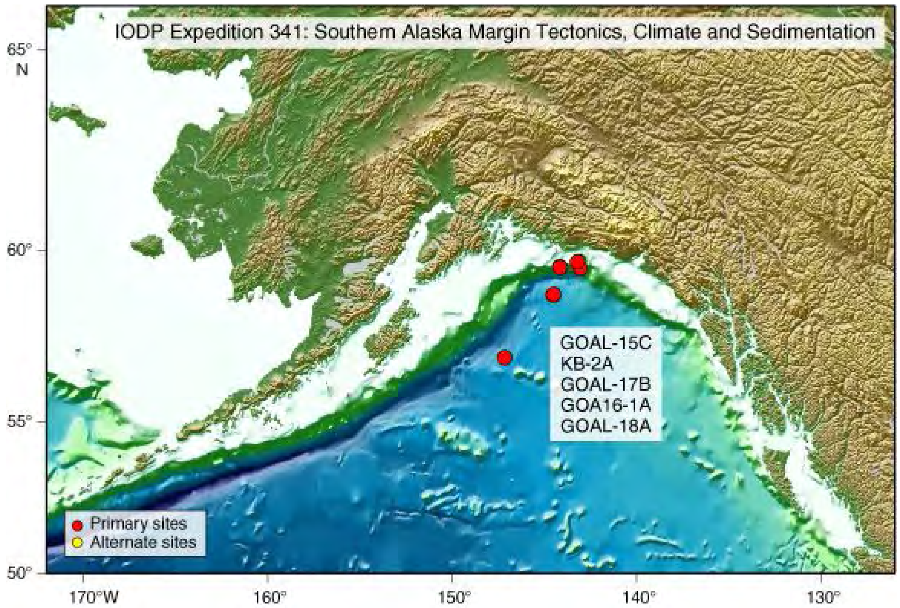


Fig.1: Proposed drill sites for the IODP expedition 341.

IODP Expedition 342: Paleogene Newfoundland Sediment Drifts

Amit K. Ghosh
Birbal Sahni Institute of Palaeobotany
53 University Road, Lucknow – 226 007, U.P.
e-mail: akghosh_in@yahoo.com

The Earth's history holds a rich record of abrupt climate and ecological changes. However, the dynamics of these changes in Earth's ecosystems are often not well resolved, particularly in past warm climates that have analogs to future global change. The complexity of Earth's biological and climatological systems hinders the use of models to confidently predict future ecosystem dynamics, yet the planet is rapidly approaching a highly altered climate forcing that has no historical analog for the past 30 ma. The approach of IODP Expedition 342 was to seek historical analogs to future climates in Earth's past.

IODP Expedition 342 was designed to recover Paleogene sedimentary sequences with unusually high deposition rates across a wide range of water depths (Sites U1403–U1411). The drilling sites were selected 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. In addition, two operational days were spared to a sea trial of the Motion Decoupled Hydraulic Delivery System (MDHDS) developmental tool (Site U1402).

The expedition was primarily targeted to reconstruct the Paleogene carbonate compensation depth (CCD) in the North Atlantic. The site located in the deepest water (Site U1403) was at a paleodepth of ~4.5 km, whereas the site located in the shallowest water (Site U1408) was at a paleodepth of 2.5 km at the same time (50 m.y. ago).

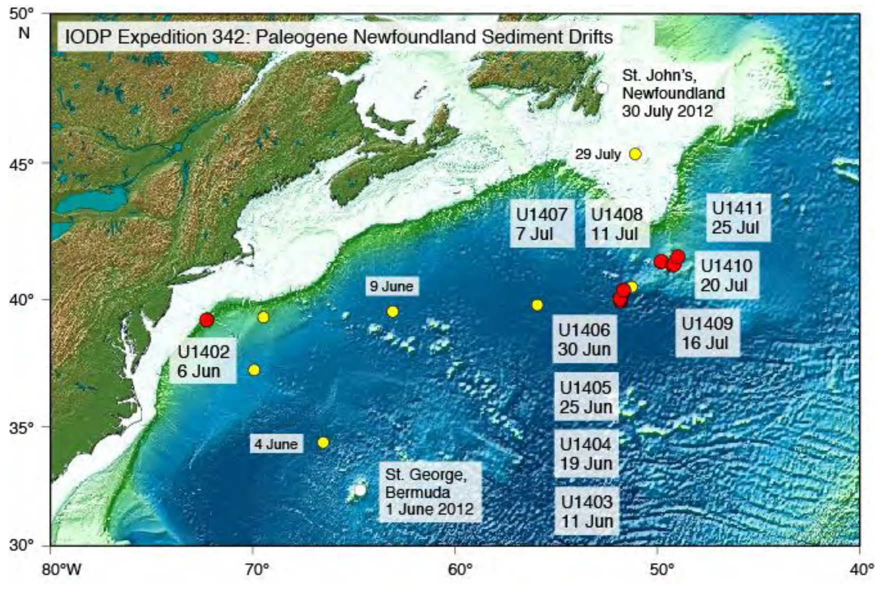


Fig: Site locations of Expedition sites 342

Notable findings based on shipboard scientific results include the discovery of intermittent calcareous sediments in the Cretaceous, Paleocene, and early to middle Eocene at 4.5 km paleodepth, suggesting a deep Atlantic CCD during these times. Evidences of carbonate deposition events following the Cretaceous/Paleogene (K/Pg) boundary mass extinction, the Paleocene/Eocene Thermal Maximum, and the Eocene–Oligocene transition have been visualized. These deposition events may reflect the rebalancing of ocean alkalinity after mass extinctions or abrupt global climate change.

One of the major objectives of Expedition 342 was to recover clay-rich sequences with well preserved microfossils. Expedition 342 recovered sequences with sedimentation rates of as much as 10 cm/k.y. high enough to enable studies of the dynamics of past abrupt climate change, including both transitions into “greenhouse” and “icehouse” climate states, the full magnitudes of hyperthermal events and rates of change in the CCD.

Times of rapid accumulation of drift deposits include the early 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. Widespread hiatuses are present near the Paleocene/Eocene boundary into the middle early Eocene and the middle Oligocene. The Eocene/Oligocene boundary is a period of slow sedimentation at most sites but is expanded at Site U1411.

An unexpected finding was the recovery of a number of Cretaceous “critical boundaries.” These include the K/Pg boundary, the Campanian–Coniacian interval, the Cenomanian–Turonian boundary and oceanic anoxic event (OAE) 2, and the Albian/Cenomanian boundary OAE 1d. These intervals were drilled opportunistically when they were encountered near or above our target depth for a given site. The K/Pg boundary was recovered at Site U1403, where it proved to have a well-preserved, normally graded spherule bed and unusually well preserved earliest Danian planktonic foraminifer community. The Campanian–Coniacian interval was cored at Site U1407 and is unusual mainly for the relative biostratigraphic completeness of a sequence that elsewhere commonly shows hiatuses in the early Campanian. The Cenomanian–Turonian transition was also cored at Site U1407 and consists of a series of organic black shales in nannofossil chalk with as much as 11 wt% total organic carbon (TOC). The Cenomanian–Turonian sequence at Site U1407 is broadly similar in biostratigraphy, sequence of black shales, and sediment color to classic Italian and northern German outcrop sections. Finally, coring at Site U1407 also recovered a lower Cenomanian nannofossil chalk and nannofossil claystone record that extends into the biozones associated with OAE 1d. The Albian–Cenomanian sequence is notable for the generally high quality of microfossil preservation and its gradational contact with underlying Albian shallow-marine carbonate grainstone and packstone.

Before the main leg of Expedition 342, a sea trial of the Motion Decoupled Hydraulic Delivery System (MDHDS) with the temperature-dual-pressure probe (T2P) was conducted at Site U1402 on the New Jersey margin. The benefit of this system over its predecessor is the complete decoupling of the penetrometer from the drill string, negating the effect of ship heave on the quality of data. This new capability opens an exciting range of future science for the drilling program.

Objectives:

IODP Expedition 342 was focused on Paleogene records on the Newfoundland ridges. As evident from the seismic record there is an extensive Cretaceous record of both drifts and fossil reefs. The primary objective was to obtain a record of the majority of the Paleogene sediments; however, a particular interval of focus was on the middle Eocene to Oligocene sediments, where there are thick sediment drift deposits that preserve unusually expanded records of the transition from the greenhouse world of the Eocene climatic optimum to the glaciated world of the Oligocene. Drilling the Newfoundland sediment drifts allowed in addressing key problems in paleoceanography, paleoclimate, and biotic evolution. These are as follows:

- Recover data on the history of the Paleogene carbonate compensation depth and forcing factors for Paleogene hyperthermals.
- Determine the flow history of the Atlantic Deep Western Boundary Current.
- Obtain high-resolution records of the onset and development of Cenozoic glaciation.
- Extend the astronomical calibration of biostratigraphic and magnetostratigraphic markers and the geological timescale.

The prime objectives of Expedition 342 were to answer a series of questions about the rate and magnitude of past ecosystem changes:

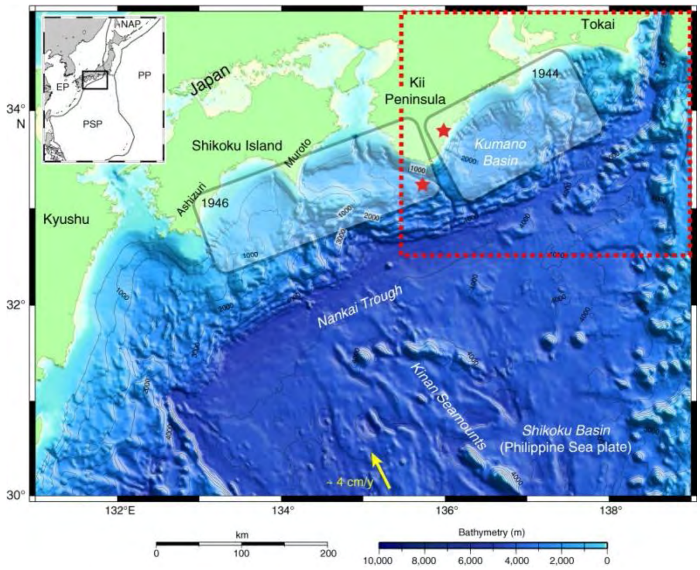
- How similar are past abrupt climate changes to model expectations for the environmental changes triggered by human modification of Earth’s environments?
- What are the consequences for Earth’s biota of variations in magnitude or rate of change during abrupt events?
- Are there any ancient analogs to what we are doing to the planet now or has humanity launched a carbon cycle perturbation without geological analog?
- How long will perturbations similar to those of the “Anthropocene” last?
- Are we missing fundamental feedbacks in our bid to model the Earth’s future under higher greenhouse gas forcing?
- What is the climate sensitivity to different rates or magnitudes of greenhouse gas forcing?

