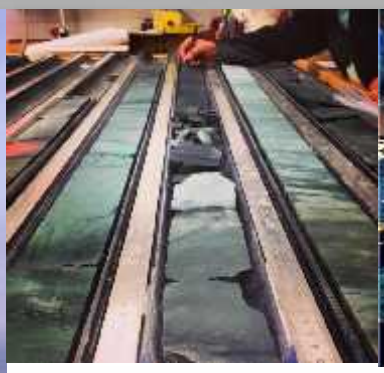
International Ocean Discovery Program (IODP) - India

September 2016

Indian Initiative towards

THE INTERNATIONAL OCEAN DISCOVERY PROGRAM (IODP): IODP-INDIA

(2012-2016)



ESSO

NCAOR

राष्ट्रीय अंटार्कटिक एवं समुद्री अनुसंधान केंद्र
पृथ्वी विज्ञान मंत्रालय, भारत सरकार

NATIONAL CENTRE FOR ANTARCTIC AND OCEAN RESEARCH
Ministry of Earth Sciences, Government of India

Table of Contents

1. BACKGROUND: THE INTERNATIONAL OCEAN DISCOVERY PROGRAM

The International Ocean Discovery Program (IODP) is an international marine research collaboration that explores Earth's history and dynamics using ocean-going research platforms to recover data recorded in seafloor sediments and rocks and to monitor sub-seafloor environments. Scientific drilling is performed through highly specialised and unique drilling platforms available before the international scientific community namely - JOIDES RESOLUTION (USA), CHIKYU (Japan) and Mission Specific Platform (MSP- Europe). Scientific research on sediment and rock core samples using these drilling platforms is conducted by exclusive access to the scientists from IODP member countries. At present, there are twenty-six representative nations, whose scientists are selected to staff IODP research expeditions conducted throughout the world's oceans. Scientific activities are managed by the IODP Program Member Offices.

IODP builds upon the earlier success of DSDP (1968-1983) and ODP (1985-2003) and Integrated Ocean Drilling program (2003-2013). The current phase of IODP program (2013-23), IODP identified the science plan as 'Illuminating Earth's Past, Present, and Future'.

2. INDIAN ENDEAVOUR TOWARDS ACTIVITIES PERTAINING TO THE INTERNATIONAL OCEAN DISCOVERY PROGRAM (IODP): IODP-INDIA

In order to provide Indian scientists and researchers a unique opportunity to carry out cutting edge geoscientific research using, sediment coring and drilling, India became an Associate member of this consortium through an MoU between Ministry of Earth Sciences (MoES) and National Science Foundation, USA. This MoU enables Indian scientists exclusive access to NSF owned drilling platform JOIDES RESOLUTION. The first phase of the MoU was carried out between 2009-2013. It was subsequently renewed and present phase is in place till 2019.

Soon after joining the IODP, India became member of various scientific and administrative panels of the IODP. These panels where India is currently nominated include Science Evaluation Panel (SEP) - both Science and Site components, JOIDES RESOLUTION Facility Governing Board and IODP Forum.

The National Centre for Antarctic and Ocean Research, Goa (NCAOR), an autonomous institute under MoES has been designated as the nodal agency to act as IODP-India and the Program Management Office (PMO). IODP-India is responsible for coordinating all Indian scientific activities pertaining to this program.

Under the MoU with NSF, provisions are made for the Indian scientists and researchers to participate in the regular IODP expeditions around the world onboard JOIDES

RESOLUTION as well as European Consortium's Mission Specific Platforms (MSP) and get involved in the active research pertaining to the deep sea drilling. In the current phase of IODP (2013-23) India has signed the MoU with NSF, USA, with the following objectives-

- Deep Sea Drilling in the Arabian Sea, to understand possible tectono-climatic links between Himalayan orogeny and Indian Monsoon as well as nature of crust in the Laxmi Basin.
- Continue the long-term scientific drilling programs in Indian Ocean, Southern Ocean and Antarctic Ocean and addressing the global and regional issues.
- Develop the research programs in the frontier area of Ocean sciences using long and continuous marine sediment cores.
- Capability building through active Indian participation in Deep Ocean Research of IODP.

So far 38 Indian scientists from 14 different institutions and a variety of disciplines have taken part since 2009 in various ocean drilling expeditions around the world (the above number includes the two scientists who were also considered for shore based sediment samples). A brief description of the on-going IODP Expedition#362 is given in the next section. A complete list of Indian scientists having participated so far in various IODP expeditions is also appended.

2.1. IODP EXPEDITION 362: DEEP OCEAN DRILLING IN SUMATRA SUBDUCTION ZONE TO UNDERSTAND EARTHQUAKE PROCESS (ONGOING)

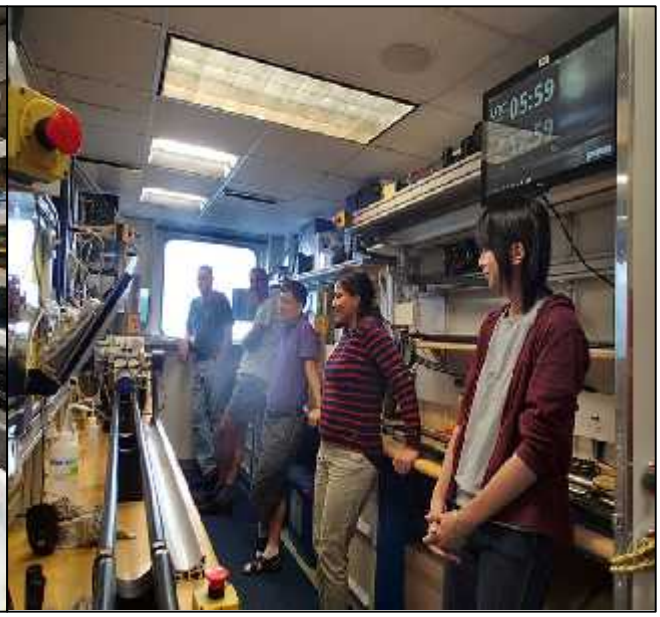
An international ocean drilling expedition in the Sumatra Seismogenic zone was flagged-off from Colombo on 6th August 2016. The 60 days long drilling expedition is being carried out under the aegis of the IODP where India is an Associate Member.

The Expedition (IODP 362) aims to establish:

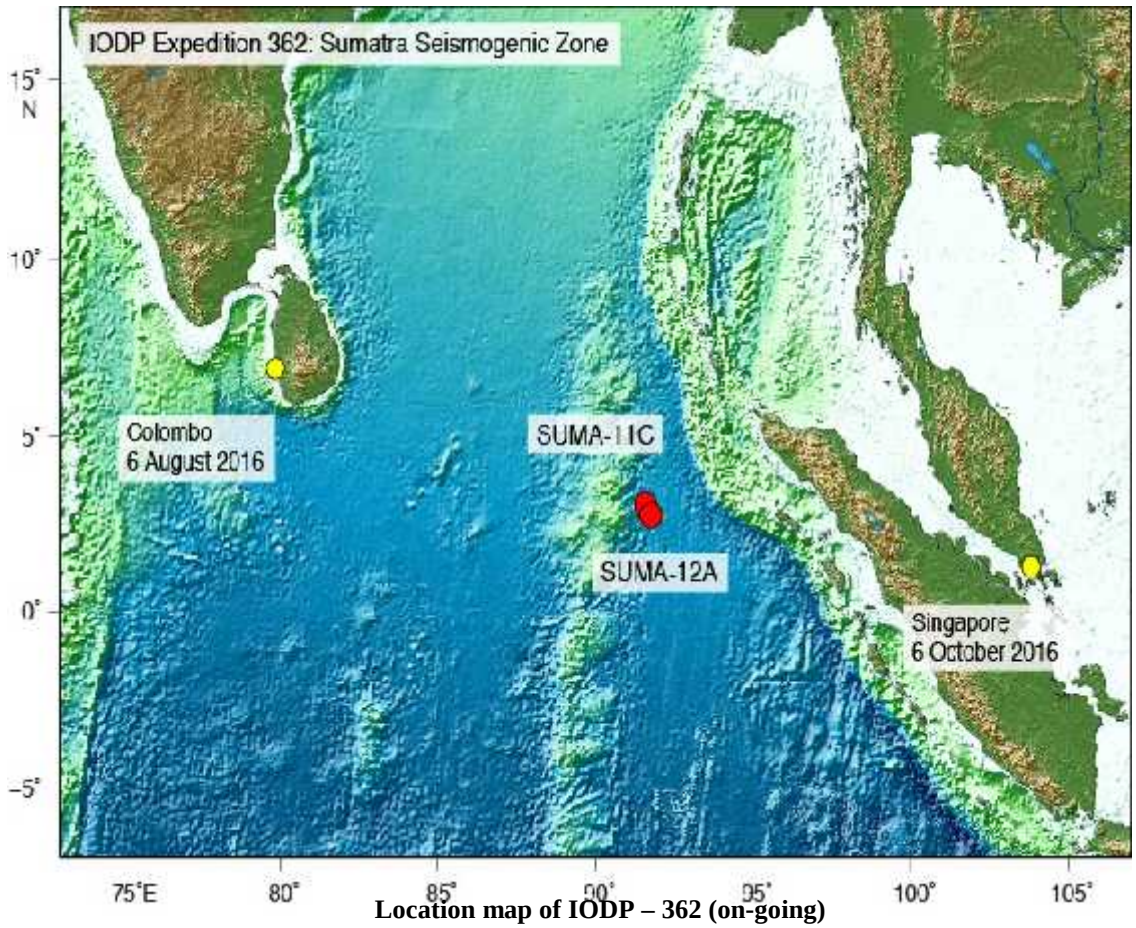
(1) The initial and evolving properties of the sediments in the Sumatra forearc region, and
(2) Their potential effect on seismogenesis, tsunamigenesis, and forearc development for global comparisons.

