Università di Trieste

Corso di Laurea in Geologia

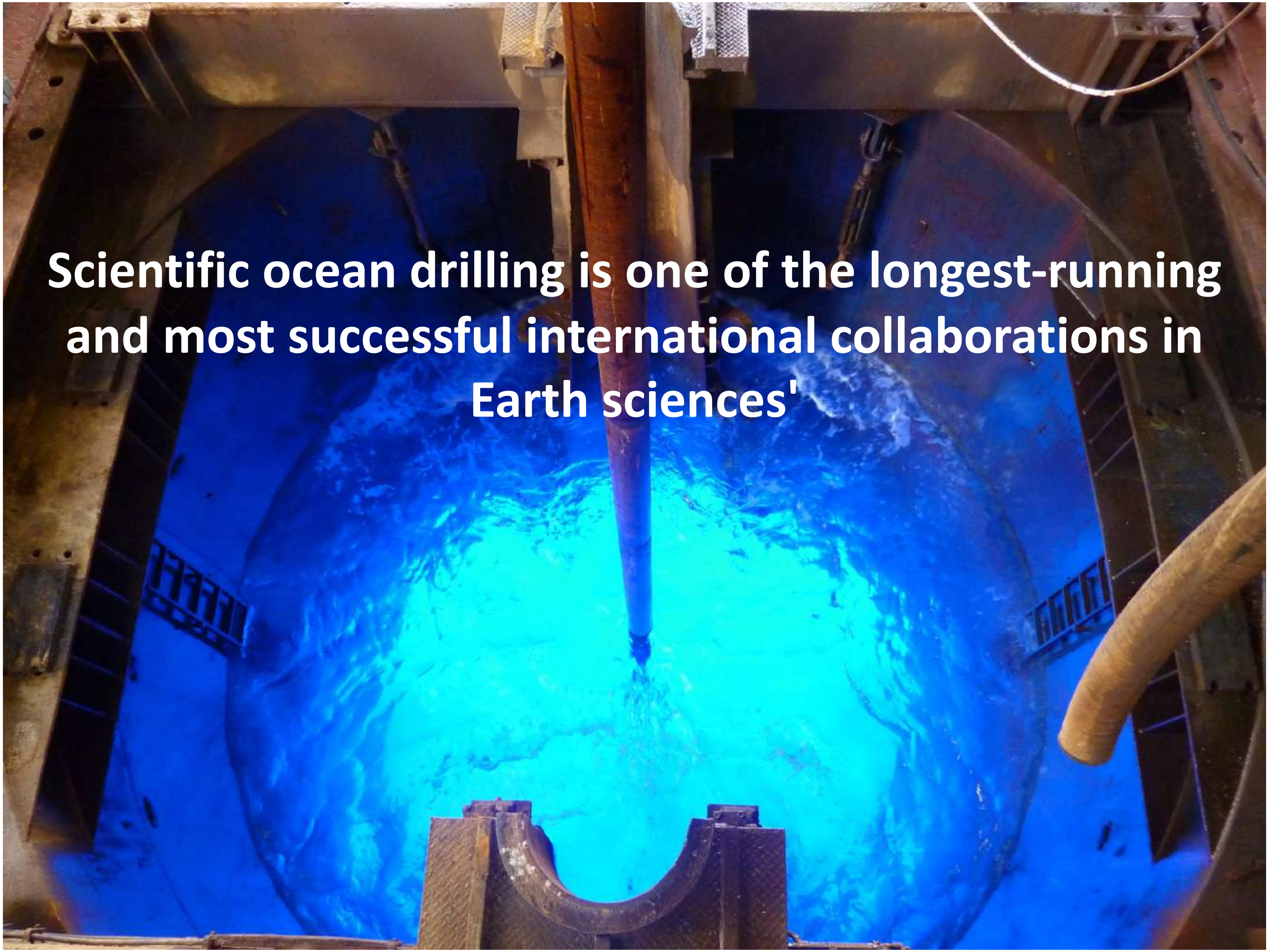
Anno accademico 2020 - 2021

Geologia Marina

Parte II

Modulo 2.4 Perforazione dei fondali oceanici

Docente
Angelo Camerlenghi


Scientific ocean drilling is one of the longest-running and most successful international collaborations in Earth sciences'

The International Ocean Discovery Program (IODP)

Exploring the Earth Under the Sea

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 subseafloor environments

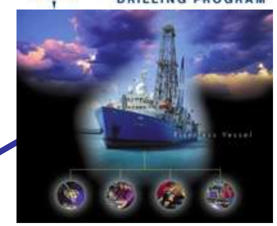
http://www.iodp.org

End in October 2023

October 2013

International Ocean Discovery Program (IODP)

IODP INTEGRATED OCEAN DRILLING PROGRAM



Integrated Ocean Drilling Program (IODP) 2003- 2013

Ocean Drilling Program (ODP) 1985-2003

Deep Sea Drilling Project (DSDP) 1968-1983

MOHOLE 1958-1966

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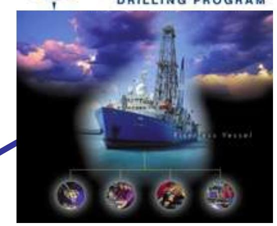


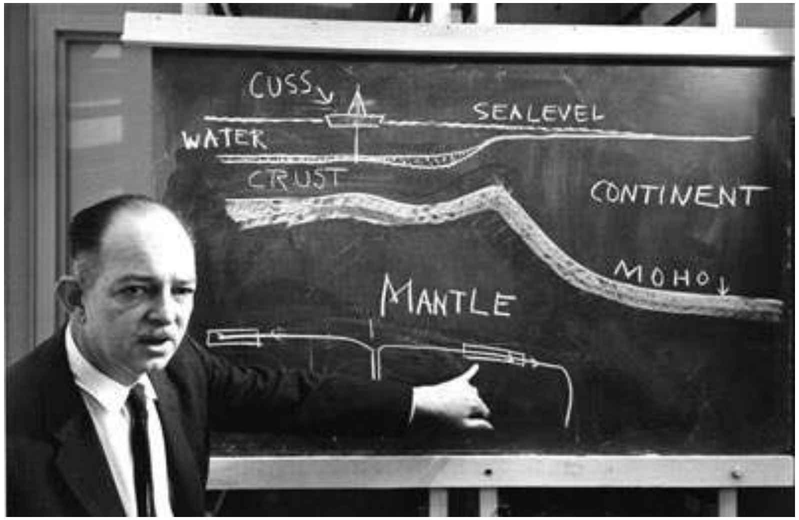
Integrated Ocean Drilling Program (IODP) 2003- 2013

Ocean Drilling Program (ODP) 1985-2003

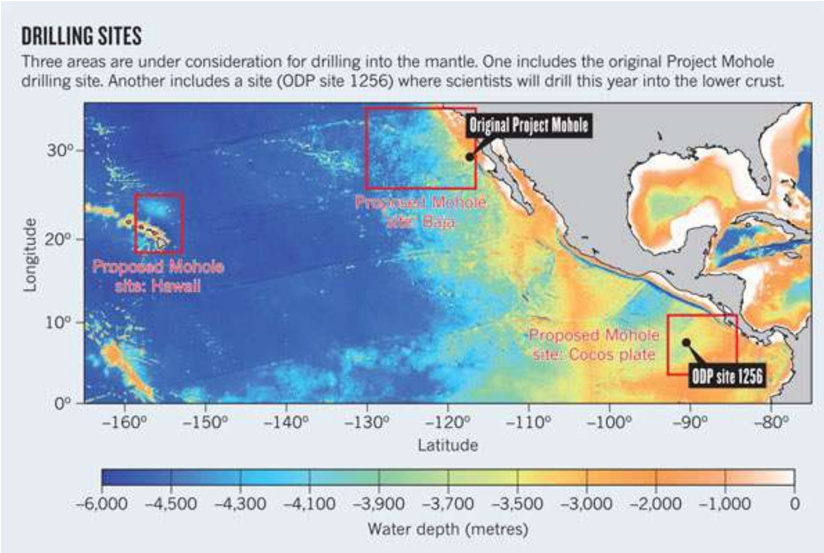
Deep Sea Drilling Project (DSDP) 1968-1983

MOHOLE 1958-1966

In 1961 scientific drilling took root as a feasible technology to study Earth's subseafloor geology. **Project Mohole,** a concept developed by the American Miscellaneous Society with funding from the National Science Foundation, considered the feasibility of **drilling through the Mohorovičić seismic discontinuity**



Harry Hess, a founding father of the theory of plate tectonics, explains Project Mohole
Damon Teagle and Benoît Ildefonse, Nature, 2011.



Drill ship CUSS 1

Five holes were drilled off the coast of **Guadalupe Island, Mexico**, the deepest to 601 ft (183 m) below the sea floor in 11,700 ft (3,600 m) of water. This was unprecedented: not in the hole's depth but because of the depth of the ocean and because it was drilled from an untethered platform. Also, the core sample proved to be valuable; penetrating through Miocene-age sediments for the first time to reveal the lowest 13 m (44 ft) consisting of basalt.

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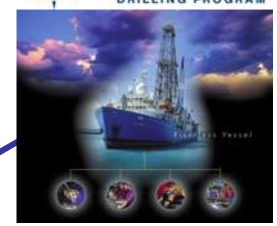
MOHOLE
1958-1966

Deep Sea Drilling Project (DSDP)
1968-1983

Ocean Drilling Program (ODP)
1985-2003

IODP INTEGRATED OCEAN DRILLING PROGRAM



Integrated Ocean Drilling Program (IODP)
2003- 2013

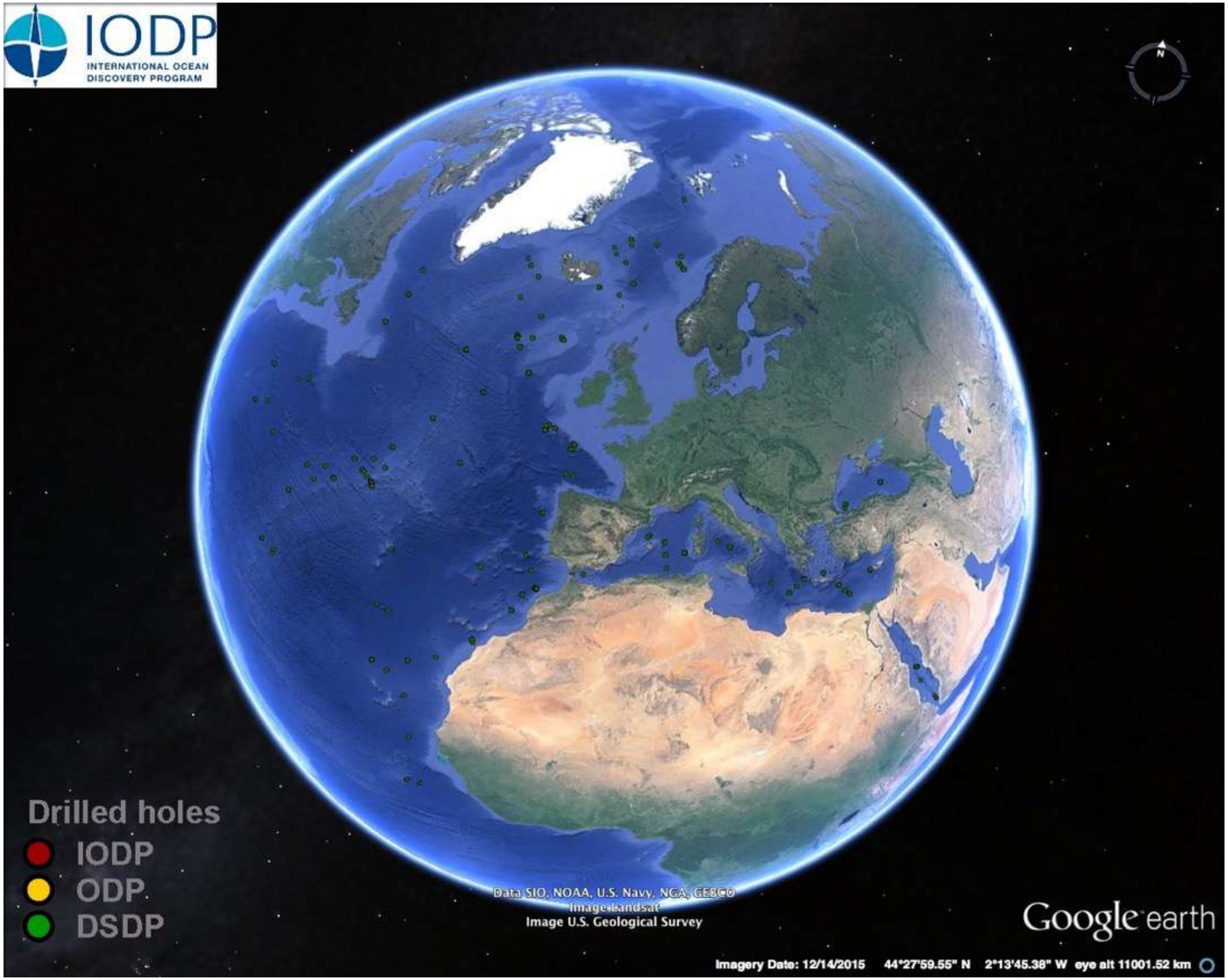
October 2013

International Ocean Discovery Program (IODP)

End in October 2023

The next phase of scientific ocean drilling, the **Deep Sea Drilling Project (DSDP),** began in 1966 using the Drilling Vessel *Glomar Challenger*. This pioneer vessel for DSDP conducted drilling and coring operations in the Atlantic, Pacific and Indian oceans as well as the Mediterranean and Red Seas. The *Glomar Challenger* also advanced the technology of deep-ocean drilling.