IODP 322: Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) Stage 2

Pawan Govil

Birbal Sahni Institute of Palaeobotany
53 University Road, Lucknow – 226 007, U.P.
Email: pawanali@gmail.com

Integrated Ocean Drilling Program (IODP) Expedition 322 is part of the Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) and was designed to document characteristics of incoming sedimentary strata and igneous basement prior to their arrival at the subduction front. To accomplish these objectives, coring was conducted at two sites in the Shikoku Basin on the subducting Philippine Sea plate. Site C0011 is located on the northwest flank of a prominent bathymetric high (the Kashinosaki Knoll), whereas Site C0012 is located near crest of the knoll.



.

Fig: Locations of drill sites of IODP Expedition 322.

The merger of lithofacies and age-depth models from the two sites spans across the Shikoku Basin from an expanded section (Site C0011) to a condensed section (Site C0012) and captures all of the important ingredients of basin evolution, including a heretofore unrecognized interval of late Miocene tuffaceous and volcaniclastic sandstone designated the middle Shikoku Basin facies. An older (early–middle Miocene) turbidite sandstone/siltstone facies with mixed detrital provenance occurs in the lower Shikoku Basin; this unit may be broadly correlative with superficially similar Miocene turbidites on the western side of the basin. When viewed together, the two sites around the Kashinosaki Knoll not only demonstrate how basement relief influenced rates of hemipelagic and turbidite sedimentation in the Shikoku Basin, they also build the complete lithostratigraphic template on which all of the postexpedition laboratory results can be placed. Those forthcoming details will include mineral and volcanic ash composition, frictional properties, and hydrological properties. Unlike other so-called reference sites in the Nankai Trough, pore fluids on top of the basement high show clear evidence of a seawater-like source, with chlorinity values increasing toward basement because of hydration reactions and diffusion; the fluids are largely unchanged by the effects of focused flow and/or in situ dehydration reactions associated with rapid burial beneath the trench wedge and frontal accretionary prism.

IODP Expedition 325: Great Barrier Reef

Manish Tiwari
National Centre for Antarctic & Ocean Research
Headland Sada, Vasco, Goa – 403804
Email: manish@ncaor.org

The IODP Expedition 325-*Great Barrier Reef Environmental Changes* (GBREC) Expedition offers an un-paralleled opportunity to reconstruct the timing of sea level change and tropical climate history at high-resolution by studying the Great Barrier Reef - the largest coral reef system in the world and sediment cores near to it. Reef-building corals (Hermatype corals or Stony corals) in tropical, near-shore environments can be excellent tool to reconstruct past climate on intra-annual to centennial scale resolution. But for studying longer time periods, recourse has to be taken to sediment cores that provide excellent climatic records. The isotopic & chemical signatures in foraminifera vary as a direct function of the temperature, salinity, upwelling, ocean circulation, and other oceanic features. The objective of the present study is to reconstruct climatic & oceanographic conditions off the north-eastern Australian coast at high temporal resolution.

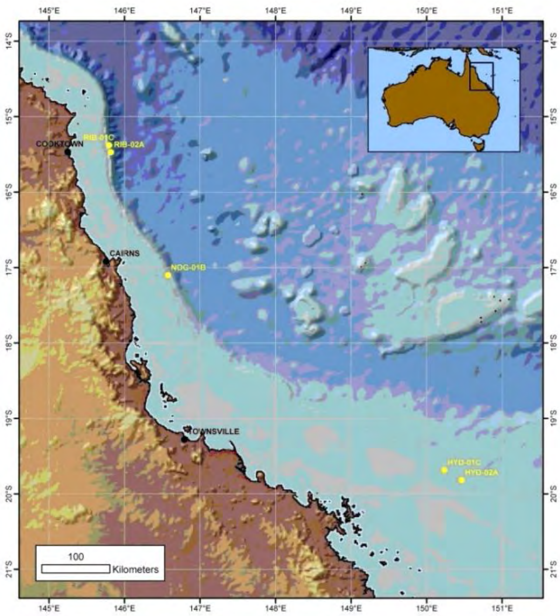


Fig: Location of Expedition 325 sites

This expedition was carried out on a mission specific platform by ESO, the ECORD (European Consortium for Ocean Research Drilling) Science Operator on behalf of IODP. The offshore phase (cruise) took place from 11th February to 2nd April 2010, spread over seven weeks where around 200 m of the cores were collected from three transects (called as Hydrographer Passage, Noggin Pass & Ribbon Reef) in the Great Barrier Reef in the Coral Sea, north-east Australia. Out of that only one hole (M0058A; 17.09°S, 146.58°E) from near the central Great Barrier Reef yielded sediment core (all other were corals). The water depth is 170 m with a total core recovery of 33.94 m. The chronology of the core was obtained through 3 AMS radiocarbon dates coupled with high-resolution Oxygen Isotope Stratigraphy. AMS radiocarbon dates were obtained on selected species of planktic foraminifera (*G. ruber, G. sacculifer, N. dutertrei;* size range: 250-420 µm) using Accelerator Mass Spectrometer (AMS) at the NSF AMS

Facility at University of Arizona. The radiocarbon ages were calibrated via the program CALIB 6.0 using the 'Marine09' calibration curve. The stable oxygen and carbon isotope analysis of the planktic foraminifera - *Globigerinoides ruber* - throughout the core has been completed at the Marine Stable Isotope Lab (MASTIL) at *National Centre for Antarctic & Ocean Research, Goa, India* using a Isoprime Stable Isotope Ratio Mass Spectrometer. The $\delta^{18}O$ values are reported here with respect to the international standard V-PDB defined by its relationship to carbonate reference materials NBS-19. The precisions of the $\delta^{13}C$ and $\delta^{18}O$ measurements are ± 0.02 ‰ and ± 0.08 ‰ respectively (1σ standard deviation) obtained by repeatedly running NBS-19 (n = 70).

The core-top (0-2 cm) yields a calibrated age of 693±34 yr BP. The core spans the past ~170 Kyr (present interglacial, last interglacial & MIS 6) while a hiatus during the sea-level lowstand of Last Glacial period is observed. The core site experiences slight upwelling during the austral summer season (Andrews & Gentien, 1982; Andrews & Furnas, 1986) linked to intensification of East Australian Current (EAC) (Brinkman et al., 2001). The $\delta^{13}C$ values are mixed signal of productivity, upwelling and associated seawater carbonate ion concentration changes (Curry et al., 1992; Spero et al., 1997; Zeebe and Wolf-Gladrow, 2001). Enhanced productivity would cause the $\delta^{13}C$ values of foraminifera to increase (Hoefs, 2009). In contrast, deeper waters posses lower $\delta^{13}C_{DIC}$ values as respiration of organic matter releases CO_2 depleted in ^{13}C (Kroopnick, 1985). Additionally, reduced amount of carbonate ion in upwelled waters results in increasing $\delta^{13}C$ values of foraminifera (Spero et al., 1997; Bijma et al., 1999; Peeters et al., 2002). To figure out a clearer picture, Peeters et al., 2002 carried out detailed study in upwelling dominated western Arabian Sea and established beyond doubt that during upwelling the $\delta^{13}C$ values of both the species of foraminifera increase as the effect of change in the carbonate chemistry (CO_3^{2-} concentration) is of much higher magnitude than $\delta^{13}C_{DIC}$ reduction due to upwelling. Additionally, the increase in productivity due to upwelling of nutrient rich waters to the euphotic zone will also result in enhanced $\delta^{13}C$ values. Thus, higher $\delta^{13}C$ values of foraminifera would indicate enhanced upwelling/productivity implying intensified EAC. Warmer period during the Holocene experienced higher $\delta^{13}C$ but interestingly warmer (colder) periods during the last interglacial & MIS-6 experienced lower (higher) $\delta^{13}C$. Out of this, 0.3 to 0.4 ‰ can be due to the global glacial-interglacial changes in $\delta^{13}C$ values of the oceanic dissolved inorganic carbon (DIC) as the transfer of organic matter between land and sea-atmosphere systems causes lowering of $\delta^{13}C$ of DIC during glacial periods (Sigman and Boyle, 2000). Despite this we observe higher $\delta^{13}C$ values during glacial periods implying stronger upwelling and strengthened East Australian Current (EAC) during colder periods. To gain further insight in to the oceanic dynamics of that region, future plans include reconstructing the SST using Mg/Ca elemental ratio (Lea et al., 1999) of the planktic foraminiferal shells.

IODP Expedition 346 – Asian Monsoon

Raj K. Singh
Wadia Institute of Himalayan Geology, 33, G.M.S. Road, Dehradun
Email: rksingh@wihg.res.in

Integrated Ocean Drilling Program Expedition 346 start from Valdez, Alaska, USA on 29th July 2013, and end at Busan, South Korea on 28th September 2013 will core and log seven sites covering a wide latitudinal range in the Japan Sea and one site in the northern East China Sea to test the hypothesis that Pliocene–Pleistocene uplift of the Himalaya and Tibetan Plateau and the consequent emergence of the two discrete modes of Westerly Jet circulation caused the amplification of millennial-scale variability of the East Asian summer monsoon (EASM) and East Asian winter monsoon (EAWM) and provided teleconnection mechanism(s) for Dansgaard–Oeschger cycles (DOC).

Specific scientific objectives of this expedition are

- To address the onset timing of orbital and millennial scale variability of the EASM and EAWM and their relation with variability of Westerly Jet circulation;
- To reconstruct orbital and millennial scale changes in surface and deepwater circulations and surface productivity in the Japan Sea during at least the last 5 m.y.;
- To reconstruct the history of the Yangtze River discharge using cores from the northern end of the East China Sea, as it reflects variation and evolution in EASM and exerts an impact on the paleoceanography of the Japan Sea; and
- To examine the interrelationship among the EASM, EAWM, nature and intensity of the influx through the Tsushima Strait, the intensity of winter cooling, surface productivity, ventilation, and bottom water oxygenation in the Japan Sea and their changes during the last 5 m.y.