Dr. Nisha Nair, an Indian Scientist from NCAOR, Goa is participating in Expedition 362 as a Physical Properties Specialist. The expedition aims to collect more than 2000m long sediment cores from two primary sites in water depths of more than 4000m. The expedition is led by Dr. Lisa McNeill (UK) & Dr. Brandon Dugan (USA) besides ~30 other scientists from different countries.

Core sections for analyses and archival



Dr. Nisha Nair with the Physical Properties team onboard JR



Location map of IODP – 362 (on-going)

2.2. LIST OF ALL INDIAN PARTICIPANT IN VARIOUS IODP EXPEDITIONS:

S.No.	IODP Expedition	Name	Organisation	Date
22	IODP-362	Ms.Nisha Nair	NCAOR, Goa	6th August 2016 – 6th October 2016
21	IODP-361	Ms. N Lathika	NCAOR, Goa	30th January 2016 – 31st March 2016
20	IODP-360	Dr. Biswajit Ghosh	Calcutta University	30th November 2015 – 30th January 2016
19	IODP-359	Dr. Nagender Nath	NIO, Goa	30th September 2015 – 30th November 2015
18	IODP-355	Dr. Dhananjai Pandey	NCAOR, Goa	31st March 2015 – 31st May 2015
		Dr. Ravi Mishra	NCAOR, Goa	
		Dr. Manish Tiwari	NCAOR, Goa	
		Dr. Rajeev Saraswat	NIO, Goa	
		Dr. A Ganesh Kumar	NIOT, Chennai	
		Prof. A D Singh	BHU, Varanasi	
		Prof. Girish K Sharma	Kumaun University, Nanital	
		Dr. T Radhakrishna	NCESS, Trivandrum	
		Mr. Anil Kumar	WIHG, Dehradun	
		Mr. G. P Gurumurthy	Manipal University, Manipal	
		Mr Rakesh Sexana	ONGC, Mumbai	
17	IODP-354	Dr. Supriyo Das	Presidency University, Calcutta	29th January 2015 – 31st March 2015
		Dr. Manoj M C	BSIP, Lucknow	
16	IODP-353	Dr. Netramani Sagar	NGRI, Hyderabad	29th November 2014 – 29th January 2015
		Dr. Aditya Paketi	NIO, Goa	
		Mr. Dinesh K. Naik	NIO, Goa	
15	IODP-346	Dr. Raj K. Singh	WIHG, Dehradun	29th July 2013 – 27th September 2013
14	IODP-345	Dr. Abhishek Saha	Calcutta University	11th December 2012 – 12th February 2013

13	IODP-343	Dr. Santanu Bose	Calcutta University	1st April 2012 – 24th May 2012
12	IODP-342	Dr. Amit Kumar Ghosh	BSIP, Lucknow	2nd June 2012 – 1st August 2012
11	IODP-341	Dr. Shyam M Gupta	NIO, Goa	29th May 2013 – 29th July 2013
10	IODP-340	Mr. K.S.V. Subramanyam	NGRI, Hyderabad	2nd March 2012 – 17th April 2012
9	IODP-339	Prof. A D. Singh	BHU, Varanasi	16th November 2011 – 17th January 2012
8	IODP-338	Dr. Ravi Mishra,	NCAOR, Goa	1st October 2012 – 13th January 2013
7	IODP-335	Dr. Parijat Roy	NGRI, Hyderabad	13th April 2011 – 3rd June 2011
6	IODP-334	Dr. Yatheesh V	NIO, Goa	13th March 2011 – 13th April 2011
5	IODP-325	Dr. Manish Tiwari	NCAOR, Goa	2nd July 2010 – 16th July 2010
4	IODP-323	Dr. Maheswar Ojha	NGRI, Hyderabad	5th July 2009 – 4th September 2009
3	IODP-322	Dr. Pawan Govil	NCAOR, Goa	1st Sept 2009 – 10th October 2009
2	IODP-321	Dr. Pawan Devangan	NIO, Goa	5th May 2009 – 22nd Jun 2009
1	IODP-318	Mr. Prakash Srivastava	GSI, Faridabad	4th January 2010 – 8th March 2010

3. DEVELOPMENT OF INDIA'S SCIENCE PLAN AND DRILLING PROPOSAL FOR DEEP SEA DRILLING IN THE ARABIAN SEA:

Looking beyond the participation of Indian scientists in the IODP activities elsewhere in the world, there was an imperative need for IODP-India to develop a concrete Science Plan of its own, addressing the scientific issues pertaining to the seas around Indian Ocean which calls for deep-drilling. Taking cognizance of this need, the Ministry constituted an Expert Group to co-ordinate India's initiatives in this regard and to help develop a Science Plan for deep sea drilling in the Arabian Sea, Bay of Bengal and adjoining regions of Indian Ocean. Subsequently, a detailed Science Plan was developed by IODP-India highlighting prominent issues from the northern Indian Ocean requiring attention of the Ocean Drilling Program.

The Science plan includes following major themes:

1. Study of Crustal Evolution of:
    - *Western Continental margin*

- *Eastern Continental margin*
- *Andaman Sea*
- *Mid Ocean Ridges*

2. Gas Hydrates
3. Climate Change

In order to emphasize the need for a long term scientific ocean drilling program for the northern Indian Ocean sector, India presented white papers at various international forums highlighting the need for scientific drilling in the Indian Ocean to validate scientific hypotheses proposed over decades.

3.1. INDIAN PROPOSAL FOR DEEP SEA DRILLING IN THE ARABIAN SEA:

Following the meeting of National Expert Committee on IODP in 2010 and the discussion meeting held at AOGS 2010, Hyderabad, wherein a resolution to submit a scientific drilling proposal in the Arabian Sea was taken, a comprehensive proposal for the scientific drilling in the Arabian Sea was prepared involving proponents from various scientific and academic institutes in India and was submitted to the IODP on October 1, 2010.

The scientific proposal entitled "Deep sea drilling in the Arabian Sea: Discovering the tectono-climatic unknowns (IODP-793CPP)" was primarily aimed at recovering deep sea cores from different sites in the Arabian Sea to:

- Obtain high-resolution climate records from regions of high pelagic sedimentation in the Arabian Sea (vs. records of Himalayan erosion in the Indus Fan).
- Reconstruct the erosion response of the western Himalaya to proposed monsoon strengthening at 8 Ma.
- Recover Paleogene sediments from Arabian Sea to understand significant issues pertaining to the evolutionary history of this region such as offshore extension of Deccan Traps and the Mesozoic sediments beneath them and the nature of crust in the Laxmi basin area of the Arabian Sea.

After its submission, the proposal was reviewed independently by the IODP through their Science Evaluation Panel (SEP) and Environmental Protection and Safety Panel (EPSP). The proposal was well rated and subsequently recommended for drilling by JOIDES RESOLUTION FACILITY GOVERNING BOARD in 2011. Drilling was scheduled to be carried out in 2015. One of the key constraints of the proposal suggested by the SEP panel was to have a site survey data around the proposed drill sites. To facilitate this, IODP-India planned site surveys at its recommended drilling locations.

