Università di Trieste

Corso di Laurea in Geologia

Anno accademico 2019 - 2020

Geologia Marina

Parte II

Modulo 2.4 Perforazione Oceanica

Docente
Angelo Camerlenghi

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

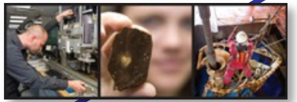
The International Ocean Discovery Program (IODP)

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



MOHOLE 1958-1966

Deep Sea Drilling Project (DSDP) 1968-1983

Ocean Drilling Program (ODP) 1985-2003

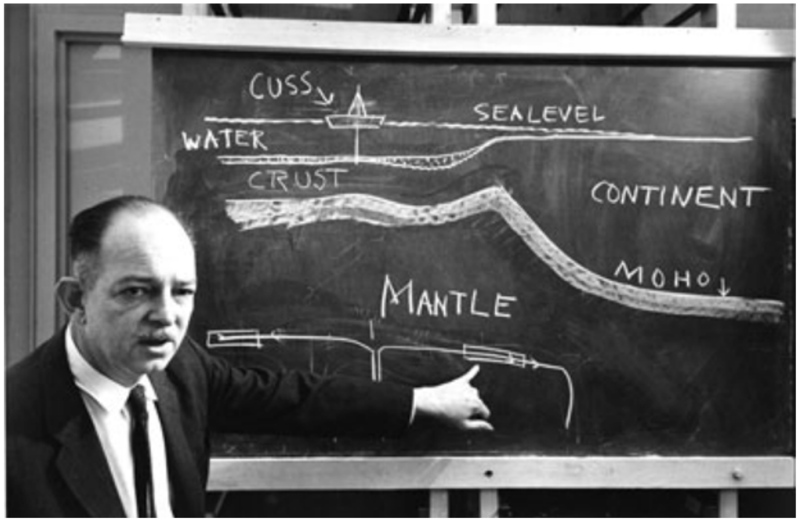
IODP INTEGRATED OCEAN DRILLING PROGRAM

Integrated Ocean Drilling Program (IODP) 2003- 2013

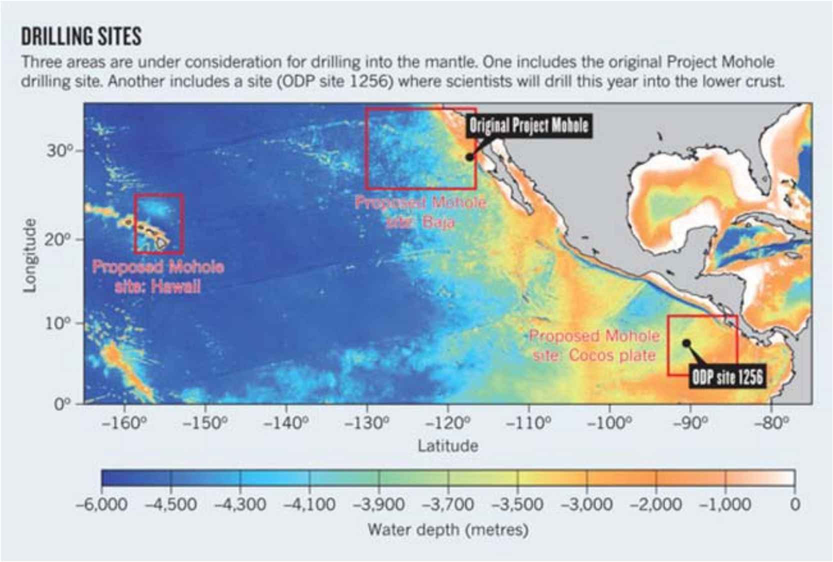
October 2013

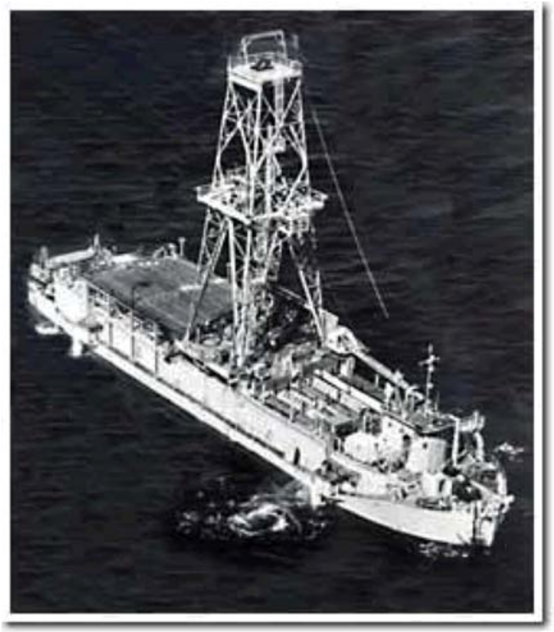
International Ocean Discovery Program (IODP)

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.