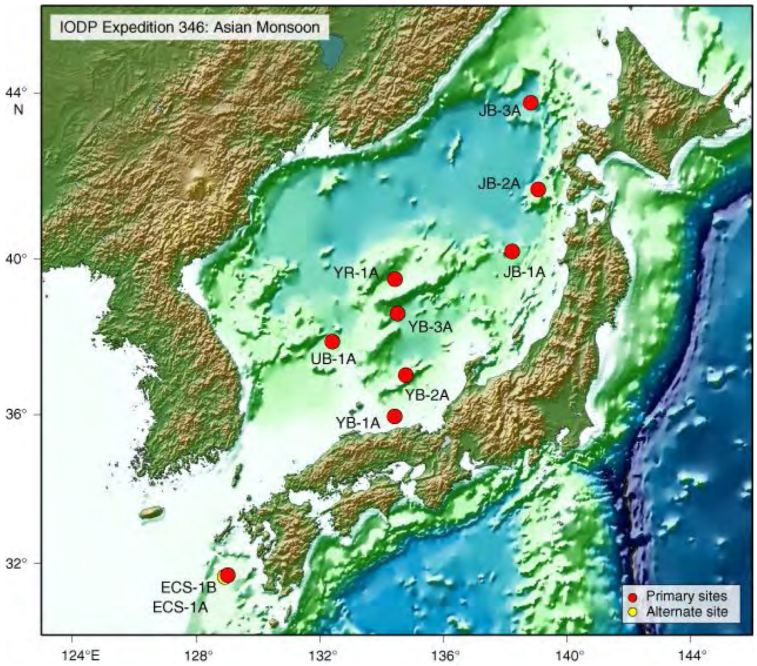


Fig: Location of the expedition 346 sites

A latitudinal transect of the Japan Sea will be cored to monitor the behaviours of the Westerly Jet, EAWM, and the Tsushima Warm Current. The southern part of the transect also will be used to reconstruct the behaviour of the Subpolar Front and examine its relationship with the Westerly Jet and sea level changes, whereas the northern part of the transect will be used to identify ice-rafted debris events and reconstruct temporal variation in its southern limit. In addition, a depth transect of sites will reconstruct the ventilation history of the Japan Sea and examine the relation between ventilation and the nature of the influx through the Tsushima Strait and/or the intensity of winter cooling. This expedition will drill in the northern part of the East China Sea to monitor the Yangtze River discharge history that should reflect variations in EASM intensity.

It has been argued that uplift of the Himalaya Tibetan Plateau [HTP] heightened the land-sea thermal contrast that led to the onset or major intensification of the Indian monsoon marked by the summer monsoon with heavy rainfall over the Indian subcontinent and cold dry winter monsoon. The continental proxy of Asia demonstrated that uplift of northern Tibet started around 3.6 Ma (Zheng et al., 2000), and uplift of Himalaya restarted during late Pliocene to Pleistocene and continued till present (Jain, et al., 2000). The Plio-Pleistocene uplift of HTP have enhanced the extent and altitude of topographic barrier against the westerly jet, it is possible that the course and intensity of the westerly jet were also influenced significantly (Rea et al., 1998) and amplified the Dansgaard-Oeschger Cycles (DOC) type millennial-scale variability of westerly jet circulation through the topographic effect. The East Asian and Indian summer monsoon varied significantly in association with the DOC (Schulz et al., 1998).

The speleothem records of the North Eastern India and North Western Himalayan caves are well established proxies for summer as well as winter monsoon (Sinha et al., 2005; Sinha et al., 2011; Kotlia et al., 2012). The correlation of Speleothem data of North Eastern and North Western Himalaya India, Speleothem data of Hulu and Dongee cave of China, summer/winter monsoon data of Arabian Sea and upcoming summer/winter monsoon data from Japan Sea and East China Sea will enhance the understanding of Asian Monsoon and its relation with global events and DOC

In addition to above mentioned specific objectives, my participation in the expedition aimed to generate and study

1) Late Pliestocene to Holocene high resolution paleoclimatic record of westerly and east Asian summer monsoon movement and its correlation with the high resolution speleothem records of North Eastern Indian Himalaya and lake records of North western Himalaya to understand the impact of westerly movement during the stadial mode
2) the timings of onset and intensification of orbital and millennial-scale variability of East Asian summer monsoon, winter monsoon, and westerly movement, within spatial and temporal framework and its possible relation with HTP using benthic and planktic foraminiferal proxies, stable isotope proxy and other geochemical proxies.
3) changes in benthic foraminifera productivity and its diversity parameters in response to paleoceanographic changes in the Japan Sea and East Asian monsoon variability and its global implications
4) seasonal variability in the selected planktic foraminifera species and their stable isotope composition to understand the response to temporal changes in surface water hydrography as planktic foraminifera are good indicators of upwelling and its distribution is controlled by the surface oceanic currents.

IODP Expedition 347: Baltic Sea Paleoenvironment

Mahesh Badnal
National Centre for Antarctic and Ocean Research
Headland Sada, Vasco, Goa-403804
Email: mahesh@ncaor.org

Baltic Sea, an arm of the North Atlantic Ocean extending northward from the latitude of southern Denmark almost to the Arctic Circle and separating the Scandinavian Peninsula from the rest of continental Europe. It is a largest expanse of brackish water in the world. Covering about an area of 386,000 sq km, the Baltic Sea's drainage is about four times as large as the sea. The Baltic Sea is so nearly landlocked (and its outlet so shallow) that its waters are remarkably fresh. Its longest rivers (Vistula and Oder) drain regions that have a temperate continental climate; they have low evaporation rates and become swollen by spring snowmelt, thus further reducing the salinity of the Baltic. The water exchange with the North Sea and the Atlantic Ocean takes place in a transition zone extending from the Kattegatt via the narrow and shallow Belt Sea and the Oresund. Due to the restricted water exchange, the deep basins exhibit a semi- permanent density stratification and temporary anoxia, which in turn guarantees minimum bioturbation and the formation and good preservation of laminated sediments. The Gotland Deep, located between the island of Gotland and mainland Latvia, is one of the major and probably most intensively studied sediment accumulation basins in the Baltic Sea. The numerous laminated sequences, often separated by homogeneous layers (bioturbated) are indications of occasional inflows of saline water from the North Sea.

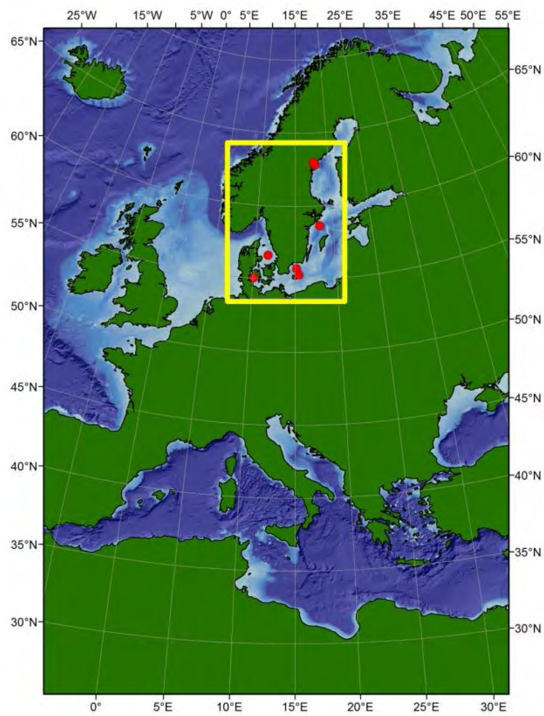


Fig: Location of Expedition 347sites

As a consequence of these, the Baltic Sea confounds with its unique oceanographic and geographical setting. The climate of the Baltic Sea basin is characterized by large seasonal contrasts, owing to its geographical location, variable topography, and land-sea contrasts. The climate is influenced by major air pressure systems, particularly the North Atlantic Oscillation during wintertime, which affects the atmospheric circulation and precipitation in the Baltic Sea basin. Further, the hydrography in the Baltic Sea is unique as it is connected to the global ocean only through the narrow and shallow Danish Straits. Also, the salinity distribution in the Baltic Sea is determined by the net freshwater supply (473 km^3/y) wherein the annual precipitation and evaporation are closely balanced on an annual basis. The Baltic Sea water is usually brackish due to this freshwater supply from the rivers. This results in a brackish surface layer separated by a halocline. The halocline separates the surface water from the deep water hence forming a distinct hydrographic feature. The actual inflow of seawater into the Baltic takes place through a mixing zone in the Kattegatt-Belt Sea-Oresund area, where outflowing Baltic surface waters mix with seawater. Due to the combined effect of shallow connections with the sea and stability stratification, deep Baltic Sea waters are renewed at irregular intervals which render the bottom water anoxic.

To understand the past variation in Baltic Sea oceanography, the signals archived in its sediments needs to be unraveled. Of all the many paleoceanographic proxies, the oxygen isotopes have been widely used as a base for deciphering past climatic conditions from marine sediments extensively. Also, to understand the variation in the past salinity (evaporation and precipitation), the paleo-water temperature needs to be reconstructed.

Objectives of the Proposed Research

The past climatic variations in the Baltic Sea are not very well understood. Since it lies in the proximity of the northern high latitude climate, its effect would be more pronounced in this region with NAO being the major climate feature. To understand the paleoclimatology in the Baltic Sea region, I propose the following objectives:

1. To reconstruct long-term sea surface temperature and salinity variability from the Baltic Sea marine sediments.
2. To understand the factors controlling the past variation of hydrography of Baltic Sea.
3. To estimate salinity changes in the Baltic Sea that will help in evaluating the NAO and its response to global climate change and also to evaluate influence of local climate.
4. To decipher changes in the paleo-bottom water conditions.
5. To characterise the provenance of detrital sediments in the marine environment over the past.

Expected Outcome

The findings from the proposed study will cater to the pool of paleoclimate data being generated all over the globe. The results will further the understanding of the global climate and its linkage to other major climates. The observations and findings made from this study will be vital in deciphering the influence of the Arctic high latitude climate over the Baltic Sea and its role in global climatic system. The temperature reconstruction of seawater is not only important for climatic studies but also important for discerning deep-water circulations and climate links. This study would provide a comprehensive picture of the role of NOA and other local climate systems through hydrographic changes. The results will be presented and discussed in national-international conferences and published in peer-reviewed journals. Since, researchers are interested in such data from the high-latitude regions, this study will help in establishing contacts and for exchange of ideas and views.

IODP Expedition 321: Pacific Equatorial Age Transect (PEAT)

Pawan Dewangan
National Institute of Oceanography (CSIR), Dona Paula, Goa – 403 004, India
Email: pdewangan@nio.org

The Pacific Equatorial Age Transect (PEAT) program (Fig. 1) was designed to achieve an age transect of eastern Pacific sediments deposited within the equatorial region (±2° of the equator) on the Pacific plate. The age of sediments within the equatorial transect span from the early Eocene through the Pliocene, with Paleocene/Eocene and late Miocene to recent intervals being covered by previous Ocean Program (ODP) Legs 138 and 199. Drill sites target specific time intervals of interest at locations that provide optimum preservation of calcareous sediments. The overall aim was to obtain a continuous well-preserved equatorial Pacific sediment section that addresses the following primary scientific objectives:

1. To detail the nature and changes of the calcium carbonate compensation depth (CCD) over the Cenozoic in the paleoequatorial Pacific;
2. To determine the evolution of paleoproductivity of the equatorial Pacific over the Cenozoic;
3. To validate and extend the astronomical calibration of the geological timescale for the Cenozoic, using orbitally forced variations in sediment composition known to occur in the equatorial Pacific, and to provide a fully integrated and astronomically calibrated bio-, chemo-, and magnetostratigraphy at the Equator;
4. To determine temperatures (sea surface and bottom water), nutrient profiles, and upper water column gradients;
5. To better constrain Pacific plate tectonic motion and better locate the Cenozoic equatorial region in plate reconstructions, primarily using paleomagnetic methods; and
6. To make use of the high level of correlation between tropical sedimentary sections and existing seismic stratigraphy to develop a more complete model of equatorial circulation and sedimentation.