3.2. SURVEYS FOR INDIAN IODP DRILLING PROPOSALS

3.2.1. *Swath Bathymetry Multibeam Survey for IODP-India Proposed Drilling Sites (23rd Oct-20th Nov 2013)*

Swath Bathymetry Multibeam and site surveys of IODP-Indian proposed drilling sites had been carried out onboard ORV SagarKanya during the cruise SK-306 from 23rd October to 20th November 2013. A total of 7740 km data along the 27 track lines, covering an area of about ~54000 sq km were collected. Sound velocity and Conductivity, Temperature, Depth profiles were also obtained from 09 stations.

In general, the topography of the area was flat and many prominent features including the Raman Seamount and Laxmi ridge were fully covered for the first time under the swath bathymetric multibeam survey.

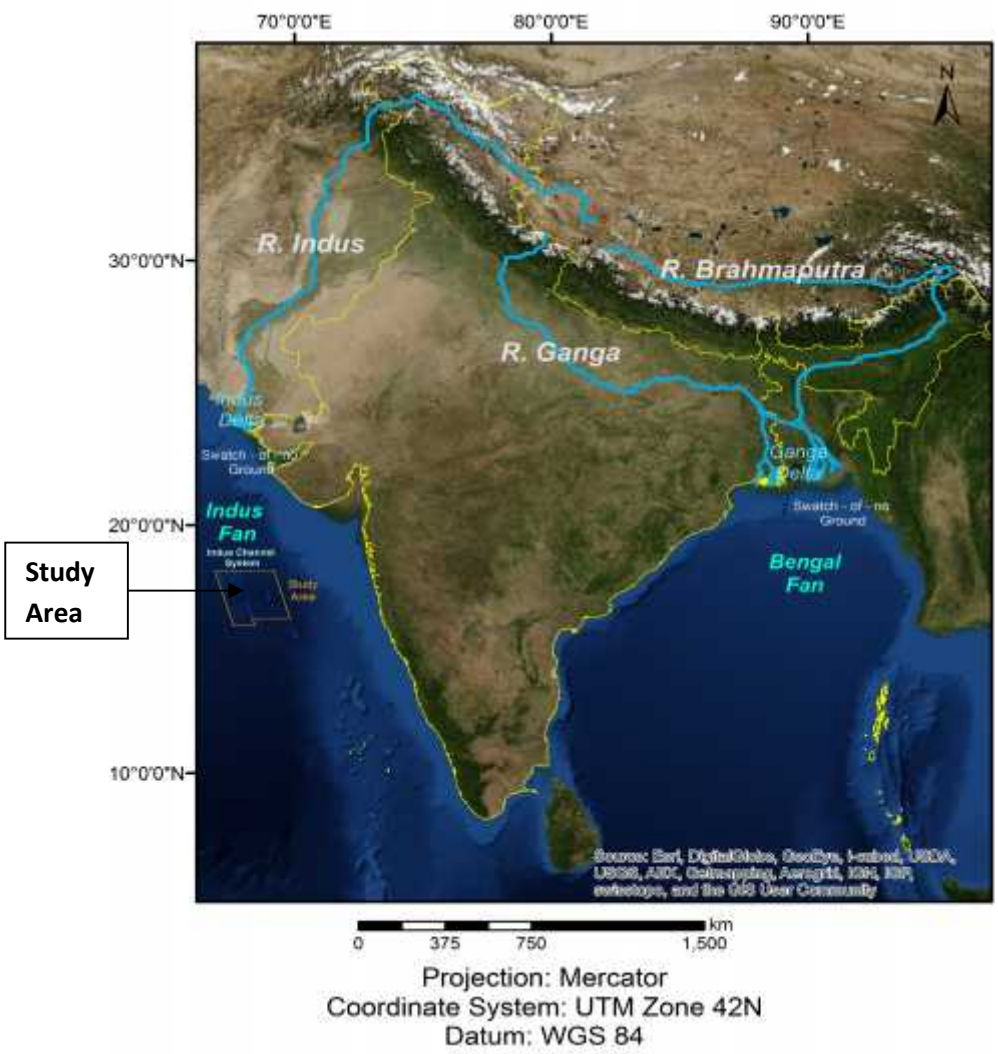


Fig: Location map of proposed drilling sites in the Arabian Sea

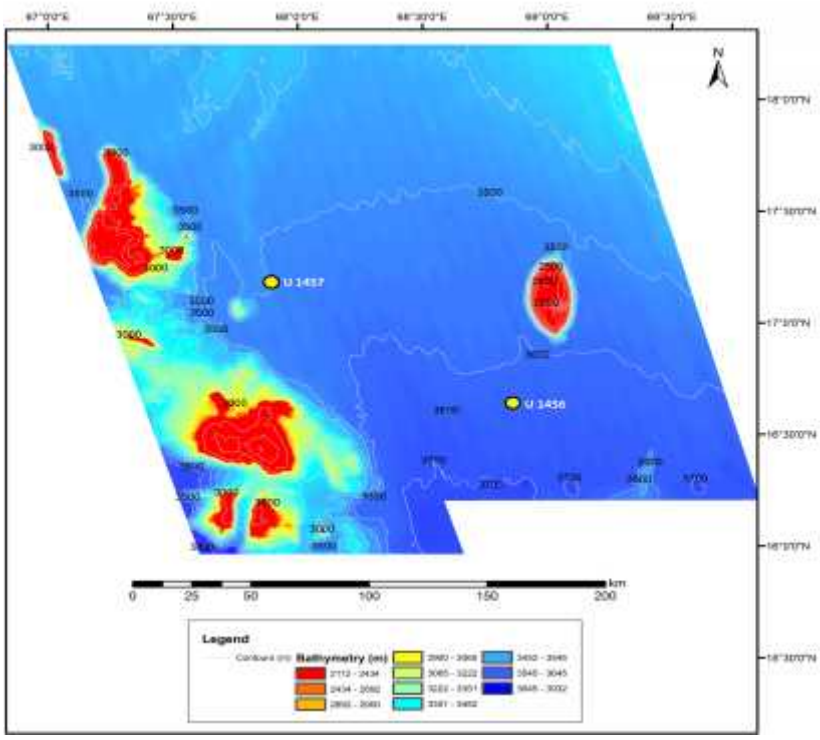


Fig: Bathymetry map of proposed drilling sites in the Arabian Sea

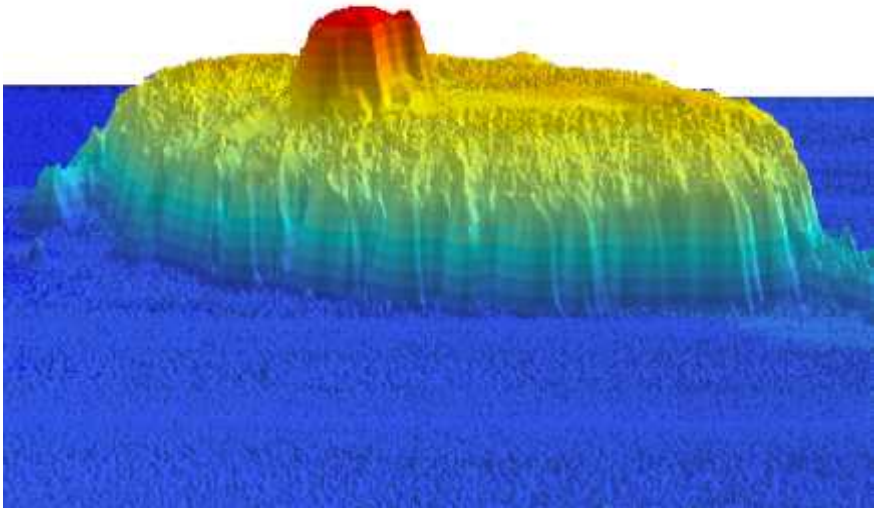


Fig: 3D view of Raman Seamount generated from bathymetry survey

3.2.2. *2 D Marine Seismic Data Acquisition in the IODP Drilling Block (23rd Sept-20th Oct 2014)*

2D multi-channel seismic survey was carried out in Arabian sea on-board chartered vessel Geo-Hindsagar. The main objectives of the survey were:

- Acquisition of deep penetration 2D multichannel seismic reflection data with precise positioning and echo sounding,
- Preliminary onboard data processing and post processing of data.

- Precise identification and depth determination of the sediment/basement interface as well as obtaining information on the type and nature of the crust(continental, oceanic or transitional) constituting the basement.

The multichannel seismic data was acquired onboard chartered vessel R/V Geo Hindsagar from 23rd Sept 2014 to 20th October 2014. The total of 1546 line km seismic data along 5 seismic lines was acquired from the proposed drilling site area.