DSDP drillsites in the Mediterranean and North Atlantic



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End in October 2023

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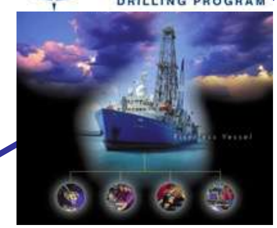
International Ocean Discovery Program (IODP)

IODP
INTEGRATED OCEAN DRILLING PROGRAM



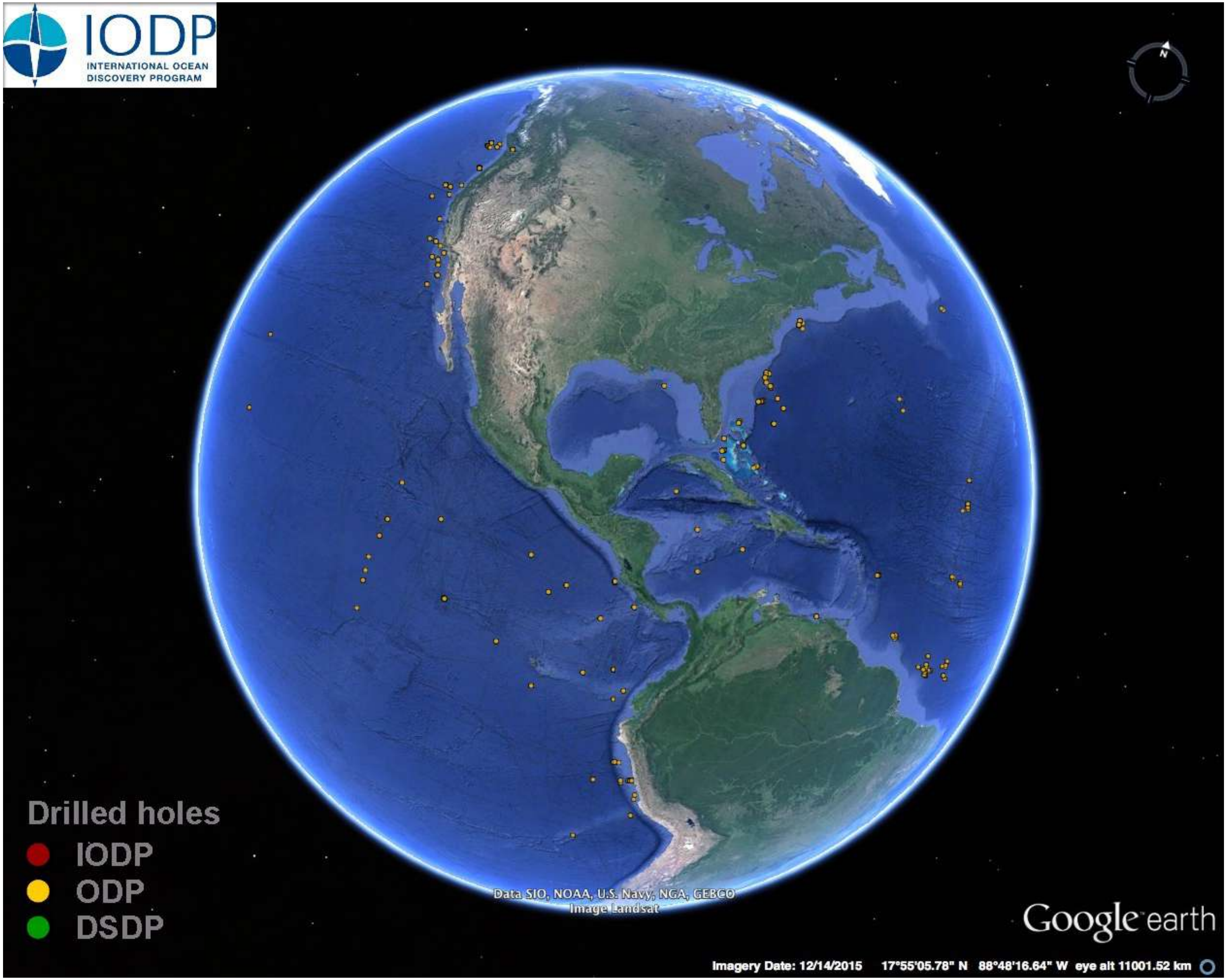
Integrated Ocean Drilling Program (IODP) 2003- 2013

Ocean Drilling Program (ODP) 1985-2003

Deep Sea Drilling Project (DSDP) 1968-1983

MOHOLE 1958-1966

In 1985, *JOIDES Resolution* replaced the *Glomar Challenger* at the start of a new program, the **Ocean Drilling Program (ODP)**. ODP was truly an international cooperative effort to explore and study the composition and structure of the Earth's subseafloors. The *JOIDES Resolution* conducted 110 expeditions for ODP at 2000 drill holes located throughout the world's ocean basins.


IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM
Drilled holes
IODP
ODP
DSDP
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Google earth
Imagery Date: 12/14/2015 17°55'05.78" N 88°48'16.64" W eye alt 11001.52 km

The International Ocean Discovery Program (IODP)

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International Ocean Discovery Program (IODP)

IODP INTEGRATED OCEAN DRILLING PROGRAM

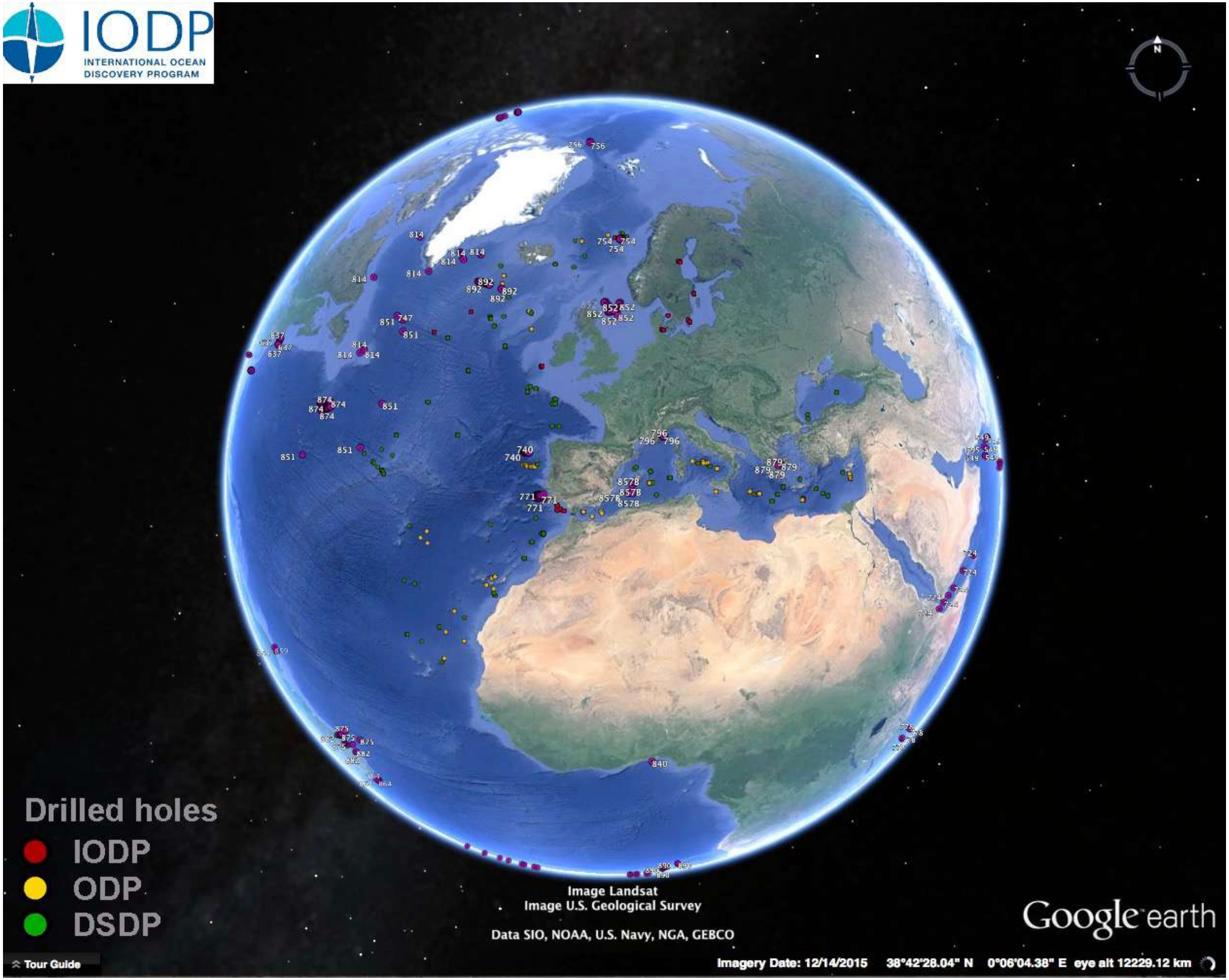
Integrated Ocean Drilling Program (IODP) 2003- 2013

Ocean Drilling Program (ODP) 1985-2003

Deep Sea Drilling Project (DSDP) 1968-1983

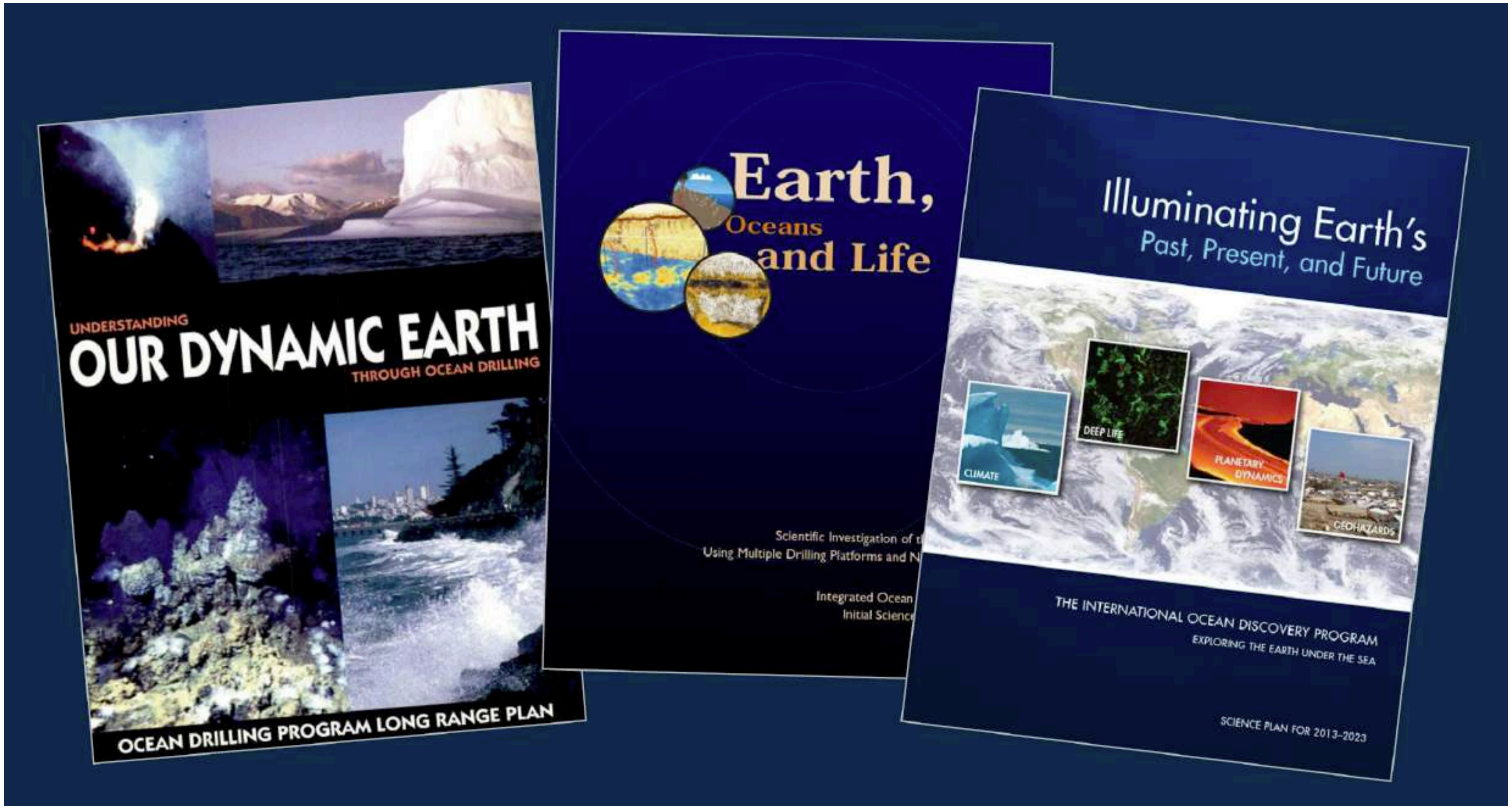
MOHOLE 1958-1966

The **Integrated Ocean Drilling Program (IODP 2003-2013)** built upon the international partnerships and scientific success of the DSDP and ODP by employing multiple drilling platforms financed by the contributions from 26 participating nations. These platforms - a refurbished *JOIDES Resolution*, the new marine-riser equipped Japanese Deep Sea Drilling Vessl *Chikyu,* and specialized Mission-Specific-Platforms - were used to reach new areas of the global subsurface during 52 expeditions.

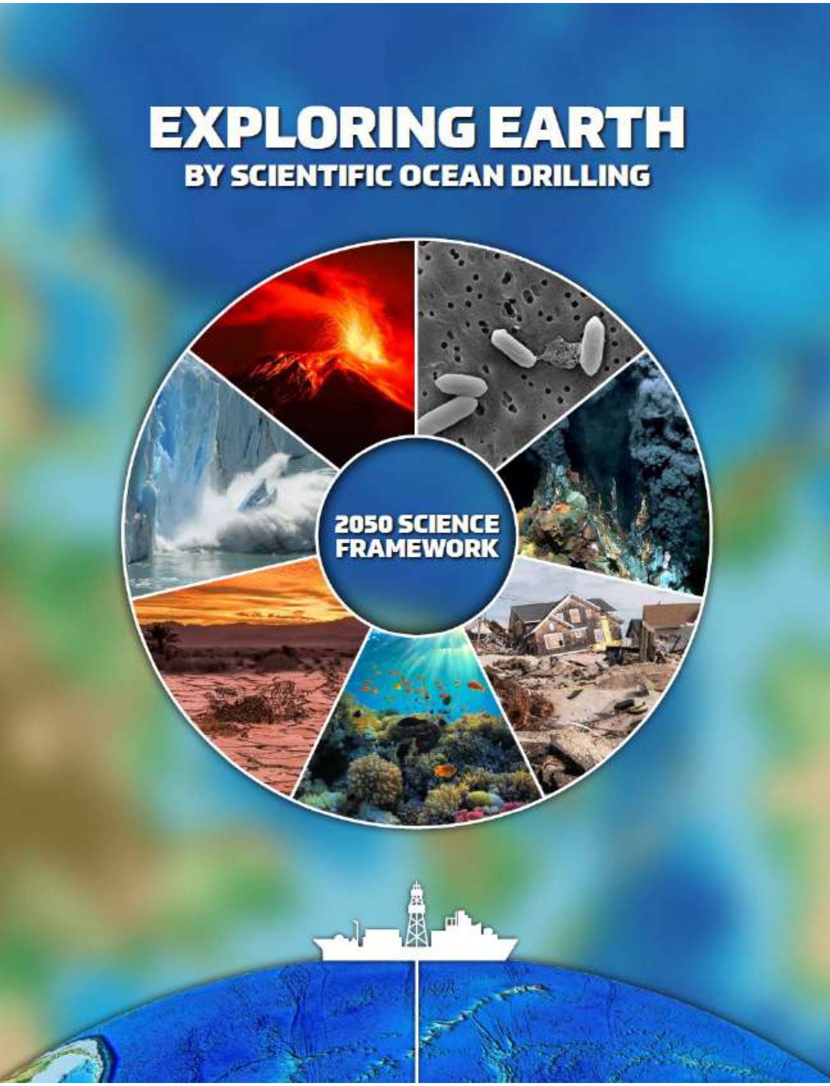

IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM
Drilled holes
IODP
ODP
DSDP
Image Landsat
Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
Tour Guide
Imagery Date: 12/14/2015 38°42'28.04" N 0°06'04.38" E eye alt 12229.12 km

Fundamental principles of IODP

- **science driven project**
- **science plan**
  - **Climate and Ocean Change**: Reading the Past, Informing the Future
  - **Biosphere Frontiers**: Deep Life, Biodiversity, and Environmental Forcing of Ecosystems
  - **Earth Connections**: Deep Processes and Their Impact on Earth's Surface Environment
  - **Earth in Motion**: Processes and Hazards on Human Time Scales
  - Education AND OUTREACH
- **multiple platform approach to drilling**


UNDERSTANDING
OUR DYNAMIC EARTH
THROUGH OCEAN DRILLING
OCEAN DRILLING PROGRAM LONG RANGE PLAN
Earth,
Oceans
and Life
Integrated Ocean
Initial Science
Illuminating Earth's
Past, Present, and Future
CLIMATE
DEEP LIFE
PLANETARY DYNAMICS
GEOHAZARDS
THE INTERNATIONAL OCEAN DISCOVERY PROGRAM
EXPLORING THE EARTH UNDER THE SEA
SCIENCE PLAN FOR 2013–2023

2020 – 2050



Mission

The *2050 Science Framework for Scientific Ocean Drilling* guides multidisciplinary subseafloor research into the interconnected processes that characterize the complex Earth system and shape our planet's future.