Data and Methodology : Physical properties at Sites U1337 and U1338 were measured on whole cores, split cores, and discrete samples. WRMSL measurements (GRA bulk density, magnetic susceptibility, and *P*-wave velocity), thermal conductivity, and NGR measurements comprised the whole-core measurements. For Hole U1337A and U1338A, compressional wave velocity measurements on split cores and MAD analyses on discrete core samples were made at a frequency of one per undisturbed section. The SHMSL, configured with the Ocean Optics sensor, was used to measure spectral reflectance on archive-half sections at a resolution of 2.5 cm.

Results - Sites U1337 and U 1338: Physical property measurements on whole-round sections and samples from split cores display a strong lithology-dependent variation at Site U1337 (Fig. 2). Variations in the abundances of nannofossils, radiolarians, diatoms, and clay in Unit I account for high-amplitude, high-frequency variations of all physical properties. Intervals enriched in biogenic silica and clay generally display lower grain density and bulk density and higher porosity, magnetic susceptibility, and NGR. Velocity is generally directly related to bulk density; however, it is commonly higher in low-density siliceous-rich sediments than it is in more calcareous intervals. Wet bulk density is low in Unit I, ranging from 1.12 to 1.46 g/cm3. Porosity is as high as 92% in this unit. Velocity also is low, averaging 1525 m/s. The natural gamma record, as at previous Expedition 320/321 sites, is marked by an anomalously high near-surface peak (~65 cps). Magnetic susceptibility varies between 4 × 10–5 and 18 × 10–5 SI. The color of Unit I is characterized by the lowest L* and high and variable a* and b* values. Unit II is characterized by a continued high variability in grain density. Together, the grain density in Units I and II averages 2.51 g/cm3 and ranges from 2.17 to 2.85 g/cm3. All other physical properties display less variability in Unit II than in Unit I, reflecting a less variable lithology. Wet bulk density increases and porosity decreases with depth in Unit II; however, in Units II and III these trends are interrupted by low-density, high-porosity diatom- and radiolarian-rich intervals. Unit II is slightly lighter colored (lower L*) and distinctly more blue (lower a*) and green (lower b*) than Unit I. Unit III is characterized by more uniform physical properties that accompany the high and uniform carbonate composition of the unit. The nannofossil oozes and chalks of this unit are characterized by a uniform grain density that averages 2.67 g/cm3. The bulk density and porosity trends of Unit II continue in Unit III. The transition from ooze to chalk is marked by a change in gradient of these properties to a more rapid decrease in wet bulk density and an increase in porosity with depth.

Wet bulk density and porosity at the base of the sediment section are 1.95 g/cm3 and 47%, respectively. The increase in velocity with depth also changes to a higher gradient in Unit III, with values increasing from 1510 m/s at ~340 m CSF-A to ~1800 m/s near the base of the hole. Magnetic susceptibility and NGR values remain low in Unit III but do vary in response to small changes in lithology. The sharp color change from greenish gray to pale yellow at ~410 m CSF-A is marked by a sharp increase in a* and b*. The change in color to pale brown chalk immediately above basement is marked by an increase in both a* and b* and a decrease in L*. Downhole temperature measurements and thermal conductivities of core samples were combined to estimate a geothermal gradient of 32.4°C/km and a heat flow of 28.4 mW/m2 at Site U1337.

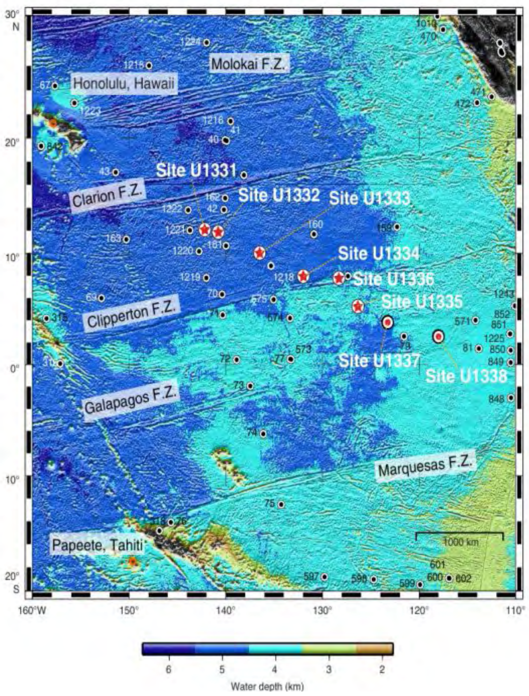


Fig.1 Location map

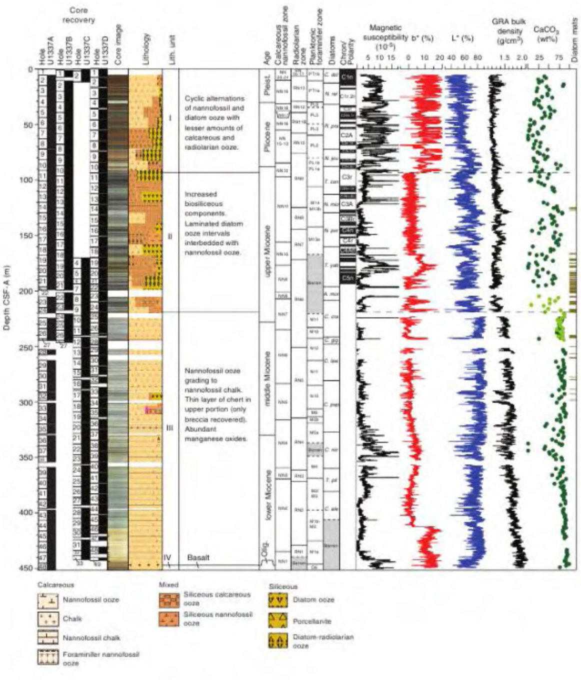


Fig.2 Summary of Site U1337A

Physical properties measurements on whole-round sections and samples from split cores display a variation strongly dependent on the relative abundance of biosiliceous and calcareous sediment components at Site U1338. As at Site U1337, intervals enriched in siliceous microfossils and clay generally display darker colors, lower grain density and bulk density, and higher porosity, magnetic susceptibility, and NGR. The variation of velocity is more complex in that it is dependent on both the wet bulk density and the sediment rigidity. These parameters vary independently with the variation in abundance of biosiliceous and calcareous components.

The physical properties at Site U1338 also display cyclicity on multiple scales, a decimeter to meter scale and a scale with a spacing on the order of tens of meters. Lithologic Unit I at Site U1338 is characterized by low wet bulk density that decreases from 1.4 g/cm3 near the seafloor to 1.2 g/cm3 at the base of the unit as a result of an increasing abundance of radiolarians and diatoms with depth. The grain density in Units I and II displays a greater variability than is found deeper at the site as a result of the greater variability in the abundance of biosiliceous and calcareous components. The average grain density for Units I and II is relatively low, at 2.59 g/cm3. The NGR signal at Site U1338 is characterized by a near-seafloor peak that is somewhat lower than those recorded at the other PEAT drill sites but extends deeper and is marked by a double peak. Spectral reflectance measurements show that Unit I is characterized by lower L* and higher a* and b* values in the upper 25 m of Unit I. Below 25 m CSF-A, the sediment becomes lighter colored (L* increases) and more bluish green (a* and b* decrease).

Unit II is characterized by increasing wet bulk density with depth to ~175 m CSF-A. Below this depth, an increase in the abundance of siliceous microfossils produces a broad density minimum. Magnetic susceptibility and NGR signals are low in Unit II to the depth at which the biosiliceous material increases in abundance. The interval of the broad density minimum is characterized by higher magnetic susceptibility values that are roughly equal to those in the upper 25 m of Unit I. Unit II is lighter colored than Unit I (higher L*) and more blue (lower b*). Unit III at Site U1338 is characterized by a higher and more uniform carbonate content and, as a result, more uniform physical properties. Wet bulk density increases from ~1.5 g/cm3 at the top of Unit III to 1.7 g/cm3 at the base of the unit. Grain density varies over a narrower range in Unit III than it does in Units I and II and displays an average (2.64 g/cm3) nearer to that of calcite. Velocity, which through much of Units I and II is close to the velocity of water, displays a regular increase in Unit III, from ~1620 m/s at the top to ~1820 m/s near the base of the unit. Velocity gradient increases near the base of Unit III accompanying the transition from nannofossil ooze to chalk. Magnetic susceptibility is low from the boundary between Units II and III, at ~245 m CSF-A, to 300 m CSF-A. Below 300 m CSF-A, susceptibility again increases to values comparable to those in the upper part of Unit I. NGR variability is lower in Unit III than in Unit II and remains uniformly low throughout the unit. Overall, Unit III is the lightest colored (highest L* values) unit at Site U1338. The transition from greenish gray to pale yellow is marked at ~385 m CSF-A by a shift to higher values of both a* and b*.

Disscussion: A Cenozoic record of the equatorial Pacific carbonate compensation depth (Pälike et al., 2012)

Atmospheric CO_2 concentrations and climate are regulated on geological time scales by the balance between carbon input by volcanic and metamorphic outgassing and its removal by weathering feedbacks involving the erosion of silicate and organic carbon bearing rocks. The integrated effect of these processes dictates the carbonate saturation state of the oceans that is reflected in the carbonate compensation depth (CCD), which has been highly influential in understanding past changes in the marine carbon cycle. The CCD is reconstructed using sediment cores from the equatorial Pacific. Eight sites were cored from the sea-floor to basaltic basement, that is aged between 53 and 18 million years before present (Ma), near the past position of the Equator at successive crustal ages on the Pacific plate. Overall, the CCD tracks ocean cooling, with a deepening from 3–3.5 km during the early Cenozoic to 4.6 km at present, consistent with findings of an overall Cenozoic increase in silicate weathering. Superimposed on this overall deepening are repeated large CCD fluctuations during the middle and late Eocene which are not associated with the bi-polar fluctuation in the ice volume. The potential of different processes to generate the CCD variability during the middle to late Eocene was modeled using the Earth System Model of Intermediate Complexity (GENIE). Overall, the modelling reveals that the CCD is remarkably well buffered against short and long term perturbations of the global carbon cycle. Only a few of the mechanisms have the capacity to change the amplitude of the steady-state CCD sufficiently and for long enough to be compatible with our reconstruction. One such mechanism is changes in the partitioning of organic carbon flux between labile and refractory components and is found to be consistent with shifts between siliceous and calcareous microfossil groups, and changes in organic carbon preservation and burial, and has sufficient amplitude to explain variability during the middle–late Eocene.