Fig: Deployment of Gun array for Seismic

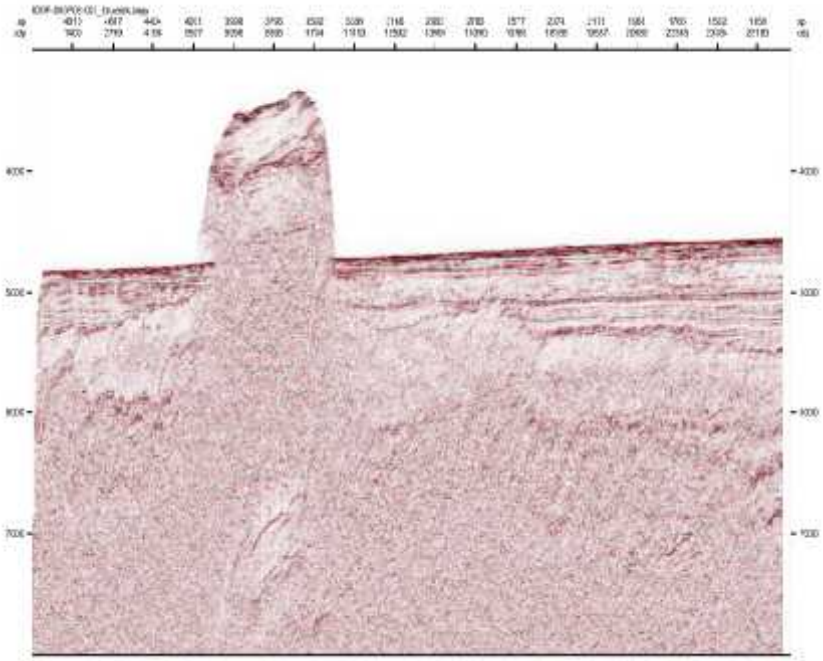


Fig: Brute stack plot of line IODP-04

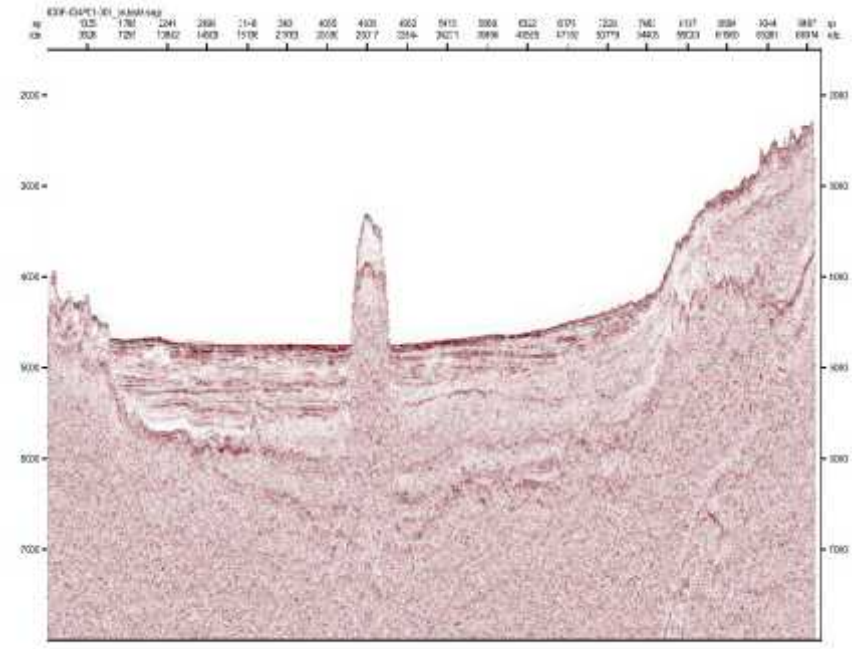


Fig: Brute stack plot of line IODP-03

4. INDIAN PREPARATION FOR PARTICIPATION IN IODP EXPEDITION 355

4.1. *IODP 355 Pre-Expedition Meet/Indian Participants Meet, Goa (14-15 Jan 2013)*

Indian IODP Participants meet was organised by IODP-India on 14-15 January 2013 at NCAOR, Goa to facilitate interaction among the Indian IODP participants. The meet was focussed on evolving future strategy to involve Indian participants in the IODP proposal on Arabian Sea submitted by India. About 30 delegates from various parts of the country attended the programme and presented the scientific work carried out by them based on their IODP expedition.

4.2. *Pre-cruise Workshop for Indian Scientist for Expedition 355*

In order to plan scientific participation from India in the IODP- Expedition 355 for scientific drilling in the Arabian Sea is in March-May 2015, a pre cruise workshop involving potential Indian participants was organized at NCAOR Goa. The objective was to discuss the scientific aspects of the expedition 355 at MoES New Delhi on 18th March 2014. The meeting was chaired by the Secretary, MoES, New Delhi. About 20 leading geo-scientists from various institutes such as NCAOR, PRL, BSIP, NGRI, NIO, Delhi University and Calcutta University participated in the meeting. Scientific and logistics requirements pertaining to the expedition was discussed and subsequently an open call for participation from Indian scientists and researchers in IODP expedition 355 was issued through national advertisement.

4.3. *2nd Pre-cruise meeting of Indian Scientist for Expedition 355*

Subsequent to the call for proposals from Indian scientists, the 2nd Pre cruise meeting to finalize the Indian participants for the IODP Expedition 355 was held at NCAOR on 16th June 2014. The meeting was chaired by the Secretary, MoES. The Indian team of 11 scientists was finalized after detailed deliberations made by all Indian proponents. One of the two Co-chiefs for the expedition was chosen from NCAOR, India. Besides Indian scientists, there were around 20 scientists from other member countries.

Photo: 2nd Pre Cruise Meeting

4.4. *Core Sample strategy/planning Meeting of Indian - IODP Participants*

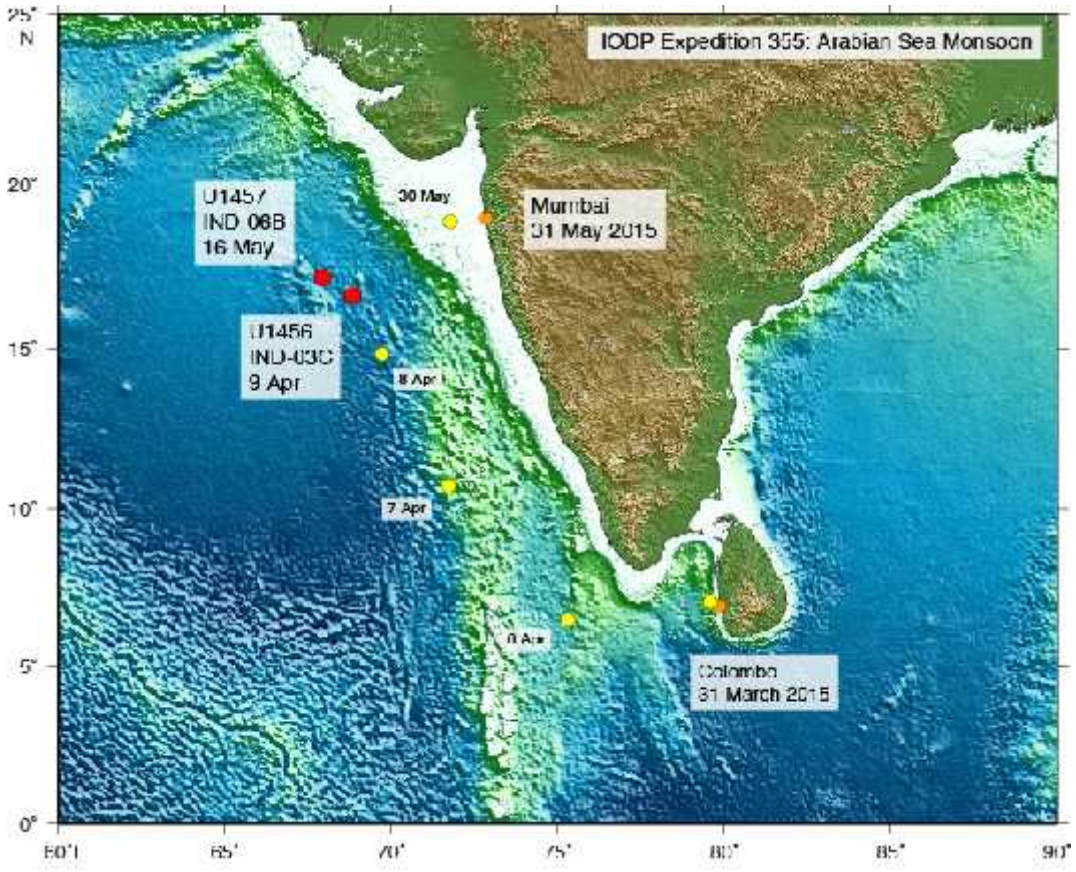
A meeting of Indian IODP 355 participants was organised at NCAOR, Goa on 7th November 2014. A total of 12 participants took part in the meeting to discuss the various aspects of sediment sampling. The post-cruise sampling approach was discussed and finalized and accordingly all members submitted their sampling request to IODP.