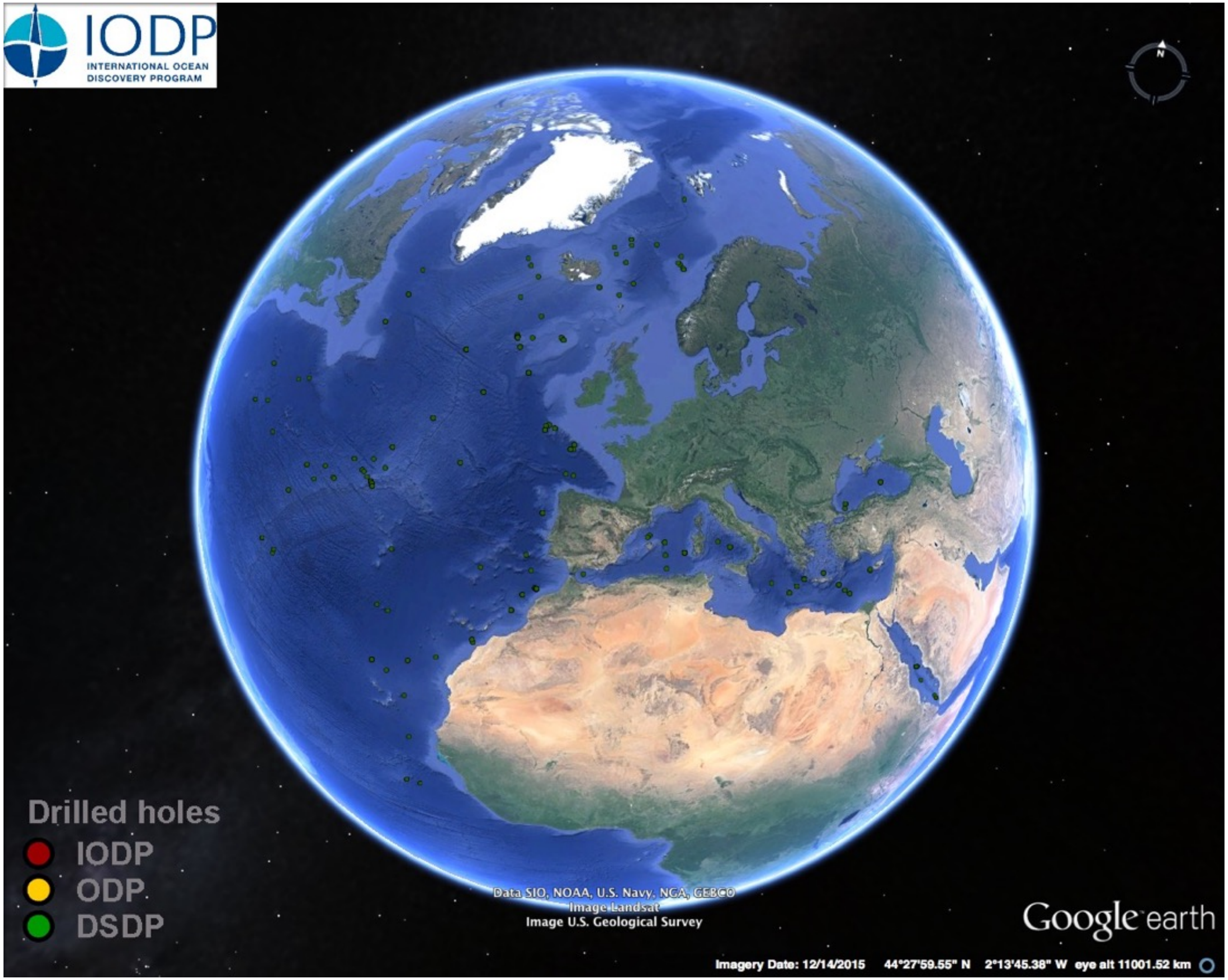


Drill ship CUSS 1

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.