IODP Expedition 323: Bering Sea Paleoceanography

Maheswar Ojha
National Geophysical Research Institute, Hyderabad-500007
Email: maheshwar_ojha@ngri.res.in

Paleoclimate and paleoceanographic studies present opportunities to study the dynamics of the climate system by examining how it responds to external forcing (e.g., greenhouse gas and solar radiation changes) and how its interacting components generate climate oscillations and abrupt changes. Of note is the amplified recent warming of the high latitudes in the Northern Hemisphere, which is presumably related to sea ice albedo feedback and teleconnections to other regions; both the behavior of sea ice–climate interactions and the role of large-scale atmospheric and oceanic circulation in climate change can be studied with geologic records of past climate change in the Bering Sea.

Over the last 5 m.y., global climate has evolved from being warm with only small Northern Hemisphere glaciers to being cold with major Northern Hemisphere glaciations every 100–40 k.y. The ultimate reasons for this major transition are unknown. Over the last hundreds of thousands of years, Milankovitch- and millennial-scale climate oscillations have occurred. Although the regional environmental changes reflected in the sediment are known in some regions, the mechanisms by which they propagate globally are not understood. Possible mechanisms responsible for both the long-term evolution of global climate as well as the generation of high-frequency climate oscillations involve processes such as intermediate water ventilation and sea ice formation in the North Pacific. However, the paucity of data in critical regions of the Pacific such as the Bering Sea has prevented an evaluation of the role of North Pacific processes in global climate change. Because North Pacific Intermediate Water (NPIW) has the potential to be influenced by dense water forming in the Bering

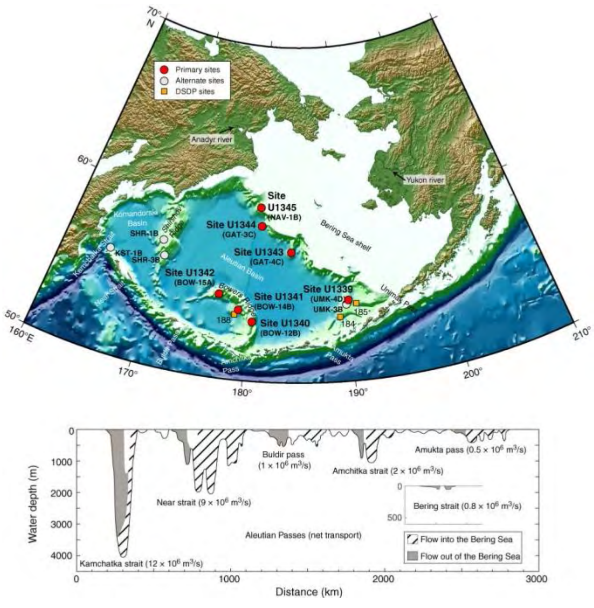


Figure1: Location map of the site 323

Sea and because of the potential far-field impacts of sea ice, the Bering Sea may be critically involved in causing major climate changes. Thus, drilling in the Bering Sea may help answer questions not only about the global extent of climate trends and oscillations but about the mechanisms that produce them.

The major objectives of Expedition 323 in the Bering Sea are

1. To elucidate a detailed evolutionary history of climate and surface ocean conditions since the earliest Pliocene in the Bering Sea, where amplified high-resolution changes of climatic signals are recorded;
2. To shed light on temporal changes in the origin and intensity of NPIW and possibly deeper water mass formation in the Bering Sea;
3. To characterize the history of continental glaciation, river discharges, and sea ice formation in order to investigate the link between continental and oceanic conditions of the Bering Sea and adjacent land areas;
4. To investigate linkages through comparison to pelagic records between ocean/climate processes that occur in the more sensitive marginal sea environment and processes that occur in the North Pacific and/or globally. This objective includes an evaluation of how the ocean/climate history of the Bering Strait gateway region may have affected North Pacific and global conditions; and
5. To constrain global models of subseafloor biomass and microbial respiration by quantifying subseafloor cell abundance and pore water chemistry in an extremely high productivity region of the ocean. We also aim to determine how subseafloor community composition is influenced by high productivity in the overlying water column.

During Expedition 323 in the Bering Sea, 5741 m of sediment (97.4% recovery) was drilled at seven sites covering three different areas: Umnak Plateau, proximal to the modern Alaskan Stream entry; Bowers Ridge, proximal to the glacial Alaskan Stream entry; and the Bering Sea shelf region, proximal to the modern sea ice extent. Four deep holes were drilled that ranged in depth from 600 to 745 m below seafloor, spanning 1.9 to 5 Ma in age. The highlights of our findings include the following:

1. An understanding of the long-term evolution of surface water mass distribution during the past 5 m.y., including the expansion of seasonal sea ice to Bowers Ridge between 3.0 and 2.5 Ma and the intensification of seasonal sea ice at both Bowers Ridge and the Bering slope at ~1.0 Ma, the mid-Pleistocene Transition.
2. The characterization of intermediate and deep water masses, including evidence from benthic foraminifers and sediment laminations, for episodes of low-oxygen conditions in the Bering Sea throughout the last 5 m.y.
3. The terrigenous and biogenic sedimentary history of the Bering Sea, including evidence for strong climatological and sea level control of siliciclastic deposition at all sites. Records of lithostratigraphic variations indicate that Bering Sea environmental conditions were strongly linked to global climate change; this is apparent both in long-term million year trends and in the orbital, millennial, and shorter oscillations within the lithostratigraphic records generated at sea.
4. A large range of inferred microbial activity with notable site-to-site variations, including significant activity as deep as 700 m core depth below seafloor (CSF) at the Bering slope sites, and, in contrast, very low rates of microbial-mediated sulfate reduction at Bowers Ridge.

IODP Expedition 334: Costa Rica Seismogenesis Project (CRISP)

V. Yatheesh

National Institute of Oceanography (CSIR), Dona Paula, Goa – 403 004, India

Email: yatheesh@nio.org

Integrated Ocean Drilling Program (IODP) Expedition 334, also known as the Costa Rica Seismogenesis Project (CRISP), was designed to understand the processes that control nucleation and seismic rupture of large earthquakes at erosional subduction zones. With a low sediment supply, fast convergence rate, abundant seismicity, subduction erosion, and a change in subducting plate relief along strike, CRISP offers excellent opportunities to learn causes of earthquake nucleation and rupture propagation. CRISP involves the only known erosional end-member of convergent margins within reach of scientific drilling. Scientific objectives of this expedition include constraining the architecture and evolution of the plate boundary megathrust and role of fluids, as well as the nature of the upper plate in a tectonically erosive margin along a drilling transect at two slope sites.

Costa Rica is located at the western margin of the Caribbean plate, where the Cocos plate subducts beneath the Caribbean plate along the Middle America Trench (Figure 1). During CRISP Expedition, drilling was carried out over two sites (U1378 and U1379) in the upper plate (Caribbean Plate) and one site (U1381) over the subducting plate (Cocos plate). The sites U1378 and U1379 were first characterized by logging while drilling (LWD) to document in situ physical properties, stratigraphic and structural features in addition to continuous core sampling to be used for laboratory studies. The Site U1381 (Figure 2) is located on the Cocos Ridge and ~90 m long core was recovered from this drilled hole. The drilling operations in sites U1378 and U1379 (Figure 2), both located in the upper plate, could retrieve ~524 m and ~890 m long sediment cores, respectively. These sediments were used primarily to determine the nature, composition and physical properties of the upper plate. The physical property measurements on whole round core were carried out using the Whole Round Multi-sensor Logger (density, magnetic susceptibility and P-wave velocity) and the Natural Gamma Ray Core Analyzer (gamma ray attenuation). Subsequent to these measurements, detailed description of the core lithology and the structures observed were documented and core samples were scanned using Section Half Image Logger (SHIL) and the Integrated Measurement System (IMS) to record the reflectance.

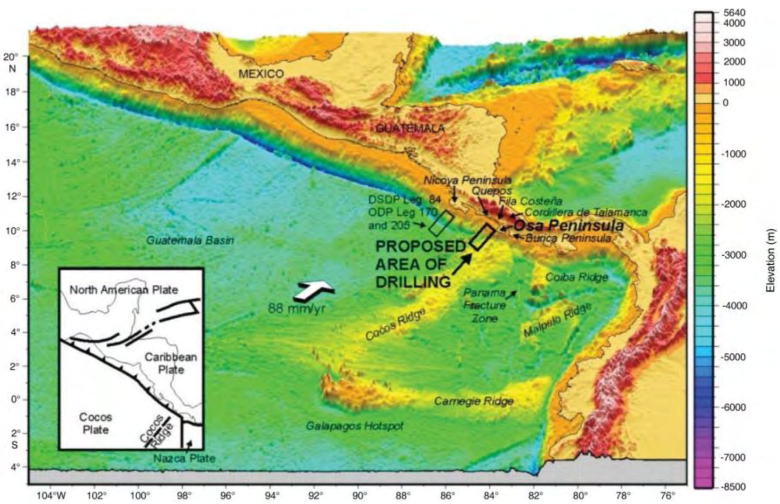


Figure 1. Bathymetric map of Middle America Trench, showing location of proposed drilling area

Thermal conductivity and P-wave velocity were measured at discrete interval using Thermal Conductivity Measuring system and P-Wave Velocity Analyzer, respectively. From each section of the cores, samples were analyzed to determine the moisture and density (MAD) measurements using a high-sensitivity balance and a Pycnometer. The Paleomagneticists analyzed the samples to look for geomagnetic polarity reversals and the paleontologists to pick microfossils to get the age information as a function of depth. Among these shipboard analyses, my role was to carry out physical property measurements (P-wave velocity, gamma ray attenuation, magnetic susceptibility, natural gamma ray, thermal conductivity and moisture and density analysis) of the retrieved core samples, in association with the other team members of the Physical Property Specialists group. Moisture and Density (MAD) measurements provided the bulk density, grain density and porosity of the sediment samples retrieved from Site U1379 and Site U1378 and those results were used to study the variation of porosity and density with respect to depth over the upper plate in an erosional subduction zone. Further, the bulk density values determined from gamma ray attenuation (GRA) measurements were compared with the density and porosity information derived from MAD measurements. In general, values of wet bulk density determined from whole round GRA measurements and measurements from discrete samples agree well. Wet bulk density increases with depth, increasing more rapidly in the upper section than in the lower section, likely a result of dewatering caused by overburden pressure. Measured porosities within the sediment section are inversely correlated with bulk density, decreasing with increasing depth. Logging-while-drilling data were then used to correlate the physical property parameters obtained from the core sample analysis.