4.5. *Scientific drilling in Arabian sea (Arabian sea monsoon): IODP Expedition-355*

IODP Expedition-355 sailed out from Colombo to commence scientific drilling in the Arabian Sea during March 31 to May 31, 2015.

The Scientific Objectives of IODP Expedition-355 were:

- Testing whether Greater Himalayan exhumation correlates with the proposed monsoon intensification after 23 Ma.
- Determining if the monsoon strengthened or weakened at 8 Ma
- Dating the age of the base of the fan to constrain the timing of upliftment of Himalaya and Tibet plateau.
- To decipher the nature of basement rocks in the Laxmi Basin (Eastern Arabian Sea) for constraining early seafloor spreading and its relation to the emplacement of the Deccan Flood Basalts. This objective would have significant implications for precise paleogeographic reconstructions in the northwest Indian Ocean.



Location Map of IODP-355 Drilling Sites

A total of 30 scientists from various discipline participated in the expedition, including 11 scientists from India. During the expedition 355 two sites were drilled in the Laxmi Basin, Eastern Arabian Sea, Indian Ocean. Site U1456, lies within the Laxmi Basin and was cored until the Miocene. However, Site U1457 penetrated to igneous basement in the transition zone between the Laxmi Basin and the Laxmi Ridge. In total ~1700m of sediment and

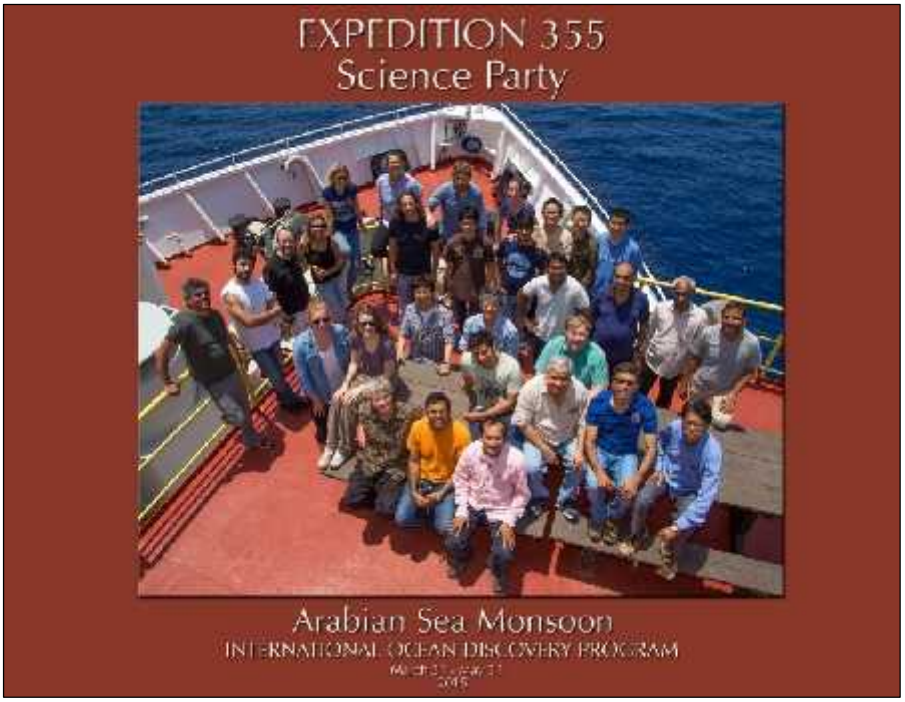
sedimentary rock, as well as 17m of igneous basement was recovered. All the recovered cores were analysed and described in details.

Based on the onboard analyses of selected samples during the course of expedition 355, major scientific findings were summarised and preliminary report of the IODP 355 was published in August 2015.

The sediment cores are expected to enable scientists to unravel long term history of Indian monsoon while the igneous basement retrieved from Laxmi Basin (for the first time) is expected to enable a better understanding of early opening of the Arabian Sea.

The science party reviewing the seismic data for Site 1457.

Scientists onboard after the recovery of Basement at Site 1457



POST CRUISE MEETINGS OF IODP EXPEDITION -355

4.6. *1st Post-cruise Sampling Party meeting of IODP Expedition 355*

The core samples collected during the IODP Expedition-355 were transferred to the IODP Core repository at College Station, Texas, USA for sub sampling. First post cruise meeting "sampling Party Meeting" was held at IODP, College Station, Texas from 24- 28, August 2015. Total of about 15 scientists, including three from India, participated in the sampling Party meeting. During the sampling party meeting more than 18000 sediment samples were sub-sampled.

Images from, 1st Post Cruise Sampling party meeting (Left), and 2nd Post-cruise Editorial party meeting (Right) of IODP Expedition-355

4.7. *2nd Post-cruise Editorial Party meeting of IODP Expedition 355*

2nd post cruise meeting of IODP Expedition -355 "Editorial Meeting" was held at IODP, College Station, Texas, USA from 16-20 Nov 2015 to finalise the proceedings of the IODP Expedition-355. Total of about 11 scientists, including three scientists from India, participated in the editorial meeting. Each scientist was allotted specific job to rectify the concern specific section of the proceeding as per their participation in the IODP Expedition-355. The proceedings of IODP Expedition-355 was finalised in the editorial meeting. The final proceedings of the IODP expedition 355 along with all the data generated has been made available online since August 29, 2016.

5. CONFERENCES/ MEETINGS

5.1. *Visit of high level delegation from Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan*

A high level scientific delegation from Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan led by Dr. Hitoshi Hotta, Executive Director visited NCAOR Goa on 16th January, 2014. The primary aim of this visit was to strengthen collaborative research programs of mutual scientific interests to both countries.

5.2. *Bilateral meeting between India and Japan for collaborative Geoscientific Research.*

A meeting on joint scientific investigations in the Indian Ocean between Indian Institutions and Japan Agency for Marine Science and Technology (JAMSTEC) Japan was held at JAMSTEC Headquarters in Tokyo, Japan on 6th July 2015. The meeting was jointly organised by Ministry of Earth Sciences (MoES) and JAMSTEC to deliberate upon key geoscientific issues on which bilateral understanding could be developed. This was a follow up program subsequent to the visit of Japanese delegation to India in previous year led by Dr. Hitoshi Hotta, Executive Director, JAMSTEC in January, 2014.

Dr. M. Ravichandran and Dr.Dhananjai Pandey participated in the meeting. Dr. Hitoshi Hotta, Executive Director, JAMSTEC and his team attended the meeting from JAMSTEC side. Technical deliberations were made about the scientific research carried out by participating members from both sides. The areas of cooperation included Oceanographic research and data sharing, Marine Biology in the Indian Ocean, Geoscientific Studies, Enhancement of earthquake and tsunami observation network and marine technology.

Dr. M. Ravichandran and Dr. Dhananjai Pandey at KOCHI core repository during JAMSTEC meeting, in 2015l.

5.3. *IGU meeting*

The 52nd Annual Convention of Indian Geophysical Union (IGU) was held at NCAOR during Nov 3-5, 2015. More than 300 scientists/delegates and young students from various parts of the country took part in three day long deliberations. The theme of this year's convention was NEAR SURFACE EARTH SYSTEM SCIENCES. The convention was inaugurated on 3rd Nov 2015 at NCAOR auditorium. Mr. A K Dwivedi, Director (exploration), ONGC limited was the chief guest during the inaugural function. Dr. Shailesh Nayak, former Secretary, MoES and President of IGU presided over the function and Dr. S W A Naqvi was the Guest of Honour. Dr. M Ravichandran, Director, NCAOR welcomed delegates at the opening ceremony. The convention concluded on 5th Nov 2015.

Inaugural function of 52nd Annual Convention of IGU on 3rd November 2015 at NCAOR, Goa

Participants, scientists from NCAOR and organizing commit members on the first day of 52nd Annual Convention of IGU, November 2015 at NCAOR, Goa

5.4. *IGU Student Session*

The Goa Chapter of IGU also organised a student talk competition at NCAOR, Goa. About 15 Ph.D. students from NCAOR took part in this competition and were felicitated by Dr. M Ravichandran, Chairman Local Organising Committee and Director, NCAOR.