Vision

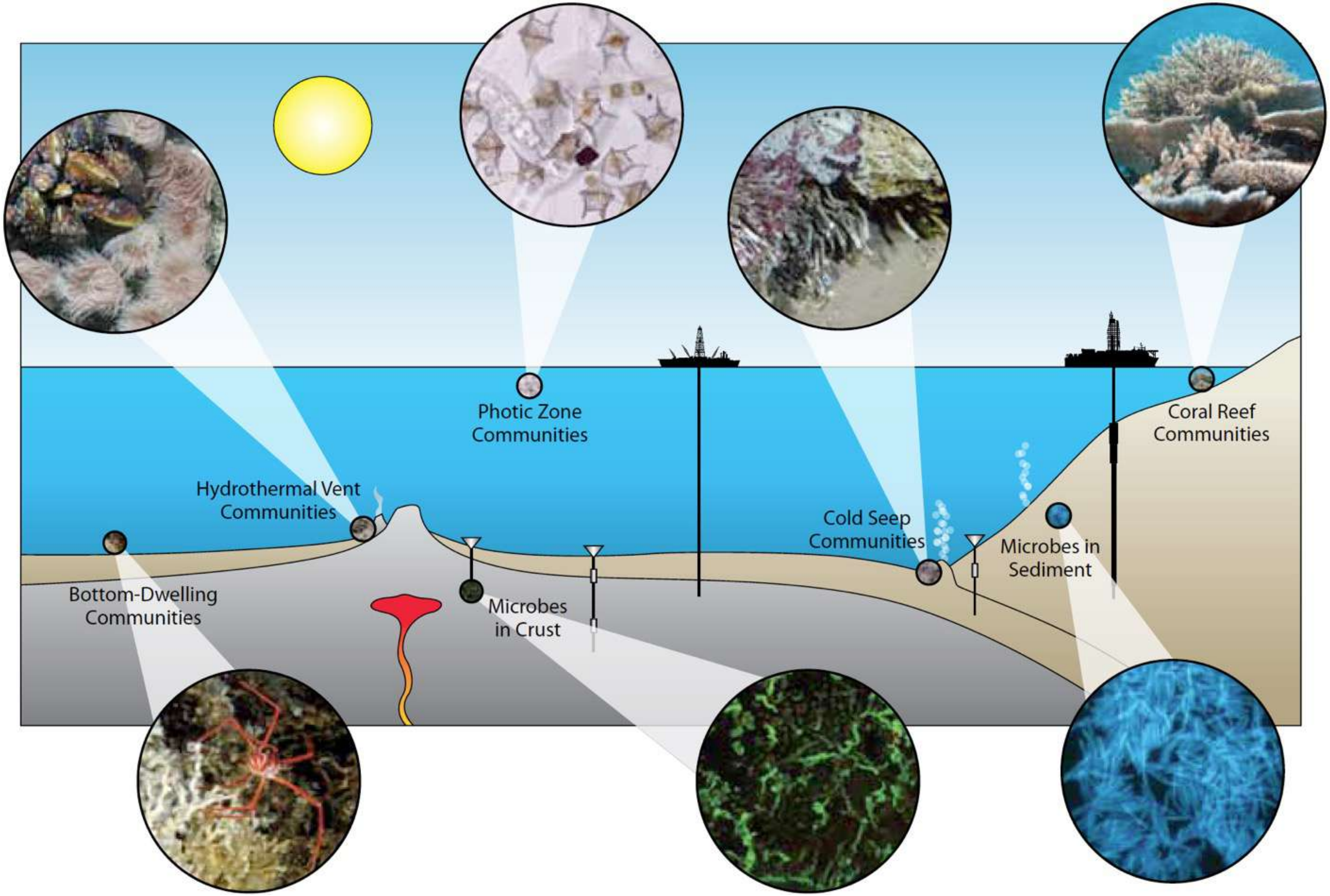
To be globally recognized as the authoritative source of information about ocean and Earth system history and its links to society.

Anthony Koppers — Co-lead Editor, Chair Science Framework Working Group
Rosalind Coggon — Co-lead Editor

and the Science Framework Authors and Reviewers

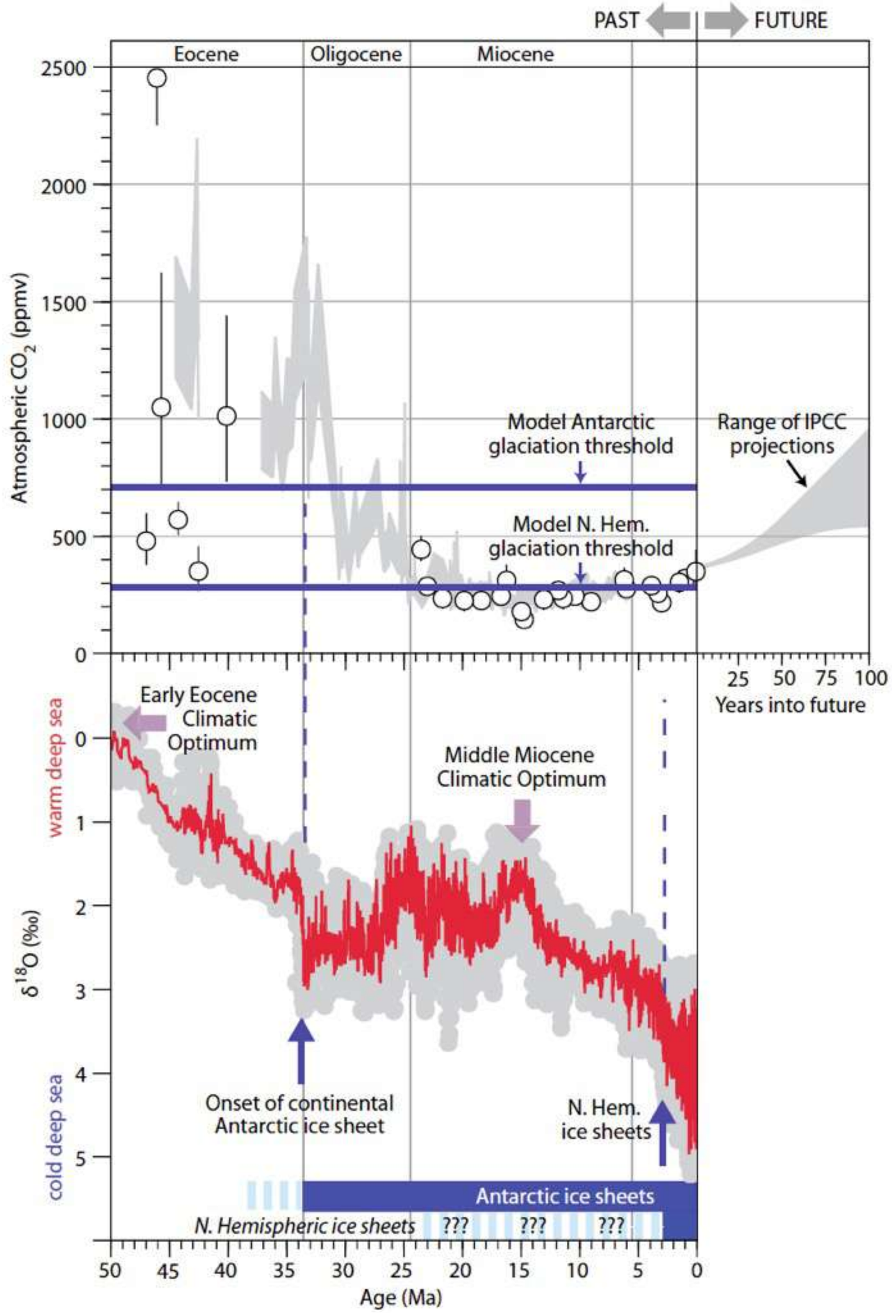
representing the international scientific ocean drilling community

https://www.iodp.org/2050-science-framework

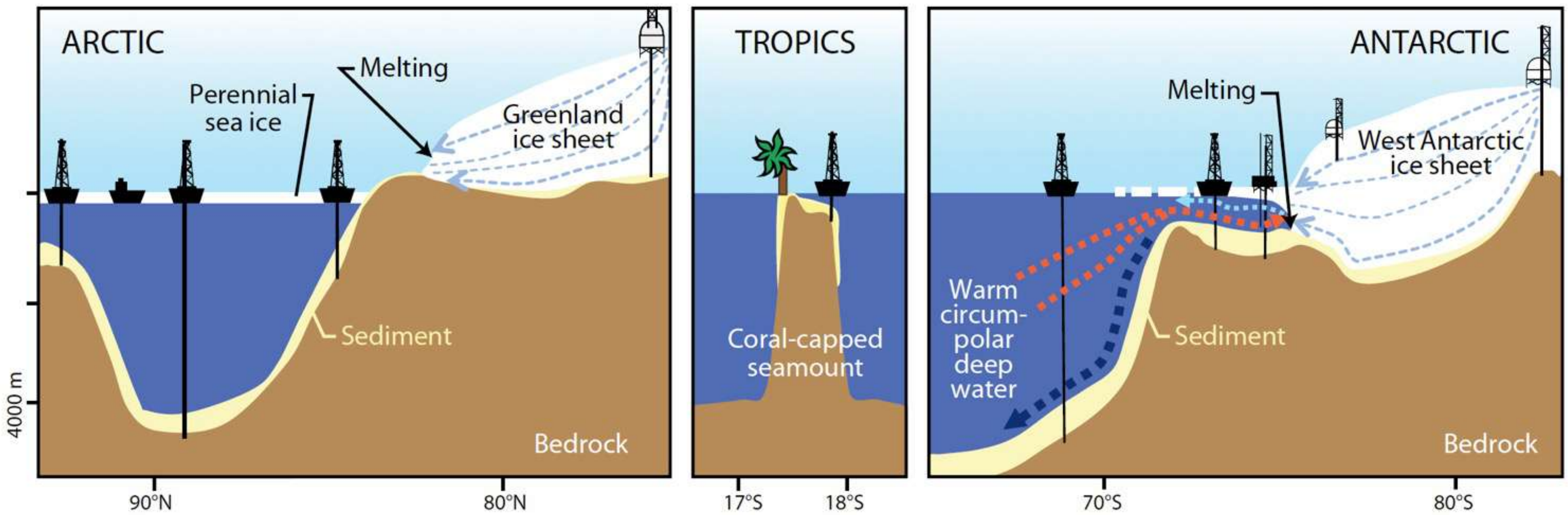


New Science Plan and as follows:
Bottom Dwelling: Ross (2007; Figure 3), Hydrothermal Vents: Devey at al. (2007, Figure 2), Microbes in Crust: Orcutt et al. (2010), Photic Zone: M. Montresor, SZN/Alfred Wegener Institute, Cold Seep Communities: Vanreusel et al. (2009, Figure 6A), Microbes in Sediment: Figure 3. 2B, Coral Reef: Coral Disease Working Group (2007; Figure 2)