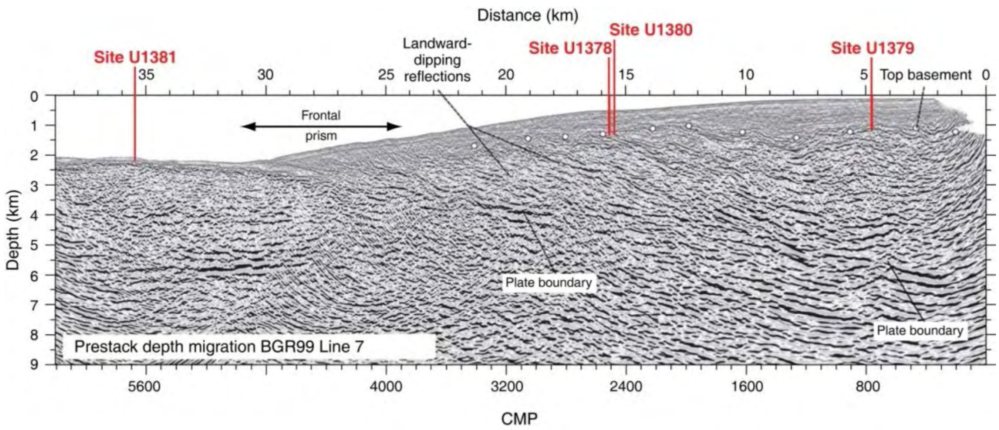


Figure 2. Seismic reflection section showing location of drill sites across Costa Rican margin

After completion of the onboard analyses of core samples, ~300 samples were brought for carrying out the proposed post-cruise research. In collaboration with National Centre for Antarctic and Ocean Research, a project entitled "*Study of seismically induced slope failure of sediments and subsurface fluid flows in the Costa Rican seismogenic zone using long sediment cores drilled during IODP expedition 334 (CRISP)*" was recently initiated with an aim to detect the imprints of tectonic events from the Costa Rica subduction environment and to decipher the timing of induced slope failure, slumping of the sediments due to the seismicity and influence of fluid flow in the sediments. Under this project, it is planned to carry out a combined geochemical, sedimentological, mineralogical and isotope chemical proxy analysis. In addition, physical properties measurements and downhole log data will be used to locate zones associated with the recent active tectonic events and for correlation of imprints of tectonic events obtained from analyses of core samples. The study is expected to provide important constraints to decipher the history of seismic events in the Costa Rica seismogenic zone.

IODP Expedition 343: Japan Trench Fast Drilling Project

Santanu Bose
Department of Geology, University of Calcutta, Kolkata – 700 019
Email: bose.santanu@gmail.com

The objective of the IODP 343 expedition is to investigate the area of fault displacement during the 2011 Japan earthquake. Two-borehole sites selection were chosen near the Japan Trench to drill upto the predicted slip zone of this earthquake, which was approximately about 1000 m below seafloor. Large slip (~ 50 m) during this earthquake in the shallow, thought to be frictionally stable, part of the subduction zone induced dreadful tsunami that inundated the NE coast of Honshu. Hence, the renewed study of subduction zone becomes important in order to reveal, if possible, the cause of such subduction earthquakes and associated tsunamis, which has great societal impacts. For these investigations, integrated understanding of fault rock properties and rupture mechanism of such earthquake area is the primary research topic.

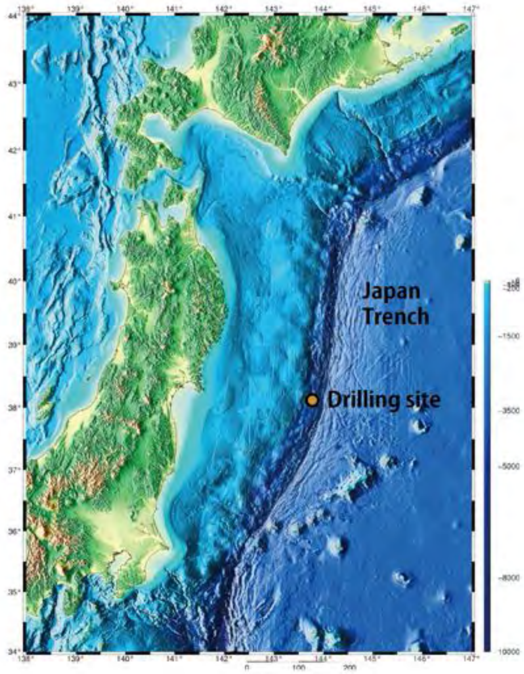


Fig 1: Expedition 343 (JFAST) site

The drilling operation had many technical challenges because of large thickness water column of approximately 7000 m above the sea floor. However, this expedition was successful in creating a record for the greatest depth of drilling borehole from the sea surface. There were two successful boreholes drilled, one of which produced geophysical data collected through Logging While Drilling (LWD) tolls and the second borehole was drilled for core that sampled depths from 648 to 845m below sea floor. Onboard analysis on geophysical data along with data from core samples identified the plate boundary fault. All these data are now being analyzed by onboard and onshore researchers, to understand the faulting mechanisms of 2011 Tohoku earthquake.

IODP Expedition 318: Wilkes Land Glacial History

Prakash K. Shrivastava

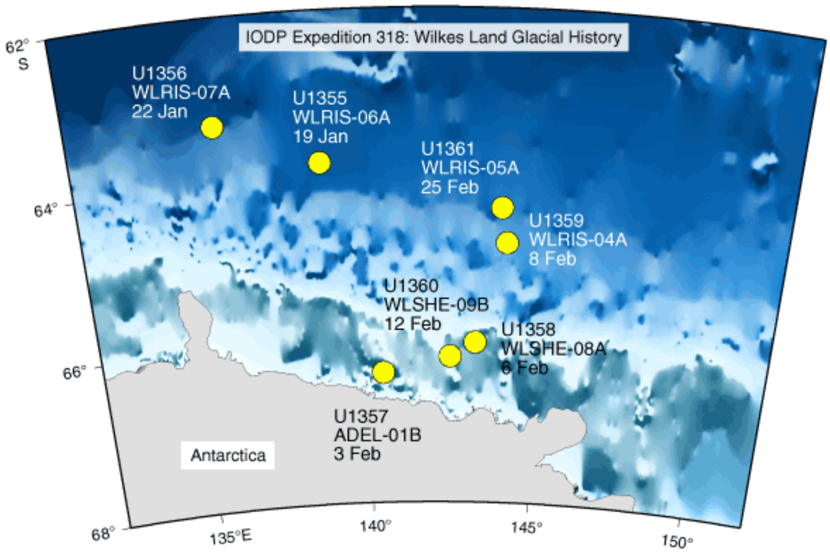
Geological Survey of India, Faridabad

Abstract Contributors: N.C. Pant[1*], P. Biswas[1], Prakash K. Shrivastava, S. Bhattacharya[2] and Kamlesh Verma[2], Mayuri Pandey[1] and IODP Expedition 318 Scientific Party

[1]Department of Geology, University of Delhi, Delhi-110007,

Email: pantnc@gmail.com

Site U1359 is located on the eastern levée of the Jussieau submarine channel on the Wilkes Land margin, East Antarctica. The upper ~60 m of the sediment core records >2.5 million year of the depositional history. Present work focuses on inferring provenance from the heavy mineral fraction from the Pleistocene sediments. Clay and non-clay fractions were characterized using X-ray diffraction and micro-beam techniques. Metamorphic minerals including orthopyroxene, high Ca-garnet and high-Ti biotite indicate a source in high-grade metamorphic terrain. Mixing from a low- to medium-grade metamorphic component is also indicated. Several basaltic rock fragments, showing mineralogical affinities to the Ferrar volcanic province in the Ross Sea sector, are present. The metamorphic component is correlatable with the Proterozoic East Antarctic cratonic shield component. Ordovician to Silurian ages of euhedral xenotime and monazite, coupled with the Ferrar equivalent basalts, indicate additional sources from the Ross orogen besides the craton. Presence of extra-terrestrial basalt is inferred using mineralogical and geochemical constraints.



Core U1359 collected from the continental rise off Wilkes Land, east Antarctica is analysed for the clay mineralogical content. The result shows a positive correlation between illite and chlorite. At 145-200, 100-120 and 40-50 meter depth smectite shows enrichment whereas illite shows enrichment at 200-260, 125-145 and 60-80 meter depth. The mineralogical analysis on the silt size fraction (>53 micron) of the same sample was also carried out. The combined result shows the presence of chlorite and illite in both size fractions, smectite and kaolinite in clay size fraction and similarity in the crystallinity state of illite having biotitic nature. This similar kind of illite in both fractions suggest negligible role of sorting probably due to the deposition in glacial environment. During times of ice growth nearby cratonic east Antarctica shield could have provided biotite rich sediments to the depositional site. On the other hand, the presence of smectite, only in the clay size fraction suggests the effective role of sorting probably due to the deposition from distal source in non-glacial condition. During times of ice retreat the Trans Antarctic Mountains (TAM) act as a barrier and diverts the smectite rich sediment derived from Ross Orogen and Jurassic tholeiites of TAM to the area of site U1359. P oor crystallinity of illite due to the intense degradation further corroborates the non-glacial condition. Thus the enrichment of smectite/illite reflects the non-glacial /glacial condition respectively. The Total Organic Carbon (TOC) content of the investigated Plio-Pleistocene sediments shows an inverse relationship with the rate of sedimentation. Change in the status of East Antarctic Ice Sheet (EAIS) from a dynamic one to persistent occurred at ~4.9 Ma, coincident with the seismic unconformity WL-U8 and the associated bathymetric change is reflected in the Total Inorganic Carbon (TIC) content.