Student participants in the Goa Chapter of IGU have been felicitated along with the awardees of IGU Convention in the Valedictory function of 52nd Annual IGU Convention on 5th Nov 2015 at NCAOR,

6. OTHER PARTICIPATIONS:

6.1. *Participation in Chikyu + 10 workshop: Tokyo, Japan April 20-23, 2013*

After the first phase of Integrated Ocean Drilling Program (2003-2013), new phase (2013-2023) of International Ocean Discovery Program (IODP), provide the scope to join two independent platforms namely D/v JOIDES RESOLUTION and D/v CHIKYU. In order to formulate new phase for the deep sea drilling vessel Chikyu, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) organised an international workshop at Tokyo, JAPAN during April 21-23, 2013. On behalf of IODP-India, Dr. D K Pandey, Program Officer (IODP-India) presented a white paper entitled "*Scientific drilling in the Indian Ocean to unravel complex geo-scientific issues*".

6.2. *Participation in National Gas Hydrate Program Expedition -02 (NGHP-02)*

National Gas Hydrate Program Expedition-02 was a scientific R&D drilling program in Krishana-Godavari and Mahanadi basin, along the eastern continental margin of India. It was carried out between 4th March 2015 and 31st July 2015, and used the Japanese vessel *Chikyu*. Its primary objective was to contribute new data towards occurrence of gas hydrate systems and to contribute towards general understanding of controls on the formation of gas hydrate accumulations in the offshore of India. The ultimate overall goal of the NGHP effort was to assess the energy resource potential of marine gas hydrates in India. It was designed as a 150 day duration scientific R&D drilling program and included the drilling of 20 logging-while-drilling (LWD) holes, 10 conventional continuous core holes, and 10 "tool holes" that featured the deployment of as many as 100 pressure core runs, wireline deployed down-hole logging operations (including vertical-seismic-profiling surveys), and 2 short duration formation pressure tests.

6.3. *Participation in IODP Science Evaluation Panel (SEP), Science Characterization Panel (SCP) and JOIDES Resolution Facility Board and IODP Forum meetings:*

The IODP Platform Providers have established Facility Boards to make or inform decisions on the effective use of the drilling facilities in fulfilling the objectives of the IODP Science Plan, including updates to the Expedition Schedule. Dr. B.K. Bansal, Adviser, Ministry of Earth Sciences India, is the Indian representative on the board and participates in the annual meetings of the JR Facility Governing board.

IODP Facility Boards make use of the JOIDES Resolution Facility's advisory panels - Science Evaluation Panel (SEP) and the Environmental Protection and Safety Panel (EPSP) - to evaluate the science, sites, environmental protection, and safety of proposed expeditions. The Science Evaluation Panel is composed of scientists and experts from IODP member countries. The mandate of SEP is to evaluate existing and new IODP drilling proposals after each submission deadlines and to submit its recommendations to the respective facility governing boards (FGB).

Prof. A.K.Singhvi (PRL, Ahmedabad) and Dr. D.K. Pandey (NCAOR, Goa) represent India in the meetings of the SEP panel.

7. POST EXPEDITION RESEARCH SUPPORT

Project Title: "*Paleoclimatic and magmato-metamorphic history of Wilkes Land, East Antarctica: constraints from accessory minerals in oceanic sediments"*

PI of the Project	**:** Dr. N C Pant
Organizations	**:** University of Delhi
Project Duration	**:** Three years
Date of Sanction	**:** 26 Nov 2012
Status	**:** Completed

Project Title: *"Millennial to centennial scale variability in the Asian summer monsoon: Foraminiferal perspective from the East China Sea"*

PI of the Project	**:** Dr R. K Singh
Organizations	**:** IIT, Bhubaneswar
Project Duration	**:** Three years
Date of Sanction	**:** 22 Dec 2014
Status	**:** Ongoing

Project Title: *"Mediterranean Outflow Water (MOW) paleoceanography and its impact on global climate during the last 3 MY"*

PI of the Project	**:** Dr. A. D Singh
Organizations	**:** BHU, Banaras
Project Duration	**:** Two (+1) years
Date of Sanction	: 14 Feb 2013
Status	**:** Ongoing

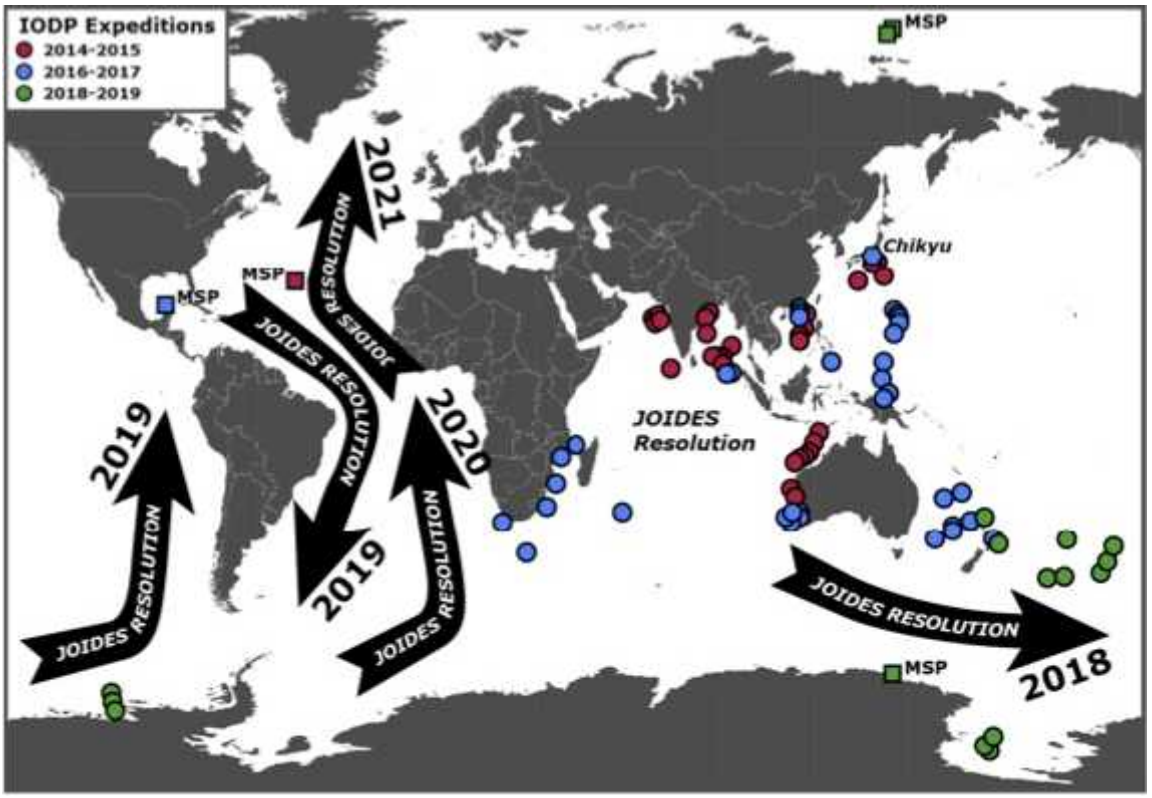
Project Title: *"Study of seismically induced slope failure of sediment and subsurface fluid flows in the Costa Rican seismogenic zone using long sediment cores drilled during IODP Expedition 334"*

PI of the Project	**:** Dr.Yatheesh Vadakkeyakath
Organizations	**:** NIO, Goa
Project Duration	**:** Two (+1) years
Date of Sanction	**:** 26 Nov 2012
Sanctioned Grant	**:** Completed

8. FUTURE COURSE OF IODP-INDIA

a. Scientific drilling in the Southern Ocean and on the Antarctic Shelf

In a recent decision taken by the JOIDES Resolution Facility Board, the long term track for the platform has been decided to be in Southern Ocean as well as on Antarctic Shelf. For IODP-India at NCAOR, by virtue of being leader of the Indian Antarctic program and Southern Ocean, this would be of extreme importance. Through the scientific ocean drilling in these areas, Indian scientists would be able to get hands on the sediment core samples that are vital for deciphering high resolution climatic variations especially in past several thousand years.



b. Scientific drilling in Andaman Subduction Zone:

Through this collaborative initiative, India also proposes to develop a scientific drilling proposal for understanding the generation and evolution of mega-fault systems in the Andaman Subduction zone which caused an unprecedented havoc in form massive damage to life and property due to strong tsunamigenic earthquake in Andamans in 2004.