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

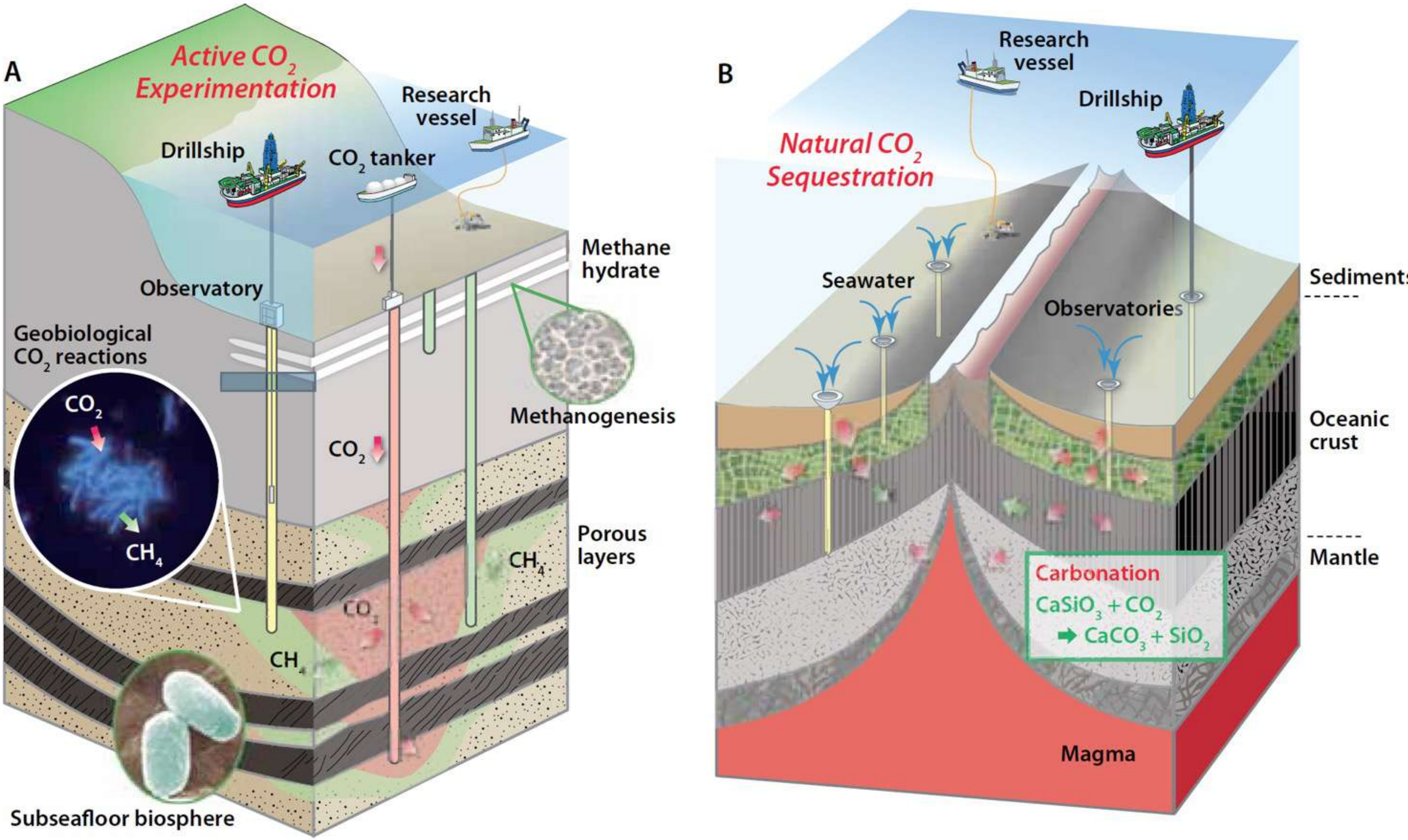


Climate and Ocean Change: Reading the Past, Informing the Future



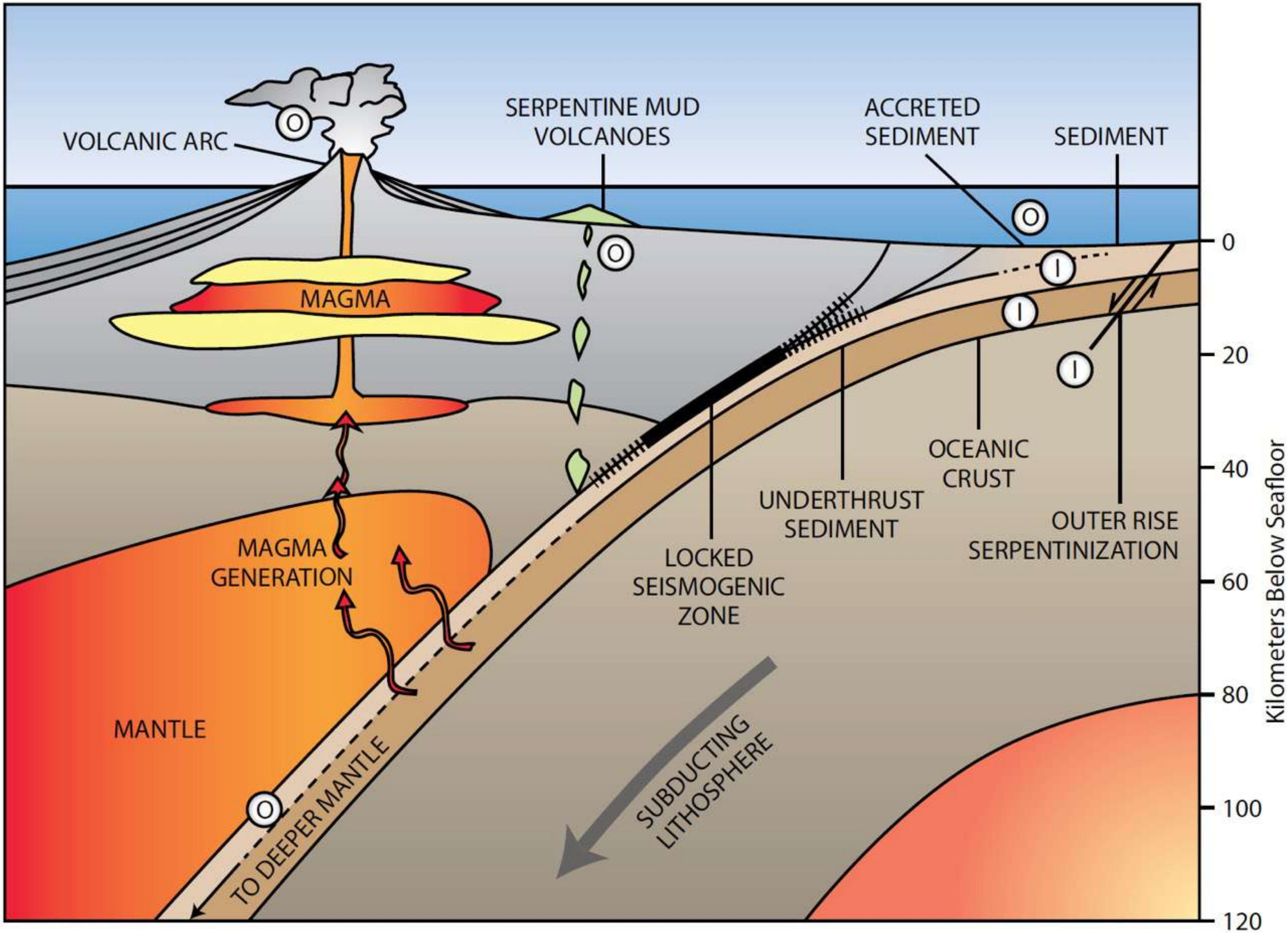
Elements of this figure were adapted from Schoof (2010)

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

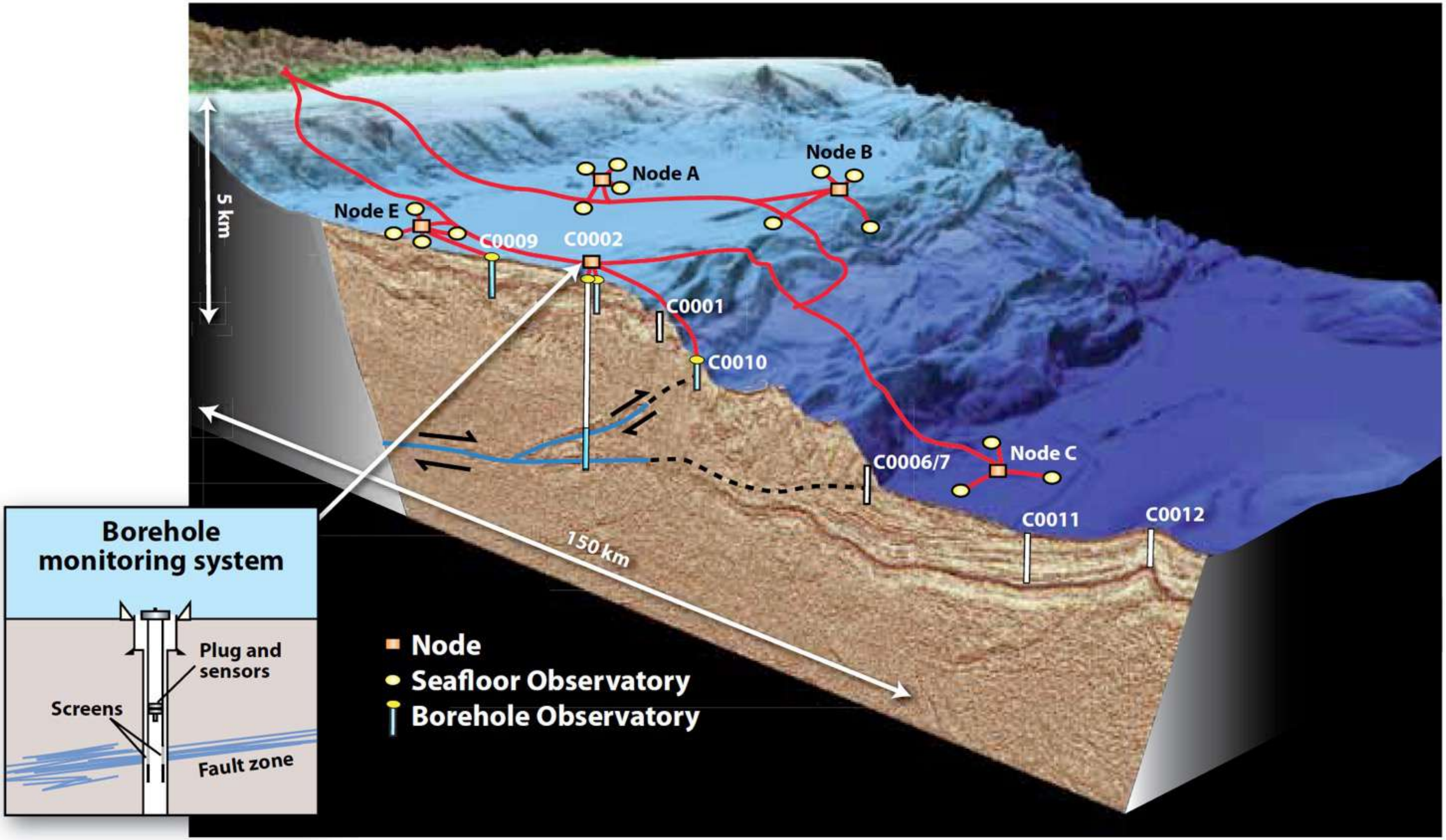


F. Inagaki, JAMSTEC

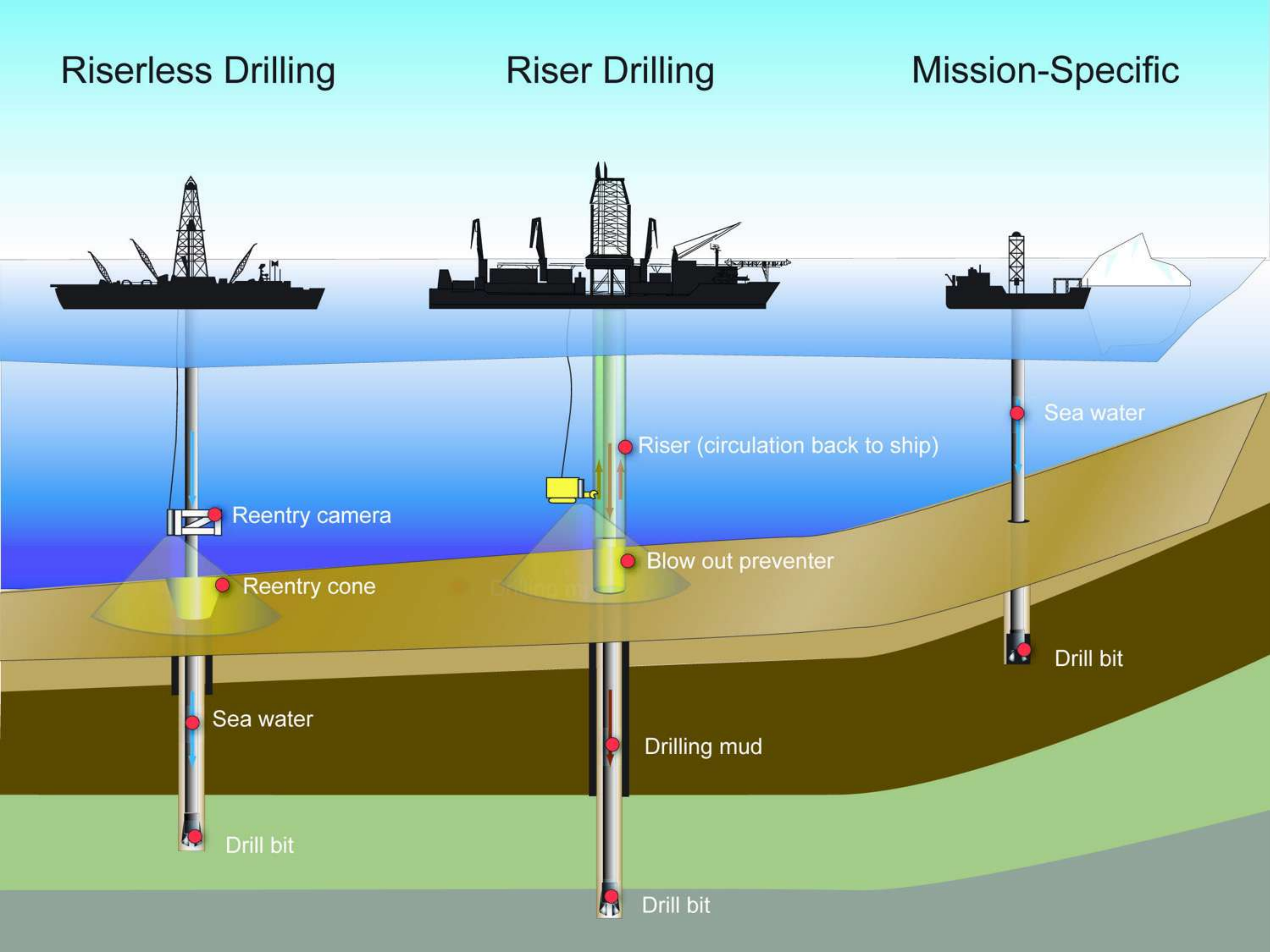
Earth Connections: Deep Processes and Their Impact on Earth's Surface Environment



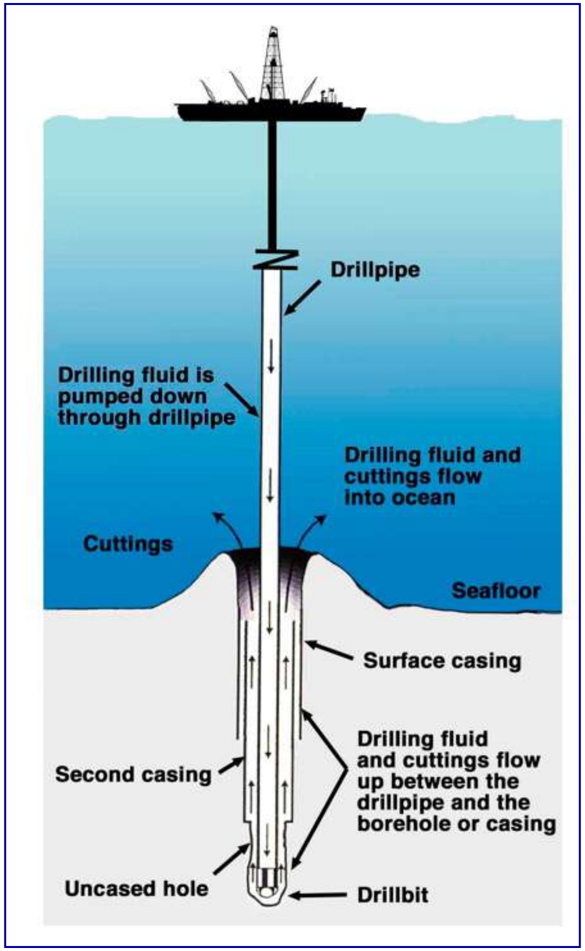
Earth in Motion: Processes and Hazards on Human Time Scales