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.

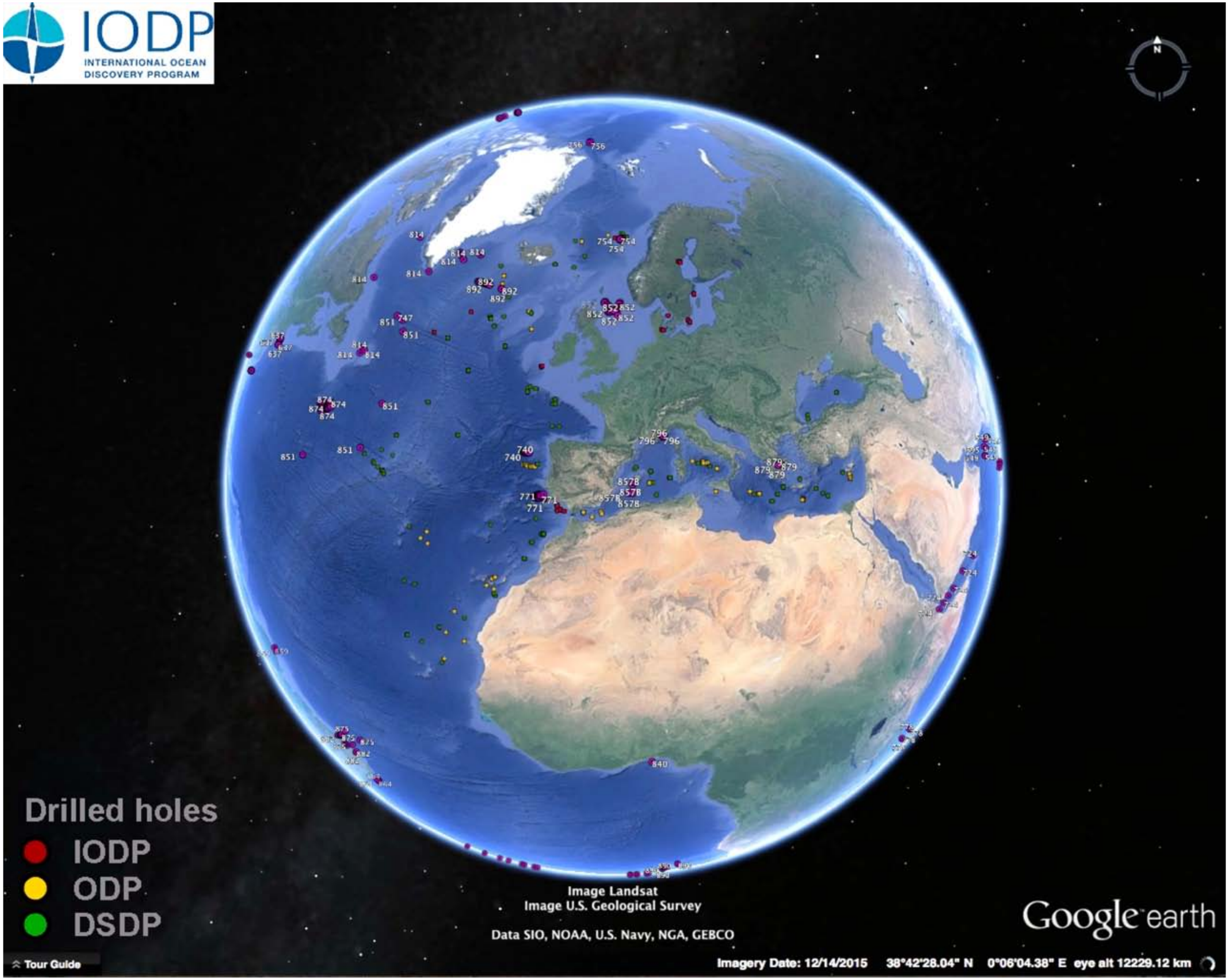
DSDP drillsites in the Mediterranean and North Atlantic



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 **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