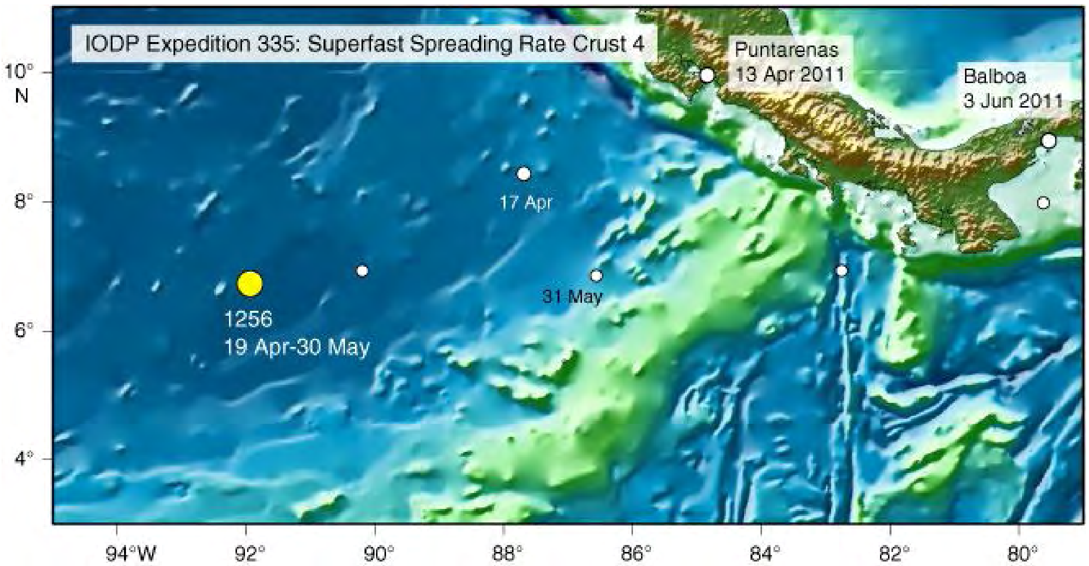
IODP Expedition 335: Superfast Spreading Rate Crust 4

Parijat Roy
National Geophysical Research Institute, Hyderabad-500007
Email: parijatroy@yahoo.co.in

Integrated Ocean Drilling Program (IODP) Expedition 335, "Superfast Spreading Rate Crust 4" (13 April–3 June 2011), was the fourth scientific drilling cruise of the Superfast Spreading Crust campaign to Ocean Drilling Program (ODP) Hole 1256D. The expedition aimed to deepen this basement reference site several hundred meters into the gabbroic rocks of intact lower oceanic crust to address the following fundamental scientific questions:

- Does the lower crust form by subsidence of a crystal mush from a high-level magma chamber (gabbro glacier), by intrusion of sills throughout the lower crust, or by some other mechanism? How does melt percolate through the lower crust, and what are the reactions and chemical evolution of magmas during migration?
- Is the plutonic crust cooled by conduction or hydrothermal circulation? What are the role and extent of deeply penetrating seawater-derived hydrothermal fluids in cooling the lower crust and the chemical exchanges between the ocean crust and the oceans?
- What are the relationships among the geological, geochemical, and geophysical structure of the crust and, in particular, the nature of the seismic Layer 2–3 transition?
- What is the magnetic contribution of the lower crust to marine magnetic anomalies?

Hole 1256D is located on 15 Ma crust in the eastern equatorial Pacific Ocean (6°44.163′N, 91°56.061′W). Oceanic crust that formed at a superfast spreading rate (>200 mm/y) was specifically targeted to exploit the observed relationship between spreading rate and depth to axial low-velocity zones, thought to be magma chambers, seismically imaged at active mid-ocean ridges. This was a deliberate strategy to reduce the drilling distance to gabbroic rocks because thick sequences of lavas and dikes have proved difficult to penetrate in the past.



During Expedition 335, we reentered Hole 1256D more than 5 years after our last visit and encountered and overcame a number of significant engineering challenges, each unique but of natures not unexpected in a deep, uncased marine borehole into igneous rocks. The patient, persistent efforts of the rig floor teams cleared a major obstruction at 920 meters below seafloor (mbsf) that initially prevented reentry into the hole to its full depth (1507 mbsf). The 920–960 mbsf intervals were then cemented to stabilize the borehole wall. A short phase of coring deepened Hole 1256D ~13 m before the C-9 hard formation coring bit failed and was ground to a smooth stump. A progressive, logical course of action was then undertaken to clear the bottom of the hole of metal junk from the failed coring bit, open up a short interval of undergauge hole, and remove a very large amount of drilling cuttings from the hole. This was successfully completed, and the hole is open to its full depth (1521.6 mbsf). The hole-cleaning phase was followed by wireline caliper and temperature measurements of the complete hole to assist with cementing operations to stabilize the lowermost 10 m of the hole and the problematic interval at 910–940 mbsf. These remedial efforts should facilitate reentry and coring on a future return to Hole 1256D. Following research work has been proposed for the samples recovered during expedition

- To study the platinum group element geochemistry of the basalt, granoblastic dykes and gabbros from the middle crust and lower middle crust section from the Superfast Spreading Ridge in Pacific Ocean to understand the PGE distribution in modern crust and mantle-crust interaction.
- Isotopic systematic studies on the sulphide rich and sulphide poor zones in oceanic crust to understand if any proportion of recycled oceanic crust is involve in the source, which may be attributed in the modern day crust.

These studies will be of great importance for understanding the PGE distribution in modern crust and the mantle-crust interaction, which may lead us in better understanding of the mechanism of formation and the source material for the generation of crust with the present day mineralogy. Hence this study will help in understanding the complex interactions mechanism in global scale and also the PGE budget of the modern day crust.

IODP Expedition-340, Lesser Antilles Volcanism and Landslides

Participants: K.S.V. Subramanyam
National Geophysical Research Institute, Hyderabad-500 007
Email: konduri2003@yahoo.com

Abstract Contributor: K.S.V. Subramanyam, V.Balaram, Dhananjai K. Pandey[#], U.V.B. Reddy
CSIR-National Geophysical Research Institute, Hyderabad-500 007
National Centre for Antarctic and Ocean Research, Vasco-Da-Gama, Goa
* Dept. of Applied Geochemsitry, Osmania University, Hyderabad-500 007.

The origin and development of modern volcanic island arc systems are better explained by plate tectonic processes which relate to the large scale melting of subducted oceanic plate. Like in other settings, chemical heterogeneity poses many problems in understanding the near actual geodynamic processes. The recycling of crustal material back in to the upper mantle due to subduction of lower plate (slab) resulting in the injection of cold lithosphere into the mantle and thus promoting mantle convection and thermal evolution of Earth in form of various magma types (Macdonald et al., 2000). All arc systems are unique and each can contribute to our understanding of subduction processes and modern day tectonics, not only the present day magmatic processes but also provides key solutions in interpreting palaeo-island arc systems.

The IODP Expedition-340, Lesser Antilles Volcanism and Landslides, aims for an understanding of **i)** constructive and destructive processes related to island arc volcanism, **ii)** magmatic evolution of the arc **iii)** sediment dispersal pattern and **iv)** alteration of volcanic material in marine conditions. Processes occurring along these arcs are among the most fundamental on Earth. Styles of magmatism and eruptive activity are diverse in this geological setting not only between different arcs, but also between the different islands that make up an arc. Because of the association of volcanic activity in island arcs with potentially large geohazards (explosive eruptions and tsunamis), it is imperative to further investigate and thus better understand the evolution of these volcanoes and the histories of their related landslides.

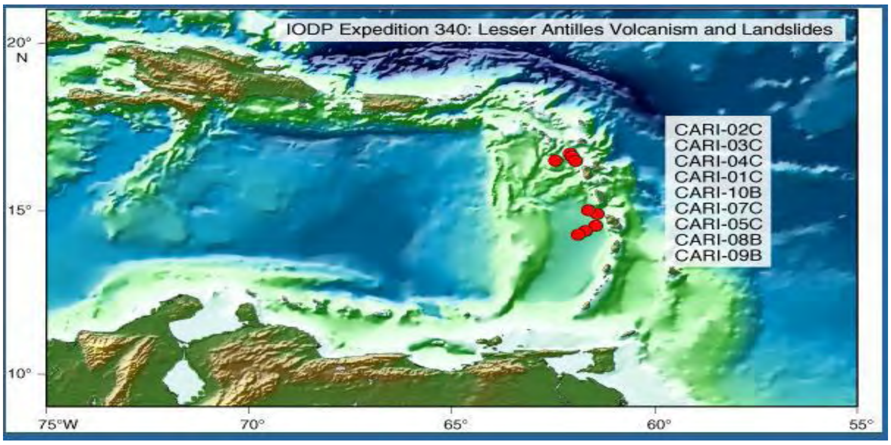


Fig. 1 Lesser Antilles Arc relief map and drill hole locations of Expedition-340**.**

The onboard geochemistry group (04 nos. of inorganic geochemists) has given the responsibility to undertake the XRD, major, Trace and REE, carbonate analyses, pore fluids collection and analysis, headspace sample collection and analysis for various lithologies identified by the core describers, to help the multi disciplinary groups working onboard. The data generated would be useful for the post cruise research projects of participants. Thus, my self engaged partly in major, trace and REE studies on various lithologies and partly in interpretation of XRD spectra of numerous samples (around 500-600 samples) during the period. I was actively engaged in preparation of daily reports, site summaries and site specific meetings. These inputs will be incorporated in the Expedition Scientific Publication to be published soon.

Studies on the behaviour of PGE and total sulphur of subduction related arc magmatic products are scanty and only few data sets from rocks of arc volcanics are reported due to the non-availability of representative samples, analytical equipments and procedures for the reliable determination of these noble metals at their crustal abundance levels. The subduction zone parameters such as temperature, depth and degree of partial melting, mantle wedge and slab interaction, volatile transport and addition of pelagic sediments have a dominant control on the generation of melts and also PGE abundances, hence, PGE geochemistry has the potential to provide important insights on mantle processes at such geodynamic settings. Hence, post cruise studies are aimed at understanding the trace, REE and PGE geochemistry of volcanogenic younger sediments derived from deep holes along Montserrat, Dominica, Guadeloupe and Martinique volcanic islands of the LAA system. Such studies certainly unravel the geochemical intricacies related to above mentioned objectives and help also understand the geochemistry of massive turbidite deposits belong to age not older than 40Ma abundantly intersected within the drill holes along the region. These massive unconsolidated turbidite deposits (Montserrat-1996 to till recent) are the resultants of debris avalanches/mass flow, flank, crator and summit collapses.

The data generated will be useful to compare the arc geochemical systems prevailed in Archean/ late Proterozoic metavocanics with the modern arc systems. A shift (to be fingerprinted, if available) in the critical geochemical ratios may be understood to identify the crust-mantle interaction in a subduction related geodynamic setting analogous to ancient and recent geological times.

Post Cruise Research:

Platinum Group Element (PGE) Geochemistry is very essential in LAA since studies are not available on the PGE abundance and fractionation behavior in an arc derived marine sediments, also iridium anomalies, impact (K/T) towards south west of Granada basin warrants thorough investigations in present younger sediments for distribution, mobility of Iridium, Platinum and Palladium. These studies can be made using HPA(High Pressure Asher) digestion technique and estimation by HR-ICPMS/ICPMS(quadrupole).

1. The proposed post cruise research will certainly help generate new data on the modern arc system.
2. The lithologies specially targeted for geochemical studies (major, trace, REE, PGE and total sulphur) are Young Unconsolidated Thick Massive Coarse to Medium Grained Mafic Volcanic Turbidite sequences which are very unique and uncommon and immensely help to understand the long eruptive history of the LAA.