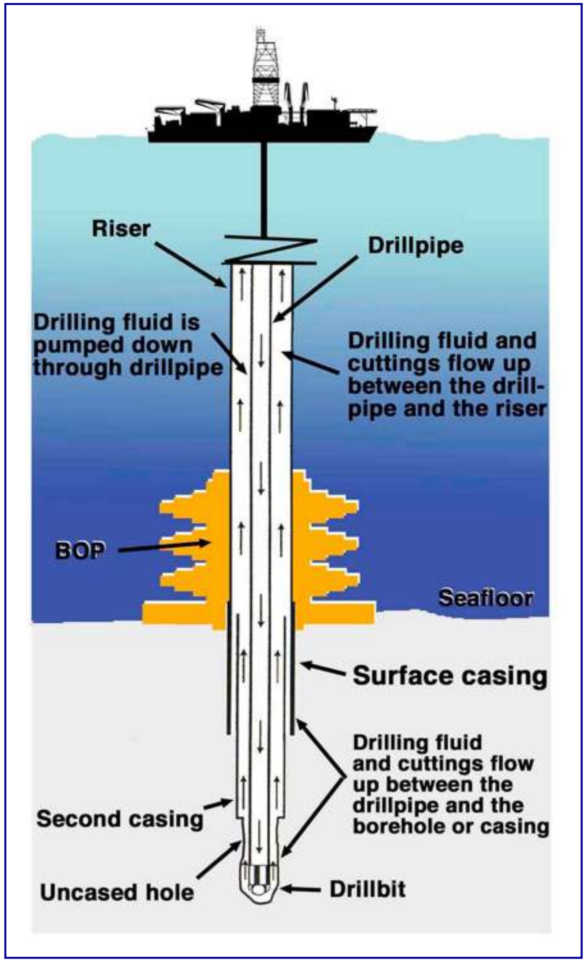


Inset from Expedition 319 Scientists (2010)

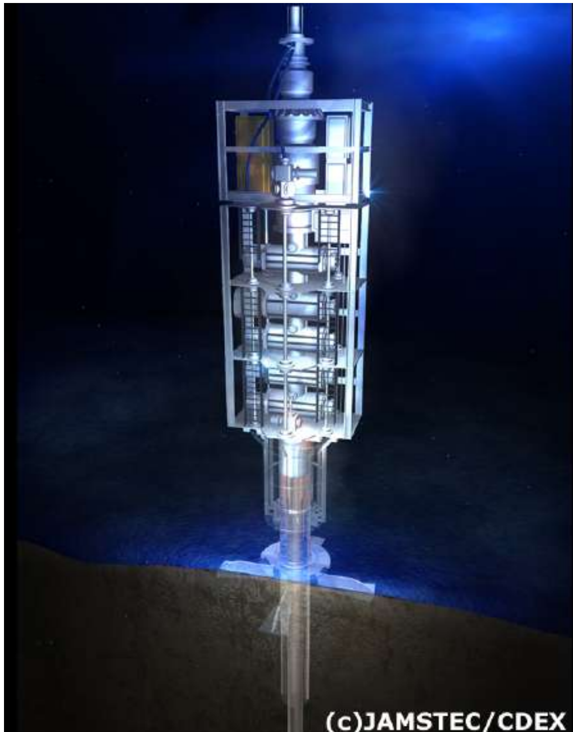

Riserless Drilling
Riser Drilling
Mission-Specific
Reentry camera
Reentry cone
Sea water
Drill bit
Riser (circulation back to ship)
Blow out preventer
Drilling mud
Drill bit
Sea water
Drill bit

THE ‘RISER’ DRILLING SYSTEM





https://www.youtube.com/watch?v=yuu0QcnOVbo



http://www.jamstec.go.jp/chikyu/

CORE ON DECK

http://www.youtube.com/watch?feature=player_embedded&v=wC9lDPvvze0

http://www.iodp.org/images/stories/swf/jamstec_english_1_deepsea_drilling.swf

http://www.iodp.org/images/stories/swf/jamstec_english_2_rotary_drilling.swf

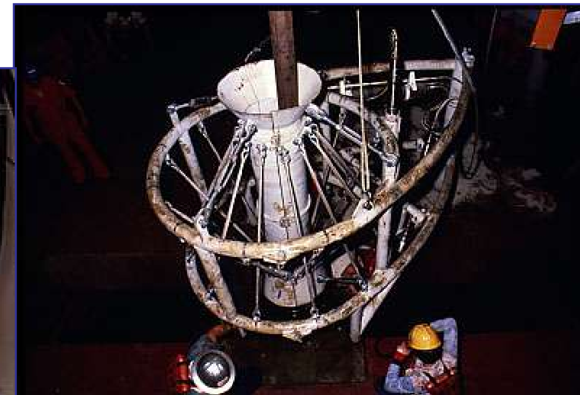
http://www.iodp.org/images/stories/swf/jamstec_english_3_riser_system.swf

http://www.iodp.org/images/stories/swf/4core_procedure_eng.swf

http://www.iodp.org/core-analyzing-process/2/

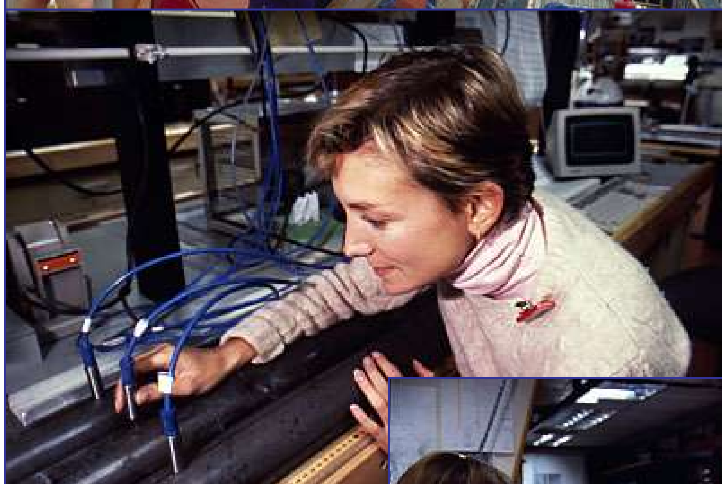
Site Surveys

Dynamic Positioning



Drilling

Hole Re-entry

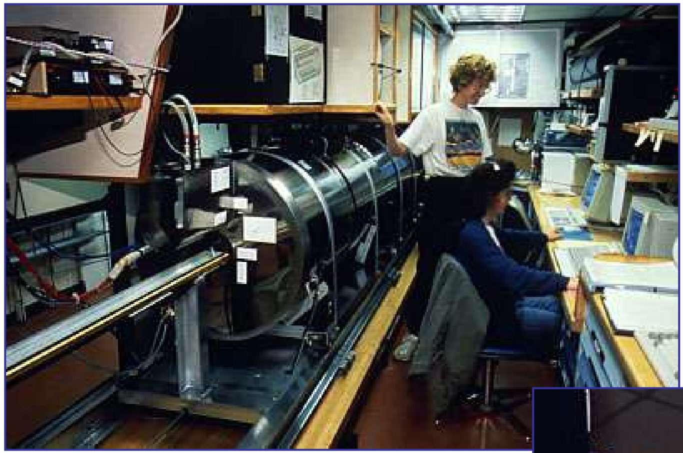


Core Handling

Core Logging

http://www.iodp-usio.org/

Geomagnetic logging



Microbiology

Micropaleontology

Geochemistry

Downhole Logging

IODP Funding Model

- Each platform operated independently by respective country or consortia
- Science Support Office funded by NSF

Science Support Office ← **NSF**

US partners → **NSF**
Australia-NZ
Brazil
China
ECORD
India
Korea

NSF ↓

ECORD ↓

MEXT ← ***Japan partners***
ECORD
Australia-NZ

MEXT ↓

ECORD
(European Consortium for Ocean research Drilling).

16 European nations + Canada

Austria	Italy
Belgium	The Netherlands
Canada	Norway
Denmark	Portugal
Finland	United Kingdom
France	Spain
Germany	Sweden
Ireland	Switzerland
Iceland	

NSF USA

MEXT Japan

MOST (People's Republic of China)

ECORD MANAGING AGENCY (EMA)

ECORD Science Operation (**ESO**)

Science Support And Advisory Committee (**ESSAC**)

ECORD Council

Funding Agencies

Logistics Expeditions Mission Specific Platforms

Scientific Community

Prevision 2005: *ECORD 12.5 Million USD, ~ 17 % of IODP*

http://www.ecord.org/

ECORD Science Operation (**ESO**)

ESO is a consortium of European scientific institutions created to manage the operations of the **Mission Specific Platforms-MSP** on behalf of ECORD in the framework of the Integrated Ocean Drilling Program-IODP.

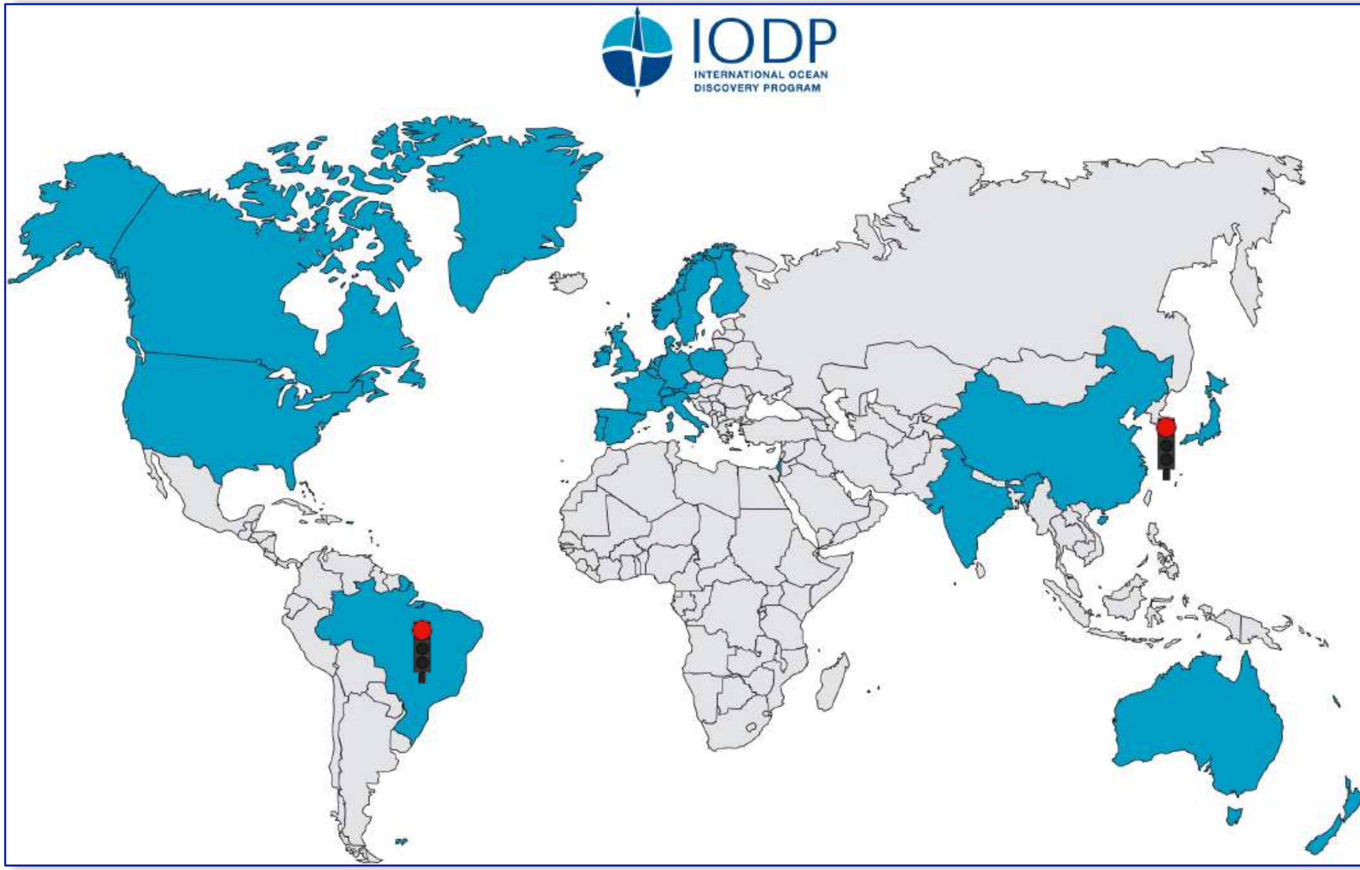
ESO is composed by:

- The **British Geological Survey - BGS**, (co-ordinator) responsibile of the overall management, under contract with EMA as indicated by the ECORD Council;

- The **University of Bremen**, sub-contracted by BGS to manage the core repository and the data management with the WDC-MARE/PANGAEA (IODP-MSP data portal). GFZ Potsdam contributes with by supporting ESO with the Drilling Information System (DIS)for offshore data acquisition;

-The **European Petrophysical Consortium**, sub-contracted by BGS to manage the Wireline Logging operations and petrophysical activities. The Consortium is composd by:

- University of Leicester (co-ordinator), U.K,
- the Université de Montpellier 2, France,
- RWTH Aachen, Germany and Vrije Universiteit of Amsterdam, Netherlands.