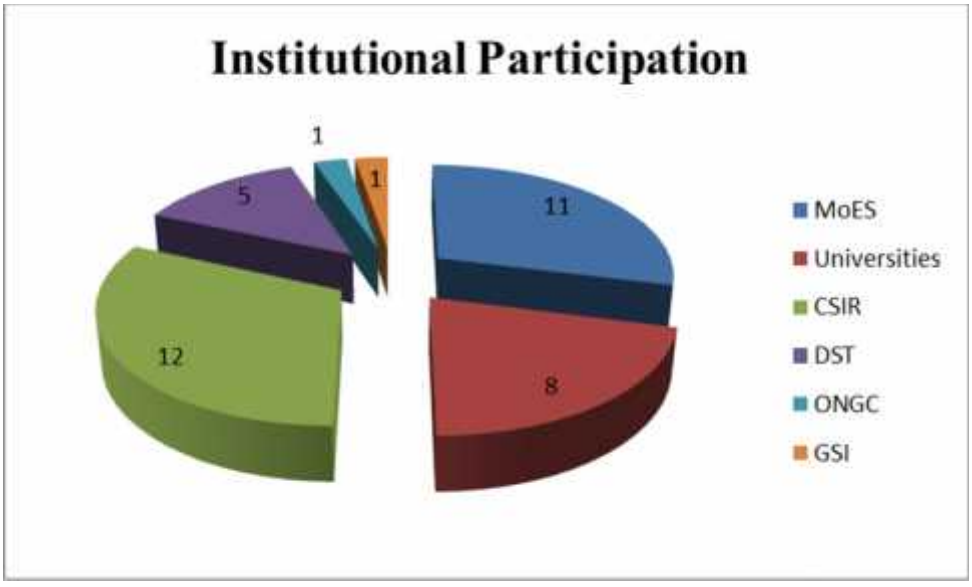
c. Indian Membership to the IODP

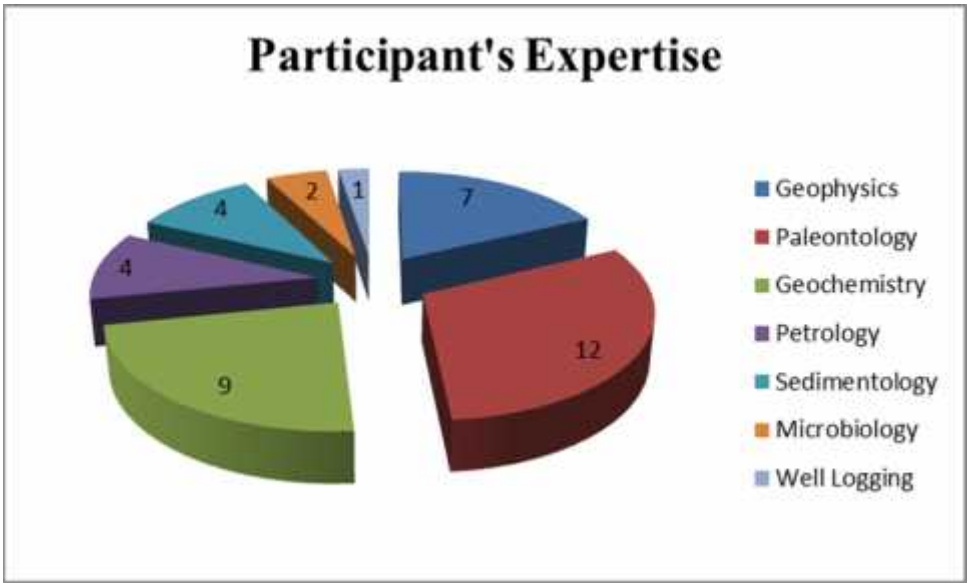
Considering the exclusive opportunities to Indian researchers to participate in IODP expeditions and get first-hand experience of deep ocean drilling and coring, it is proposed that such collaborations would continue in future to help nurture cutting edge geo-scientific research in the country.

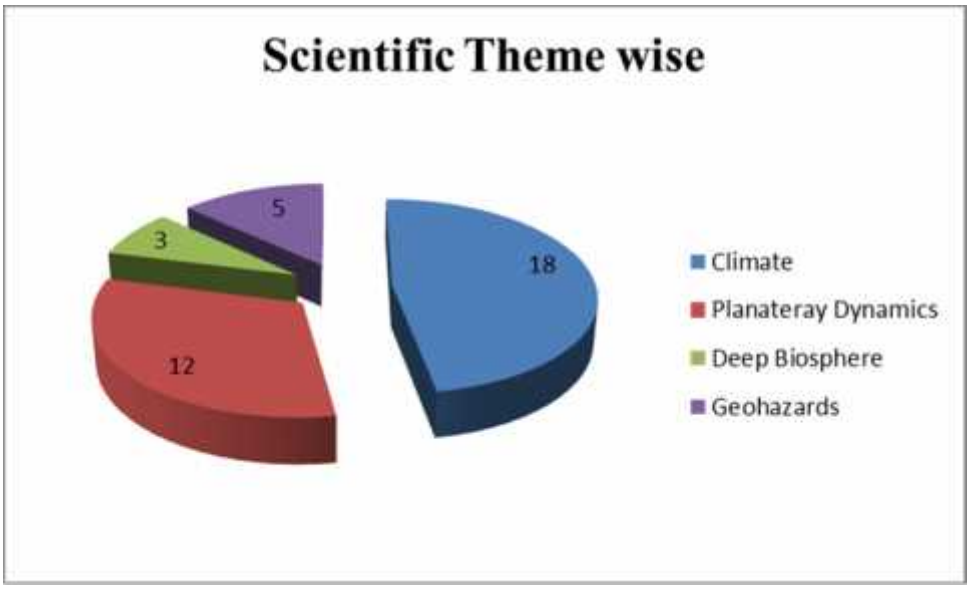
Upcoming IODP Expeditions with expected Indian Participation:

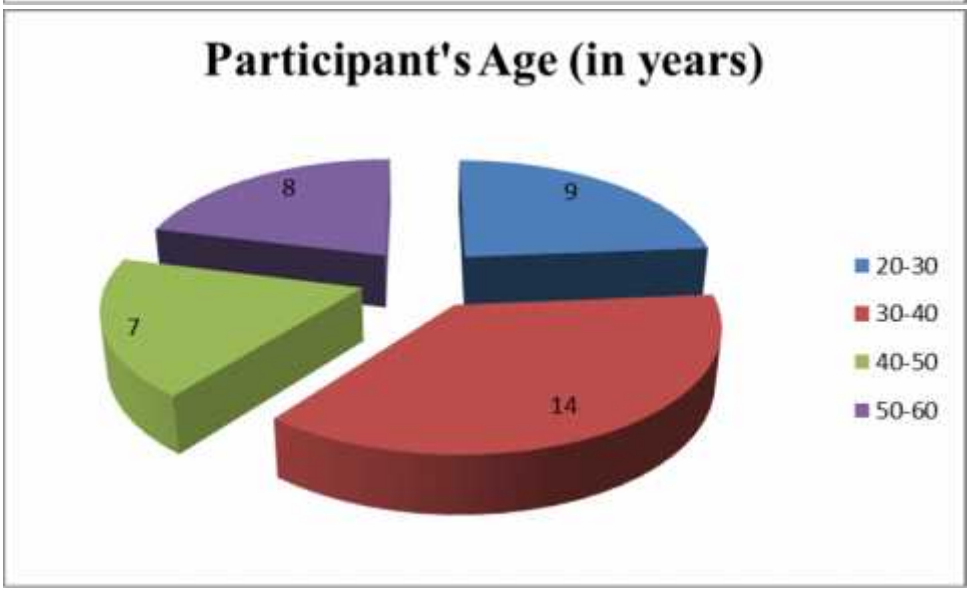
S.No.	Expedition Name	IODP Expedition #	Location/Ports	Date
1	South China Sea Rifted Margin A	IODP-367	Hong Kong / Hong Kong	Feb - April, 2017
2	South China Sea Rifted Margin A	IODP-368	Hong Kong / Shanghai	April - June, 2017
3	Tasman Frontier Subduction Initiation and Paleogene Climate	IODP-371	Townsville / Hobart	July 27-Sept 26, 2017
4	Australia Cretaceous Climate and Tectonics	IODP-369	Hobart / Fremantle	Sep 26-Nov 26, 2017
5	Creeping Gas Hydrate Slides and Hikurangi LWD	IODP-372	Fremantle / Wellington	Nov 26, 2017-Jan 4, 2018
6	Antarctic Cenozoic Paleoclimate	IODP-373	Hobart (provisional)	Dec 24, 2017-Feb 22, 2018
7	Ross Sea West Antarctic Ice Sheet History	IODP-374	Wellington / Wellington	Jan 4-Mar 8, 2018
8	Hikurangi Subduction Margin Observatory	IODP-375	Wellington / Auckland	Mar 8-May 5, 2018