IODP Expedition 345: Hess Deep Plutonic Crust

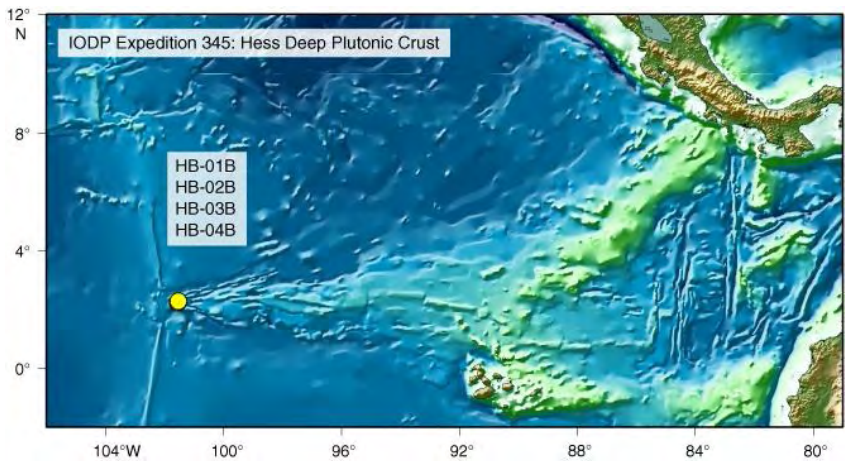
Abhishek Saha

University of Calcutta, Kolkata – 700 019

Email: ashaha.geocal@gmail.com

Integrated Ocean Drilling Program Expedition 345 (11 December 2012 to 10 February 2013) will be the second offset drilling program at the Hess Deep Rift to study crustal accretion processes at the fast-spreading East Pacific Rise (EPR). The expedition will take advantage of well-surveyed crustal exposures to recover the first cores of young, primitive plutonic rocks that comprise the lowermost ocean crust. The principal objective for drilling at Hess Deep is to test competing hypotheses of magmatic accretion and hydrothermal processes at fast-spreading mid-ocean ridges. These hypotheses make predictions that can only be tested with drill core, including the presence or absence of modally layered gabbro, the presence or absence of systematic variations in mineral and bulk rock compositions, and the extent and nature of hydrothermal alteration and deformation. With detailed petrological, chemical, and structural data for cores of deep, primitive gabbros, we will be able to address fundamental questions, such as, What proportion of the plutonic lower crust is constructed through crystal subsidence, and what proportion is constructed through in situ crystallization? How is melt transported from the mantle through the crust? What is the origin and significance of layering? How, and how fast, is heat extracted from the lower plutonic crust? What are the fluid and geochemical fluxes in the EPR lower plutonic crust?

The highest priority for drilling at the Hess Deep Rift will be to sample one or more 100 to ≥250 m long sections of primitive gabbroic rocks. Three primary drill sites have been identified; however, if coring is proceeding well in the first or second of these sites, it will be continued as long as possible in order to obtain the longest possible continuous sample. The alternate site is located near Ocean Drilling Program Site 894, where shallow-level gabbros are exposed. This plan differs slightly from Proposal 551, as there is no alternate site in upper mantle peridotite. Drilling and coring operations are anticipated to be challenging during the Hess Deep expedition because of water depths >4800 m, a thin sediment cover, and, potentially, unstable basement formations.

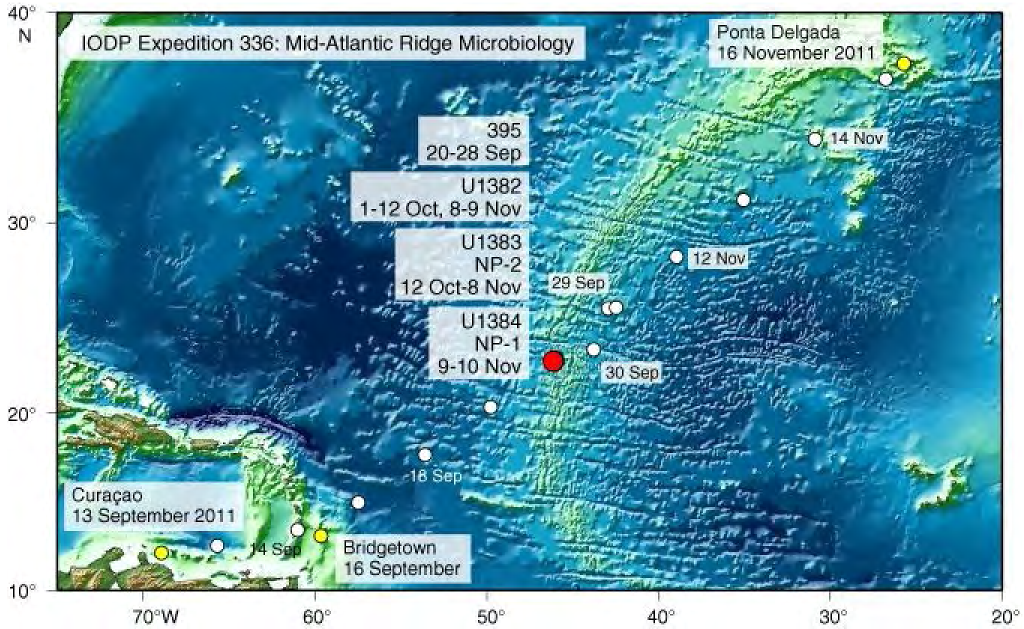


IODP Expedition 336: Mid-Atlantic Ridge Microbiology

Participants: Mamatha SS.
National Institute of Oceanography (CSIR), Goa, 403004

Abstract Contributors: Mamatha SS., Gonsalves MJBD and Loka Bharathi PA.,
National Institute of Oceanography (CSIR),Goa, 403004
Email: mamatha@nio.org

Deep-sea sediments, one of the largest carbon reservoirs in the ocean, play an important role in the global biogeochemical cycles. Lipids are polymers of fatty acids, the compositions of which can vary significantly depending upon groups of organisms (nekton, plankton, bacteria, archeae etc). These in turn could contribute to food web dynamics of benthic organisms. These fatty acids remain unchanged even when they are transferred through food chain (Bachok *et al.* 2009; Patience et al. 1990). More importantly, these compounds are also one of the most useful biochemical measures of the structure of past and present oceans and extant and extinct microbial communities.



Consequently the need for culturing and isolation for understanding changes in bacterial communities even over geological time scales can be bypassed (White, 1988). Therefore, the proposal envisages to understand the sources and the processes which control the contents and signatures of organic matter in the deep-sea sediments using fatty acid profiles. It postulates that fatty acid biomarkers (polyunsaturated fatty acids, PUFAs) could be as abundant as in shallow sediments and continue to be stable in deeper layers of the sediment cores from western flank of the mid-Atlantic ridge.

Fatty acids biomarkers will be identified and quantified in lipid extracts from sediment of western flank of the Mid-Atlantic ridge using gas chromatography with mass spectrometry (GC-MS). These profiles would be interpreted to understand microbial communities in relation to the then prevailing sediment characteristics.

In sediments, lipid is one of the important biomarkers present in all organic matter. Fatty acids are constituent of lipids which include saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs). Fatty acids are important for metabolism and cell membrane formation in aquatic organisms. These fatty acids can remain unchanged when they are transferred through the food chain (Bachok *et al.* 2009). Fatty acids are important in the marine ecosystem as they contribute a significant amount of total carbon (Rossi et al. 2006). Biomarkers provide quantitative information about the structure of extant microbial communities without the need for culturing and isolation (White, 1988). Lipids are also one of the most useful biochemical measures of *in situ* interactions between microbial species and their environments because lipid compositions can indicate temperature-, redox-, stress-, or nutritional conditions (Jahnke, 1992). However, many organic compounds in the sediments provide information which can be used for paleo-environmental reconstruction (Muri et al. 2004; Meyers, 2003) which could be linked to understanding changes in bacterial communities over geological time scale. The molecular distribution of lipids in particular provides useful information about the source, diagenetic alteration, preservation and historical changes in organic matter, as well as changes in trophic status of the lakes (Muri et al. 2004) which is also applicable to understanding the prokaryotic communities of sediment cores on geological scale. These cores harbour organic matter belonging different ages.

The majority of organic matter originates from autochthonous and allochthonous sources such as bacteria, phytoplankton, micro and macrobenthic algae. The oxidation of deposited organic matter, regeneration of inorganic nutrients and in some cases, transformation of those organic materials, is generally attributed to the sediment microbiota (Fichez 1991). Therefore, the fatty acid profiles have been useful tools in systematic studies of marine sediments. Therefore, the proposal envisages to understand the sources and the processes which control the contents and signatures of organic matter in the deep-sea sediments using fatty acid profiles. It hypothesises that fatty acid biomarkers (polyunsaturated fatty acids, PUFAs) could be as abundant as in shallow sediments and continue to be stable in deeper layers of the sediment cores from western flank of the mid-Atlantic ridge.

Work Plan

Sediment samples have been collected from drilling of the mid Atlantic region IODP-336 and preserved at -80ºC till analysis. The procedure consists of following four steps lipid extraction, lipid fractionation, methylation of fatty acids and analysis by GC-MS

Indian IODP Participants Meet: Program Details

Venue: NCAOR Seminar Hall

Date: 14-01-2013

09.30 AM – 10:00 AM	Inaugural session
10.00 AM – 10:30 AM	Invited lecture by Prof. V K Gaur (Structure of Bay of Bengal)
10.30 AM – 11.00 AM	Vote of Thanks & Tea Break

Expedition Presentations:

Session 1: (*Moderators: Prof. A C Narayana & Dr. Thamban Meloth***)**

11.00 AM – 11:30 AM	Indian proposal for drilling in the Arabian Sea (D K Pandey)
11.30 AM -13.30 PM	Presentation on IODP expeditions (**338**, **339**, 341 and **342**)
13.30 PM - 14.30 PM	Lunch Break (at NCAOR, Goa)

Session 2: (*Moderators: Prof. A K Singhvi & Dr. Rahul Mohan***)**

14.30 PM - 15.30 PM	Presentation on IODP expeditions (**325**, 346, 322* and 347)
15.30 PM -16.00 PM	Tea Break
16.00 PM - 16.30 PM	Invited talk by Prof. I B Singh
16.30 PM - 17.00 PM	Invited talk by Prof. A C Narayana

20:00 PM onwards	Dinner at Hotel HQ, Vasco da Gama, Goa

Date: 15-01-2013

Session 3: (*Moderators: Dr. K S Krishna & Dr. Dhananjai Pandey***)**

10.00 AM - 11.30 AM	Presentation on IODP expeditions (**321**, 323*, **334** and **343**)
11.30 AM -12.00 AM	Tea Break

Session 4: (*Moderators: Prof. I B Singh & Dr. K P Krishnan*)

12.00 AM -13.30 PM	Presentation on IODP expeditions (**318**, **335**, **340**, 345* and **336**)
13.30 PM – 14.30 PM	Lunch Break
14.30 PM – 16.00 PM	Interactive session towards further collaborations
16.00 PM -16.30 PM	Tea Break
16.30 PM – 17.00 PM	Concluding session

D/V CHIKYU

D/V JOIDES RESOLUTION