USA ***(--> 2023)***

ANZIC ***(--> 2022)***

China ***(--> 2023)***

India ***(--> 2023)***

Japan ***(--> 2023)***

ECORD ***(--> 2023)***

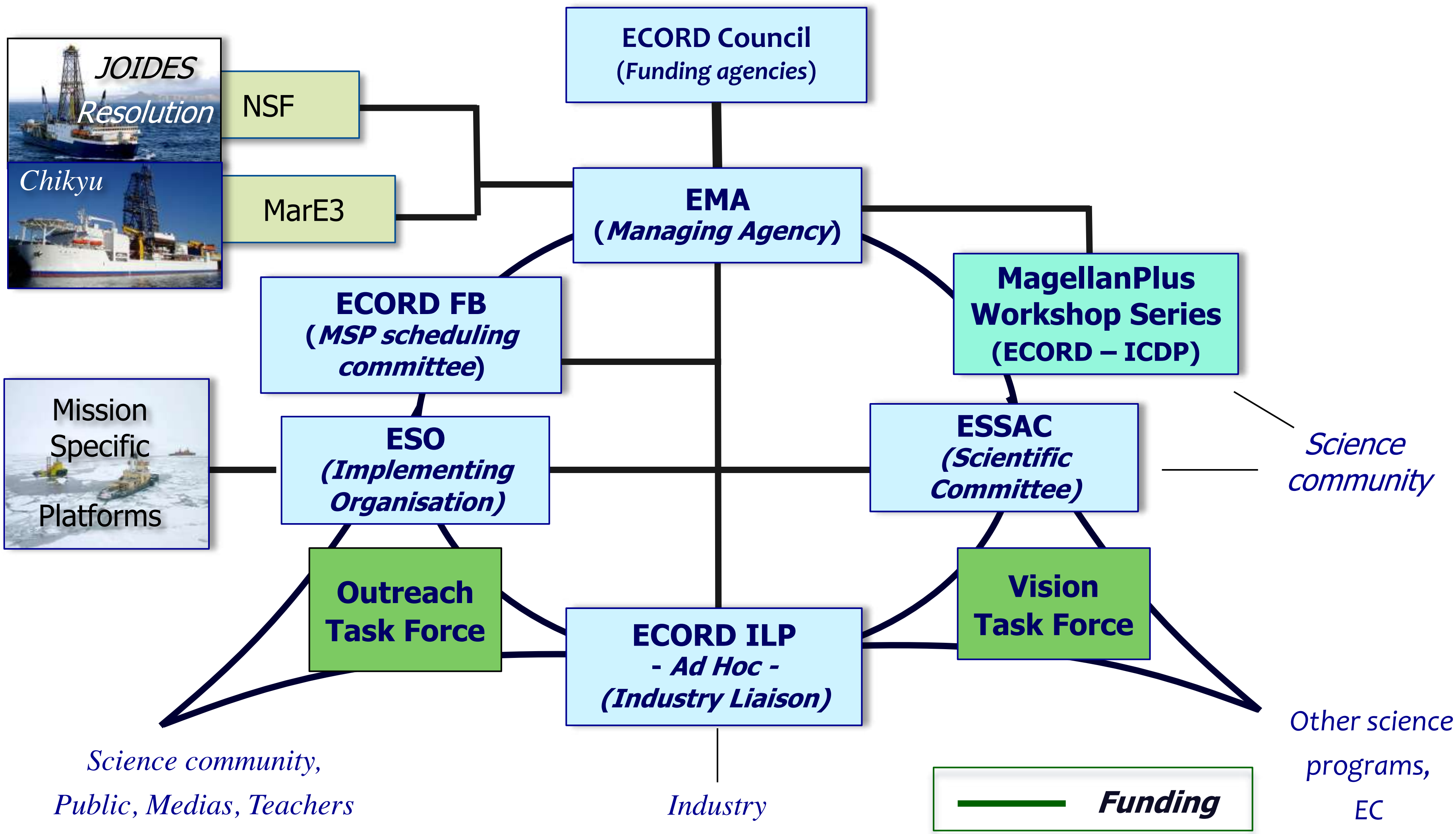
S-Korea ***(On hold)***

Brazil ***(On hold)***

IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM

Budget ± 130-140 M$/yr

23 member countries


ECORD Council
(Funding agencies)
JOIDES Resolution
NSF
Chikyu
MarE3
EMA
(Managing Agency)
ECORD FB
(MSP scheduling committee)
MagellanPlus Workshop Series
(ECORD – ICDP)
Mission Specific Platforms
ESO
(Implementing Organisation)
ESSAC
(Scientific Committee)
Science community
Outreach Task Force
Vision Task Force
ECORD ILP
- Ad Hoc -
(Industry Liaison)
Science community,
Public, Medias, Teachers
Industry
Funding
Other science programs, EC

Credit: Simone Sauer / ECORD / IODP

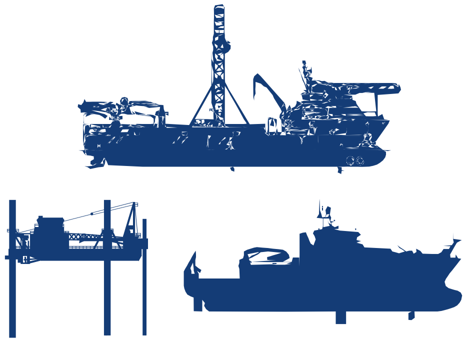
Capabilities of mission-specific platforms (MSPs) & coring technologies

THANKS TO DAVID MCINR
British Geological Survey
dbm@bgs.ac.uk

Why are MSPs needed?

- To work in lithologies where alternative coring methods might yield better recovery
- To implement science that cannot be implemented by any other IODP operator or national facilities

ECORD Science Operator



Any suitable vessel

40


ECORD
Science Operator
British Geological Survey
UNIVERSITY OF LEICESTER
EPC
EUROPEAN PETROPHYSICS CONSORTIUM
marum
Universität Bremen
UNIVERSITÉ DE MONTPELLIER
Géosciences Montpellier
United Kingdom
London
Amsterdam
Netherlands
Brussels
Belgium
Cologne
Paris
France
Switzerland
Milan
Munich
Austria
Vienna
Poland
Warsaw
Copenhagen
Denmark
Stockholm
Czechia
Slovakia
Budapest
Hungary
Zagreb
Italy
Rome
Madrid
Spain
Portugal
Lisbon
Valencia
Seville
Granada
Málaga
Gibraltar
Algiers
Tunis
Malta
Sarajevo
Serbia
Greece
Athens
41

Photo credits: 1 Eileen Gillespie / 2 David McInroy / 3 Chris Lowery / 4 NOC / 5 Michael Rubis, Fugro Marine Services / 6 JAMSTEC / 7 ECORD-IODP / 8 David Smith. 1-3 & 8 also ECORD / IODP.

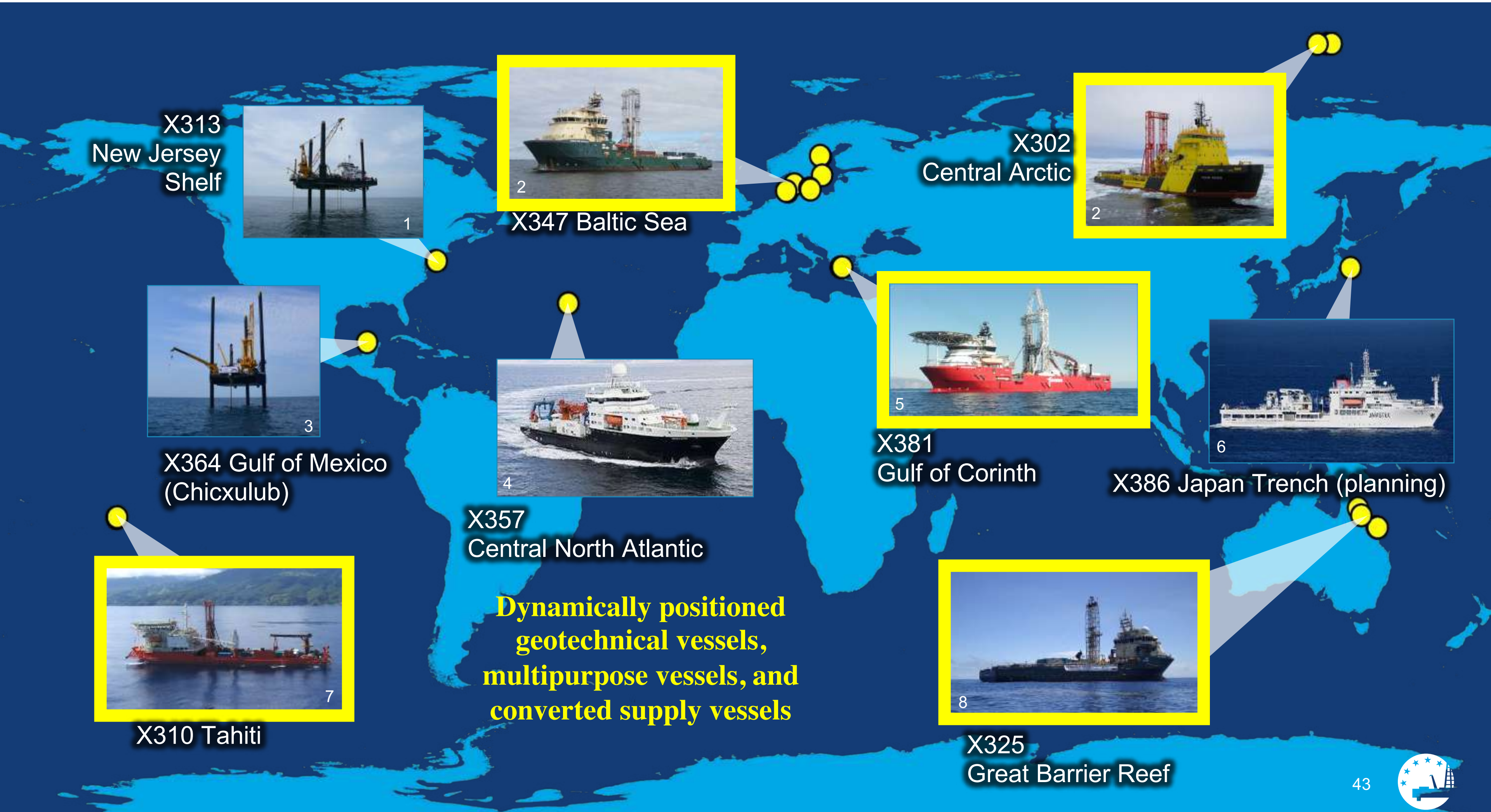


Photo credits: 1 Eileen Gillespie / 2 David McInroy / 3 Chris Lowery / 4 NOC / 5 Michael Rubis, Fugro Marine Services / 6 JAMSTEC / 7 ECORD-IODP / 8 David Smith. 1-3 & 8 also ECORD / IODP.

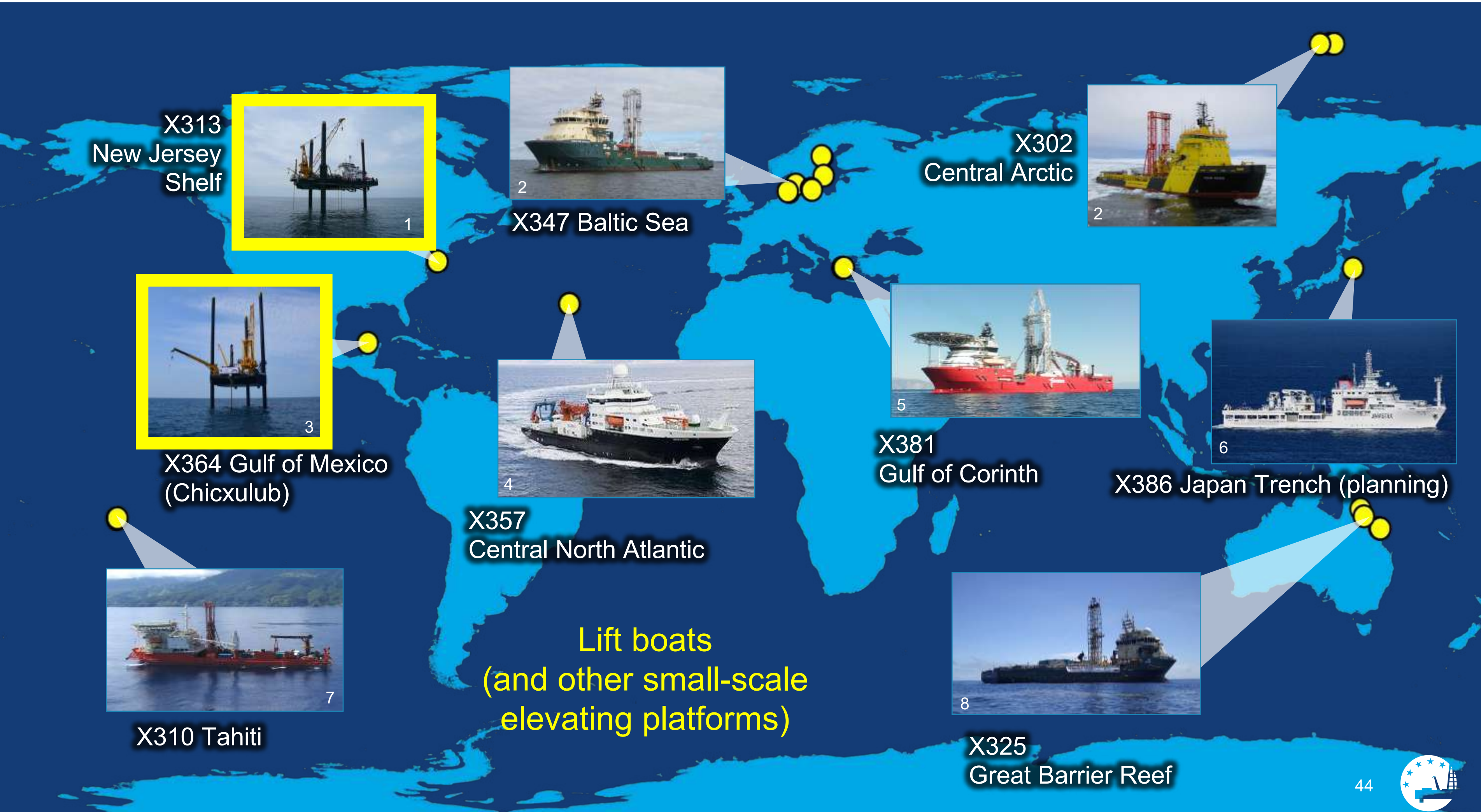


Photo credits: 1 Eileen Gillespie / 2 David McInroy / 3 Chris Lowery / 4 NOC / 5 Michael Rubis, Fugro Marine Services / 6 JAMSTEC / 7 ECORD-IODP / 8 David Smith. 1-3 & 8 also ECORD / IODP.