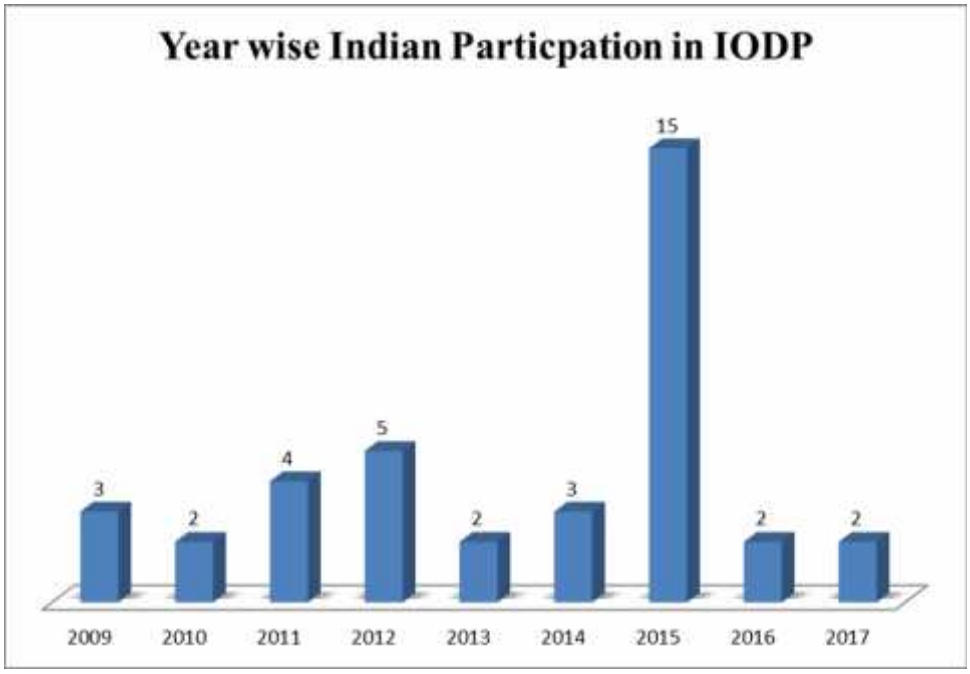
9. A STATISTICAL ANALYSIS OF IODP INDIA PARTICIPATIONS SINCE THE COMMENCEMENT (2009-2016):




Participant's Expertise
7
12
9
4
4
2
1
Geophysics
Paleontology
Geochemistry
Petrology
Sedimentology
Microbiology
Well Logging


Scientific Theme wise
18
12
3
5
Climate
Planateray Dynamics
Deep Biosphere
Geohazards


Participant's Age (in years)
9
14
7
8
20-30
30-40
40-50
50-60



10. SELECTED PEER REVIEWED PUBLICATIONS:

- Pandey, D.K. et al, 2016. Arabian Sea Monsoon. Proceedings of the International Ocean Discovery Program, 355: College Station, TX (International Ocean Discovery Program). http://dx.doi.org/10.14379/iodp.proc.355.2016

- Pandey, D.K. et al, 2015. Expedition 355 Preliminary Report: Arabialn Sea Monsoon. International Ocean Discovery Program. http://dx.doi.org/10.14379/iodp.pr.355.2015.

- Betzler Christian et al, (including Bejugam Nagender N.), 2016, The abrupt onset of the modern South Asian Monsoon winds. NATURE|SCIENTIFIC REPORTS|6:29838|doi: 10.1038/srep29838.

- Ravi Mishra, Dhananjai K Pandey, Ramesh, P. (2015). Active channel systems in the middle Indus fan: results from high-resolution bathymetry surveys, Current Science, Vol. 108 (3), 409-412.

- Prerna Ramesh, D K Pandey and Ravi Mishra (2015). Approximation of Flow Patterns for Submarine Channel Systems in the Arabian Sea using a GIS Approach. International Journal of Advanced Remote Sensing and GIS 2015, Volume 4, Issue 1, pp. 1142-1160.

- Ravi Mishra, D. K. Pandey, Prerna Ramesh, Peter D. Clift (2016). Identification of new deep sea sinuous channels in the eastern Arabian Sea. SpringerPlus, 5(1), 1-18. DOI 10.1186/s40064-016-2497-6.

- Bose Santanu, Saha Puspendu, Mori James J., Rowe Christie, Ujiie Kohtaro, Chester Frederick M., Conin Marianne, Regalla Christine, Kameda Jun, Toy Virginia, Kirkpatrick James, Remitti Francesca, Moore J. Casey, Wolfson-Schwehr Monica, Nakamura Yasuyuki,

Gupta Anchit, 2015, Deformation structures in the frontal prism near the Japan Trench: Insights from sandbox models, Journal of Geodynamics, 89: 29-38.

- Singh A.D., Verma K., Jaisawal S., Alonso-Garcia M., Li B. and Abrantes F., 2015. Planktic foraminiferal responses to orbital scale oceanographic changes off the western Iberian margin since the MPR: Results from the IODP site U1391. Global and Planetary Change, Elsevier, 135, 47-56.

- Singh A.D., Rai A.K., Tiwari M., Naidu P.D., Verma K., Chaturvedi M., Niyogi A. and Pandey D., 2015. Fluctuations of the Mediterranean Outflow Water circulation in the Gulf of Cadiz during the MIS 5 to 7: Evidences from benthic foraminiferal assemblage and stable isotope records. Global and Planetary Change, Elsevier, 133, 125-140. doi: 10.1016/j.gloplacha.2015.08.005.

- Ojha Maheshwar, Maiti Saumen (2013): Sediment classification using neural networks: An example from the site-U1344A of IODP Expedition 323 in the Bering Sea; IODP Expedition 323, http://dx.doi.org/10.1016/j.dsr2.2013.03.024; M. Ojha, S. Maiti / Deep-Sea Research II 125-126 (2016) 202 213; Science Direct journal homepage: www.elsevier.com/locate/dsr2 Deep-Sea Research II.

- Pant N.C., P. Biswas, Shrivastava Prakash K., Bhattachaya S. and Verma Kamlesh, Pandey Mayuri and IODP Expedition 318 Scientific Party, 2013, Provenance of Pleistocene sediments from Site U1359 of the Wilkes Land IODP Expedition- evidence for multiple sourcing from east Antarctic craton and Ross orogen, Accepted for publication in Special Publication on Antarctic Paleoclimate Evolution and Earth Surface Processes, Geological Society of London.381, dx.doi.org/10.1144/SP381.11.IF- 2.304.

- Pälike et al (including Dewangan Pawan) (2012): A Cenozoic record of the equatorial Pacific carbonate; IODP Expedition 321 (ARTICLE doi:10.1038/nature11360) 30 AUGUST 2012 | VOL 488 | NATURE | 609.

- Verma, Kamlesh, Bhattacharya, Sanjeeb, Biswas, P., Shrivastava, Prakash., Pandey, Mayuri, Pant, N. and IODP Expedition 318 scientific party, 2014, Clay mineralogy and carbon content record of the ocean sediments from the Wilkes Land margin, East Antarctica: implications on the palaeoclimate, provenance and sediment dispersal pattern, International Journal of Earth Sciences . Nov2014, Vol. 103 Issue 8, p2315-2326.

- Felis T. et al (including Tiwari M.), 2014, Intensification of the Meridional Temperature Gradient in the Great Barrier Reef Following the Last Glacial Maximum. Nature Communications, 5, 4102, doi: 10.1038/ncomms5102.

- Vannucchi P., Sak P. B., Morgan J.P., Ohkushi K., Ujiie K., and IODP Expedition 334 Scientists (including V. Yatheesh), 2013. Rapid pulses of uplift, subsidence, and subduction erosion offshore Central America: Implications for building the rock record ofconvergent margins. Geology 41(9), 995-998.

- Gillis, K.M. et al (including Saha A.), 2013, Primitive Layered Gabbros from Fast-Spreading Lower Oceanic Crust. Nature v.505 (7482), pp.204-207.

-

Contact us:

National Centre for Antarctic and Ocean Research
Ministry of Earth Sciences, Government of India

Headland Sada, Vasco-da-Gama, Goa 403 804, India
Tel: +91-832-2525569 / 2525580

Email: iodp.india@ncaor.gov.in

Compiled by:

Ayush Verma, Tejaswini Pakhidde and Dhananjai K Pandey, IODP-India, NCAOR, Goa. September 2016