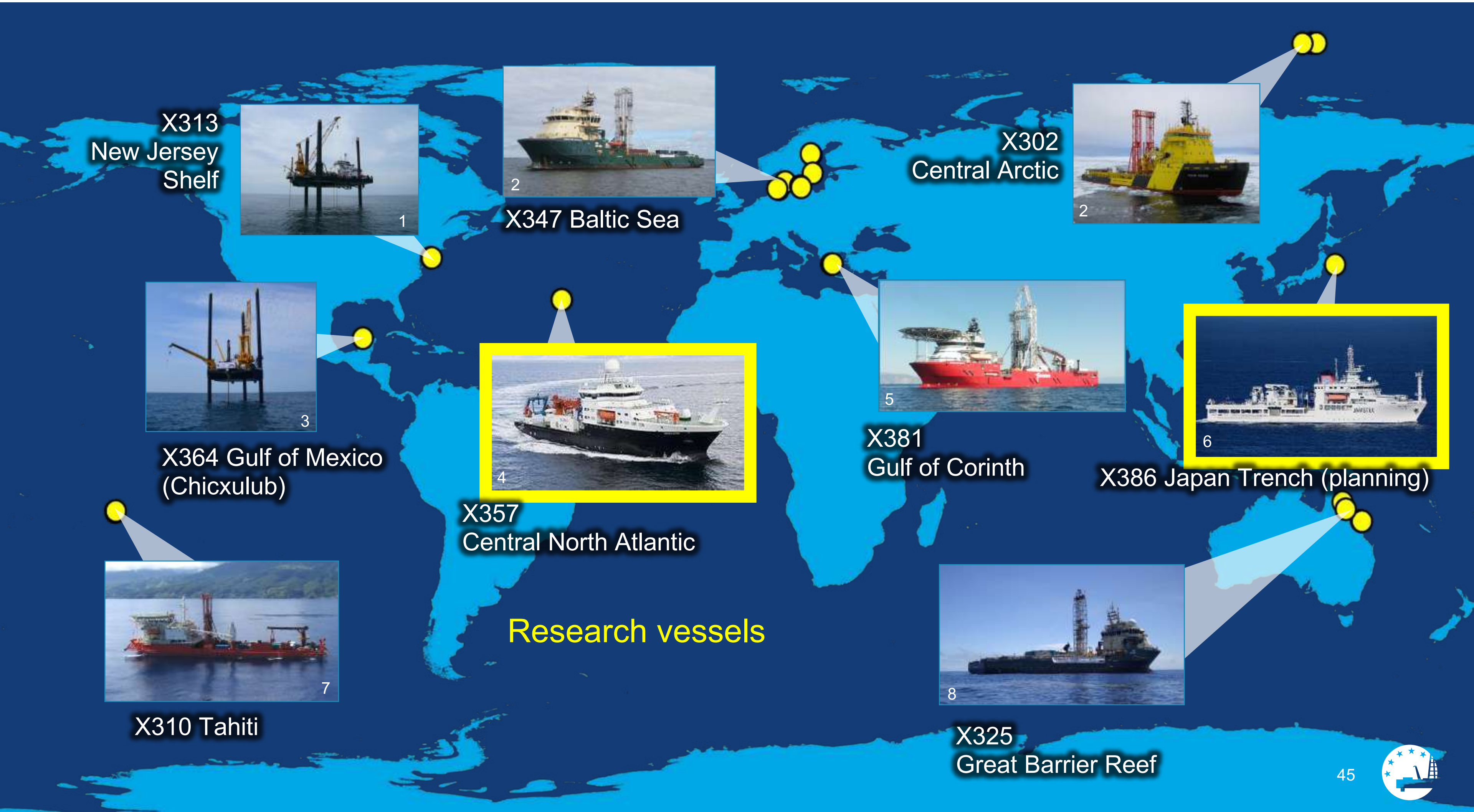
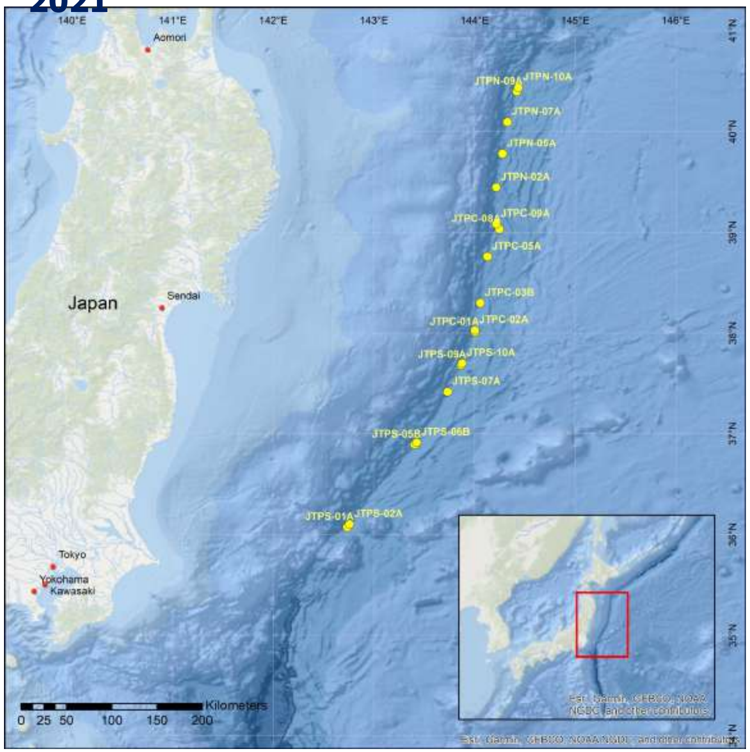
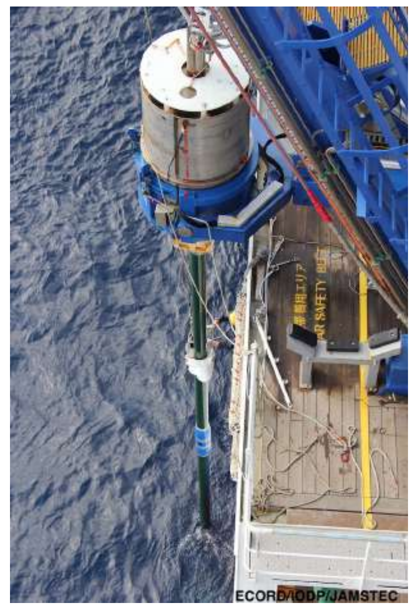


Photo credits: 1 Eileen Gillespie / 2 David McInroy / 3 Chris Lowery / 4 NOC / 5 Michael Rubis, Fugro Marine Services / 6 JAMSTEC / 7 ECORD-IODP / 8 David Smith. 1-3 & 8 also ECORD / IODP.

IODP Expedition 386:
Japan Trench Paleoseismology, April – June 2021



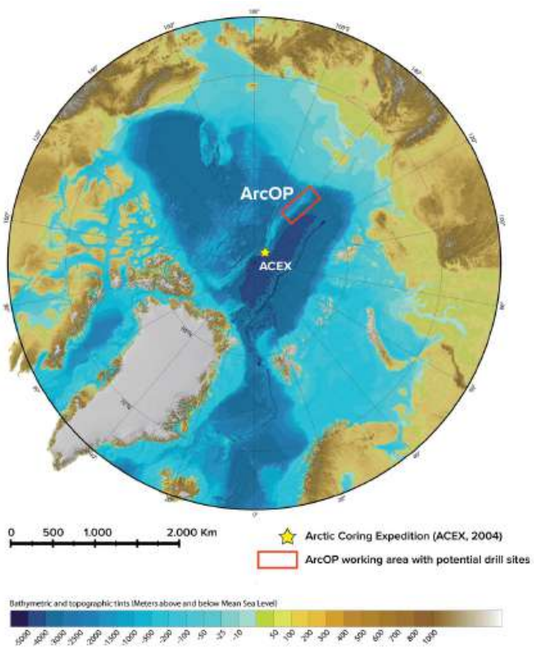


JAMSTEC ECORD

Drillships: Offshore R/V Kaimei; Onshore Science Party D/V Chikyu

the deepest water site ever
drilled and cored at the
water depth of 8023 m

Exp. 377 Arctic Ocean Paleoceanography (ArcOP)
Aug-Sept 2022



Tracking Arctic climate change from a Greenhouse to an Icehouse world

GOAL:
Recovery of a continuous stratigraphic record of the long-term Cenozoic climate history of the central Arctic Ocean.

ECORD EUROPEAN CONSORTIUM FOR OCEAN RESEARCH DRILLING
IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM
SWEDISH POLAR RESEARCH SECRETARIAT
arctic marine solutions

Drillship: *Dina Polaris*

Summary of MSP coring methods 2004-2021

Photo credits: 1 Henk Brinkhuis / 2 Hans-Joachim Wallrabe-Adams / 3 Thomas Andrén / 4 Rob Gawthorpe / 5 Carol Cotterill / 6 Graham Tulloch / 7 Auriol Rae / 8 David Smith / 9 OSIL. 1-8 ECORD-IODP.

Seafloor drill technology

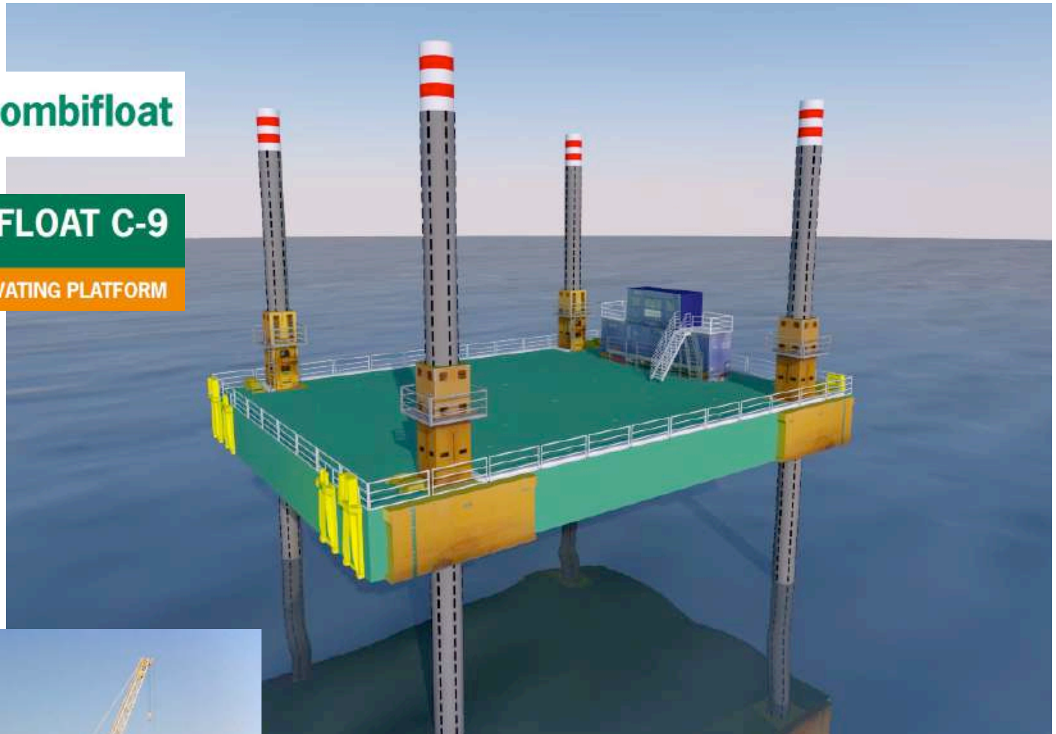
Photo credits: 1 David Smith ECORD-IODP / 2 benthic.com / 3 wassoc.com / 4 cellula.com / 5 fugro.com / 6 helixesg.com / 7 royalihc.com

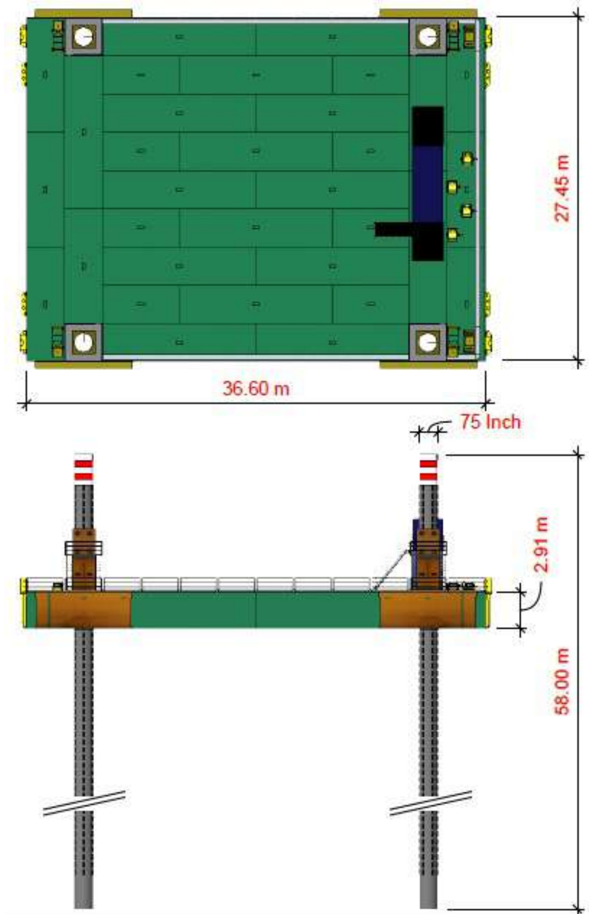
Possible future MSP platforms

combifloat

COMBIFLOAT C-9

SELF ELEVATING PLATFORM





- Can elevate in up to 56m water depth
- Size can be altered
- Can be transported and mobilised almost anywhere

Credit: Australian Antarctic Division

RSV Nuyina

Australian Government
Department of the Environment and Energy
Australian Antarctic Division

Possible future MSP platforms for polar regions

RRS Sir David Attenborough

Natural Environment Research Council

Credit: UKRI / Natural Environment Research Council

Take-home messages

- New Science Framework until 2050, with periodic assessments
- New structure of the program: Flagship Initiatives
- One or multiple Programs?
- Land-Sea: Amphibious projects
- For our community: FOCUS ON MISSION SPECIFIC PLATFORM
- New proposals needed – Magellan Workshops

Why robotic drilling ?

Disadvantage

- Less control on drill process

Advantage

- Safety
- Access to extreme environments (steep walls, extraterrestrial environments, **sea floor**)

Picture: Roboclimber (Molfino, 2005)

Courtesy Time Freudenthal, MARUM, Bremen

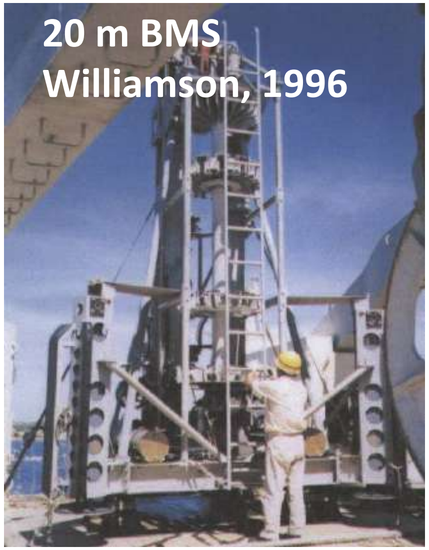
Advantages of sea bed drill rigs

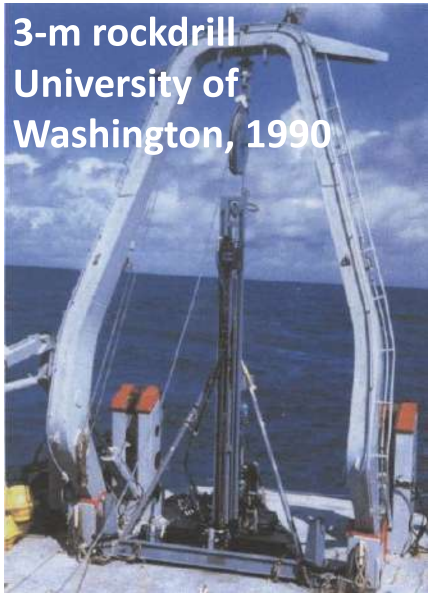
- Stable platform – optimal drill bit control
- No need for drill pipe through the water column
- Operation from multipurpose research vessels

Seabed Rig AS

Courtesy Time Freudenthal, MARUM, Bremen

Existing seabed drill rigs





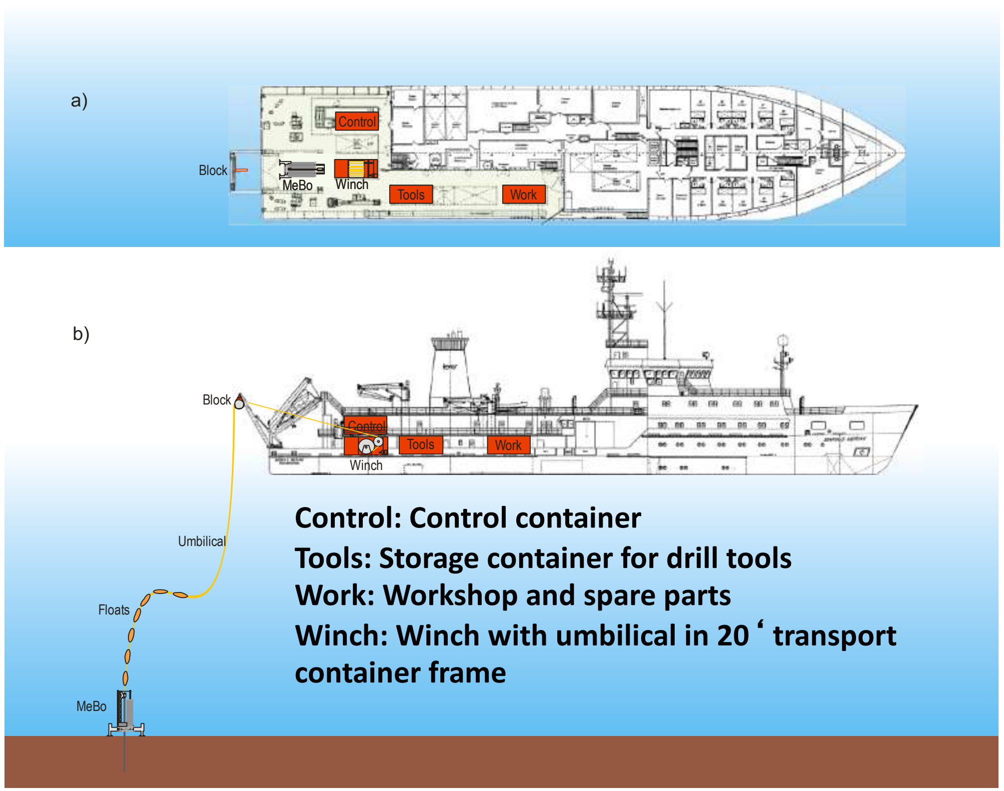
Courtesy Time Freudenthal, MARUM, Bremen

MeBo specifications

- Drilling depth 70 m
- Coring of soft sediments and hard rocks
- Core diameter 55 – 84 mm
- Deployment depth 0 – 2000 m
- MeBo weight about 10 tonnes
- Total system weight about 75 tonnes
- Transport within six 20 ‘ containers

Courtesy Time Freudenthal, MARUM, Bremen

Concept of MeBo



- Umbilical is used to lower the drill rig to the sea floor
- Umbilical is used for energy supply and remote control from the vessel

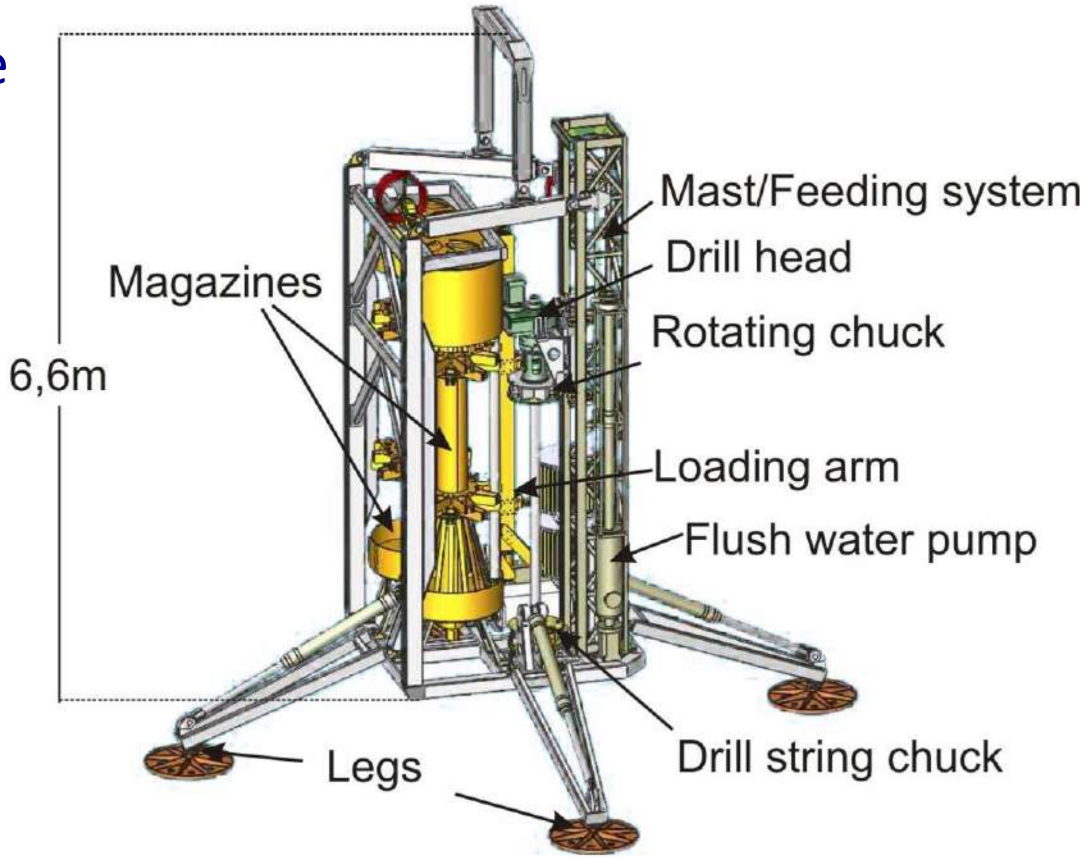
- Transport of the System within 20 ‘ shipping containers, that are mounted on the working deck of the research vessel

Courtesy Time Freudenthal, MARUM, Bremen

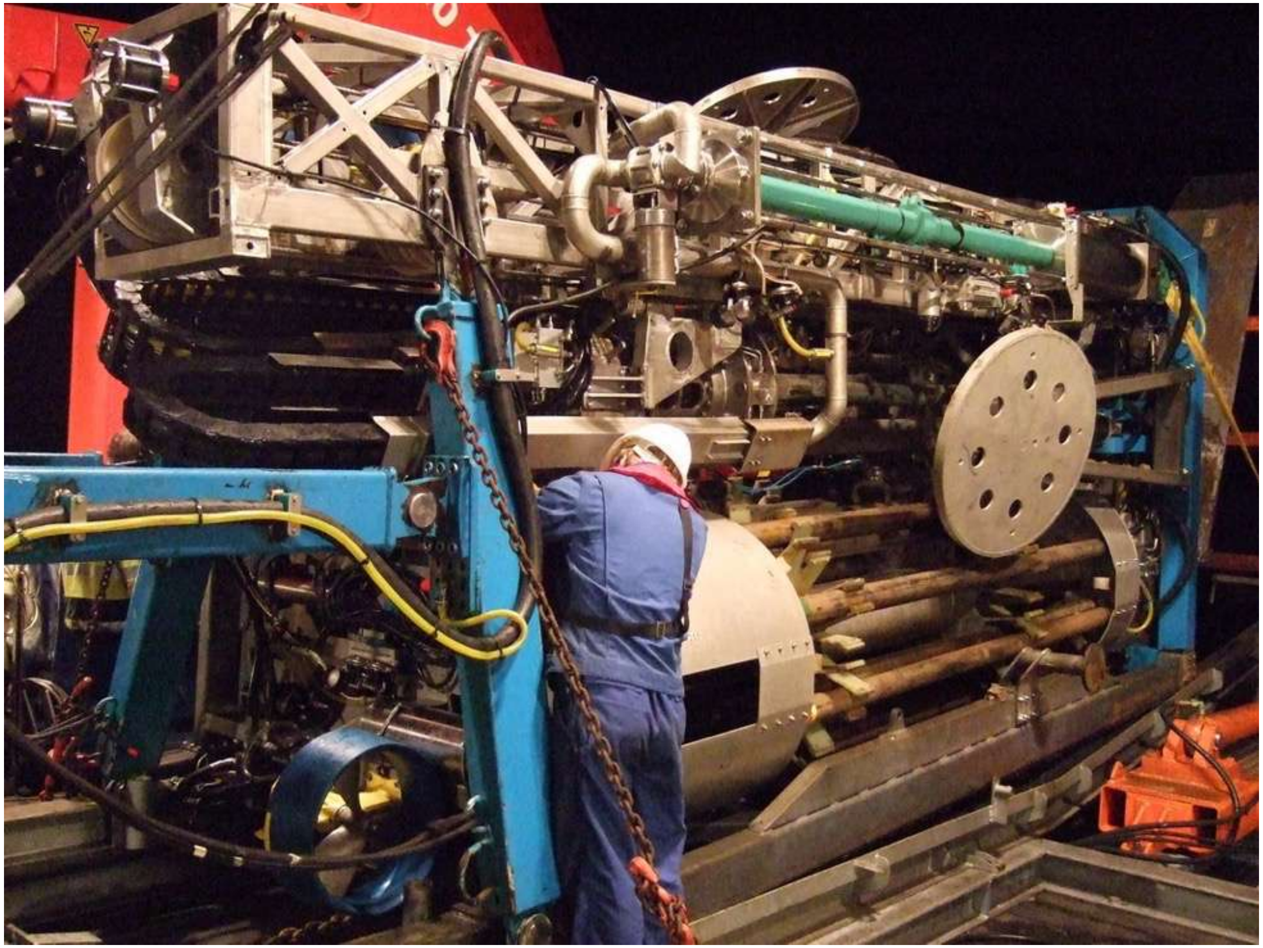
marum

Concept

- Mast, drill head and flush water pump form the central drilling unit
- Drill rig has access to drilling tools stored within two magazines
- The drill string is built up and down using a loading arm and two chucks
- Stability on the sea floor is increased by movable legs



System



Drill rig

For maintenance work between deployments the MeBo lies horizontally on deck. The movable legs are armed in. The rig weighs about 10 tonnes.

Courtesy Time Freudenthal, MARUM, Bremen

System

Winch

The winch stores 2500 m of the umbilical. The pull force of the winch in the upper layer is 12 tonnes.

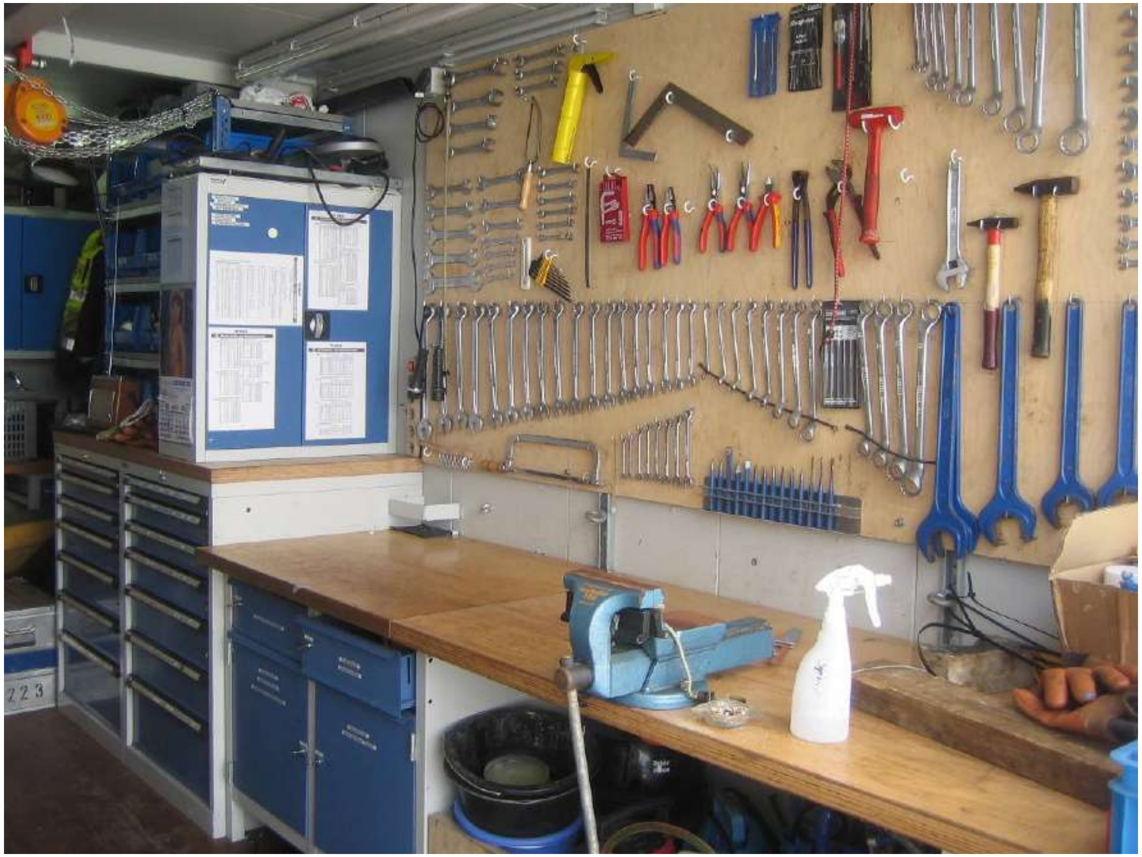
System

Control Unit

The drill rig is remotely controlled from the control container. All actions are surveyed by video cameras and sensors.

Courtesy Time Freudenthal, MARUM, Bremen

System



Workshop

A mechanical workshop and spareparts are transported within a workshop container for maintenance and repair on sea

Courtesy Time Freudenthal, MARUM, Bremen

System

Drill tools

2.35m rods are used to build up the drill string. 30 core barrels and 29 rods are required for core drilling down to 70 m below the sea floor.

MeBo 2004/2005 (HBFG)

Cooperations:
Prakla Bohrtechnik
Schilling Robotics
NSW, STA …

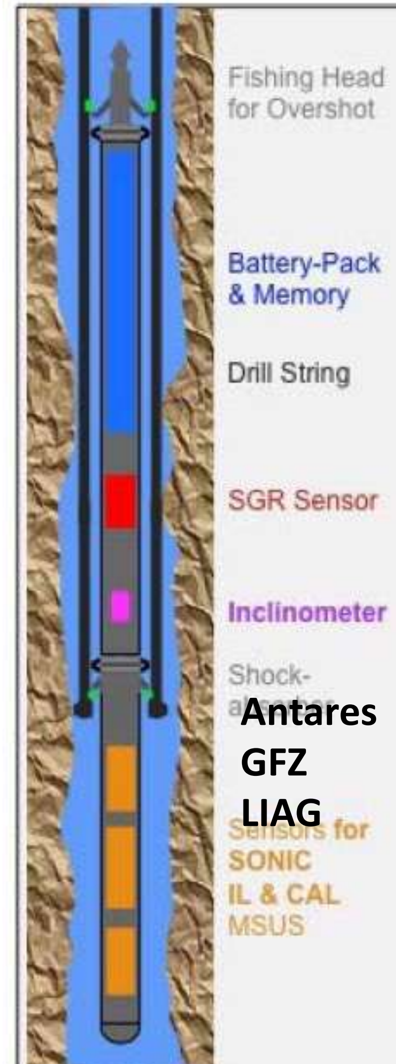
Wire-line 2007/2008 (HBFG)

Prakla Seyferle

Pressure Core Barrel 2008/2010 (BMBF, SUGAR)

Prakla Bohrtechnik
TU Clausthal

Borehole Logging (2010)



Antares
GFZ
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Courtesy Time Freudenthal, MARUM, Bremen

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