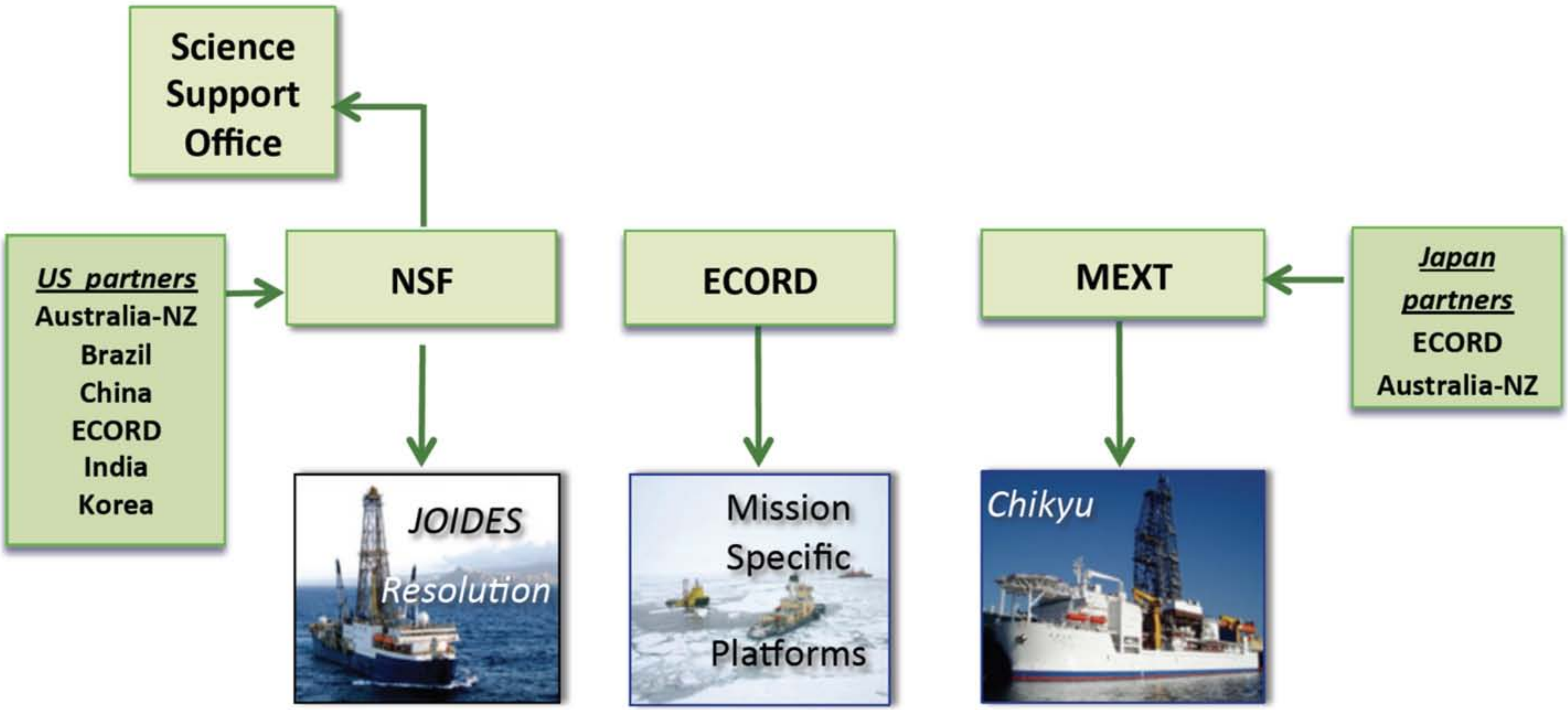
Fundamental principles of IODP

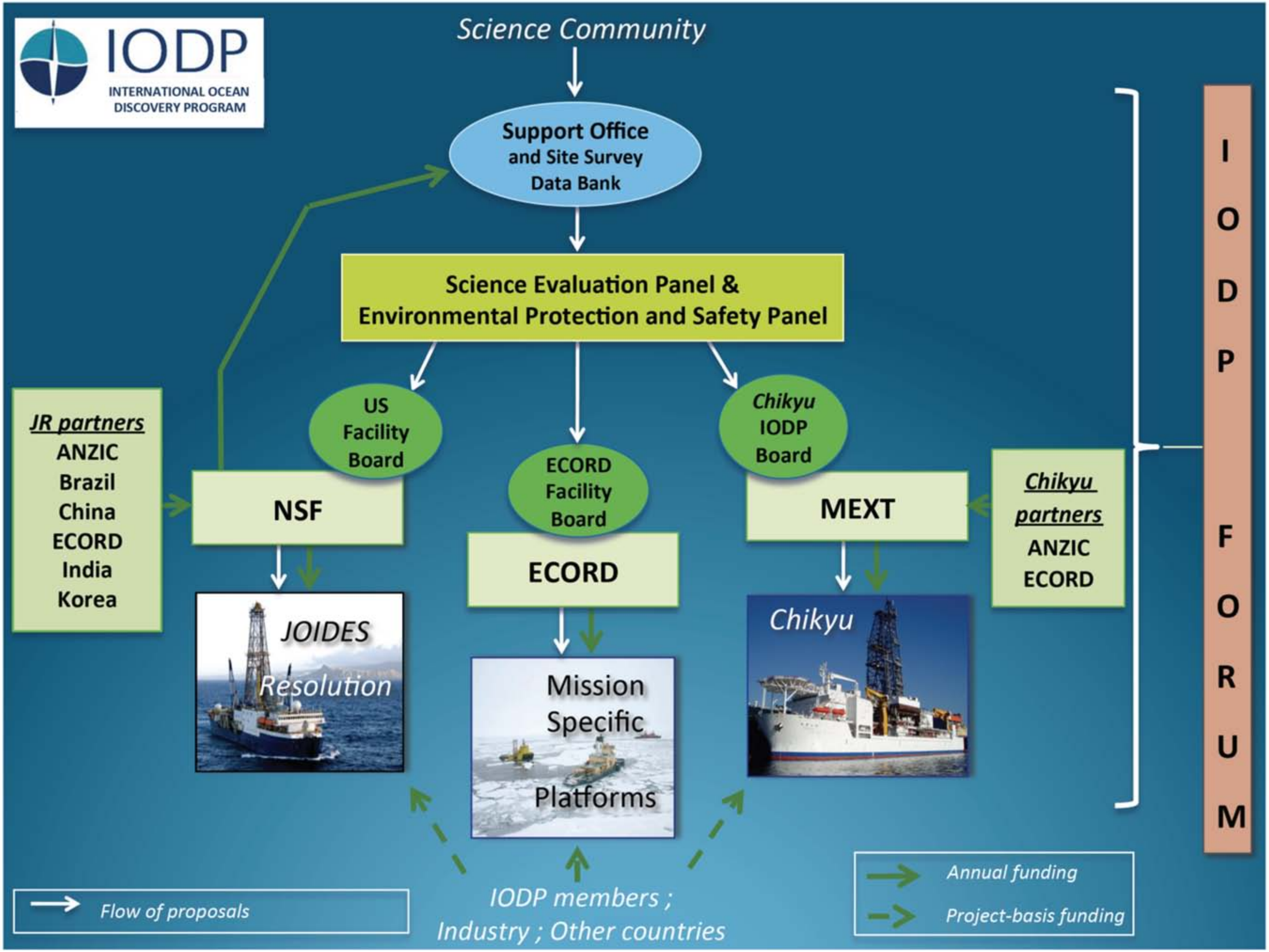
- ***science driven project***
- ***science plan*** **:**
  - **Climate and Ocean Change**: Reading the Past, Informing the Future
  - **Biosphere Frontiers**: Deep Life, Biodiversity, and Environmental Forcing of Ecosystems
  - **Earth Connections**: Deep Processes and Their Impact on Earth's Surface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

http://www.iodp.org

IODP Funding Model

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




IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM
Science Community
Support Office and Site Survey Data Bank
Science Evaluation Panel & Environmental Protection and Safety Panel
US Facility Board
ECORD Facility Board
Chikyu IODP Board
JR partners
ANZIC
Brazil
China
ECORD
India
Korea
NSF
ECORD
MEXT
Chikyu partners
ANZIC
ECORD
JOIDES Resolution
Mission Specific Platforms
Chikyu
IODP FORUM
Flow of proposals
IODP members ; Industry ; Other countries
Annual funding
Project-basis funding

IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM

HOW MUCH DOES IT COST? Example from end of IODP phase

NSF and MEXT Total program costs (75 M USD / anno)
Platform operation costs
Science operation costs

ECORD 7 M USD / year (2003-2006)
16.8 M USD (2006)

MOST 5.5 M USD 2003-2008 (1.0 - 1.5 M USD / year)

http://www.iodp.org

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**)
  - Logistics Expeditions Mission Specific Platforms
- Science Support And Advisory Committee (**ESSAC**)
  - Scientific Community
- **ECORD Council**
  - Funding Agencies

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:

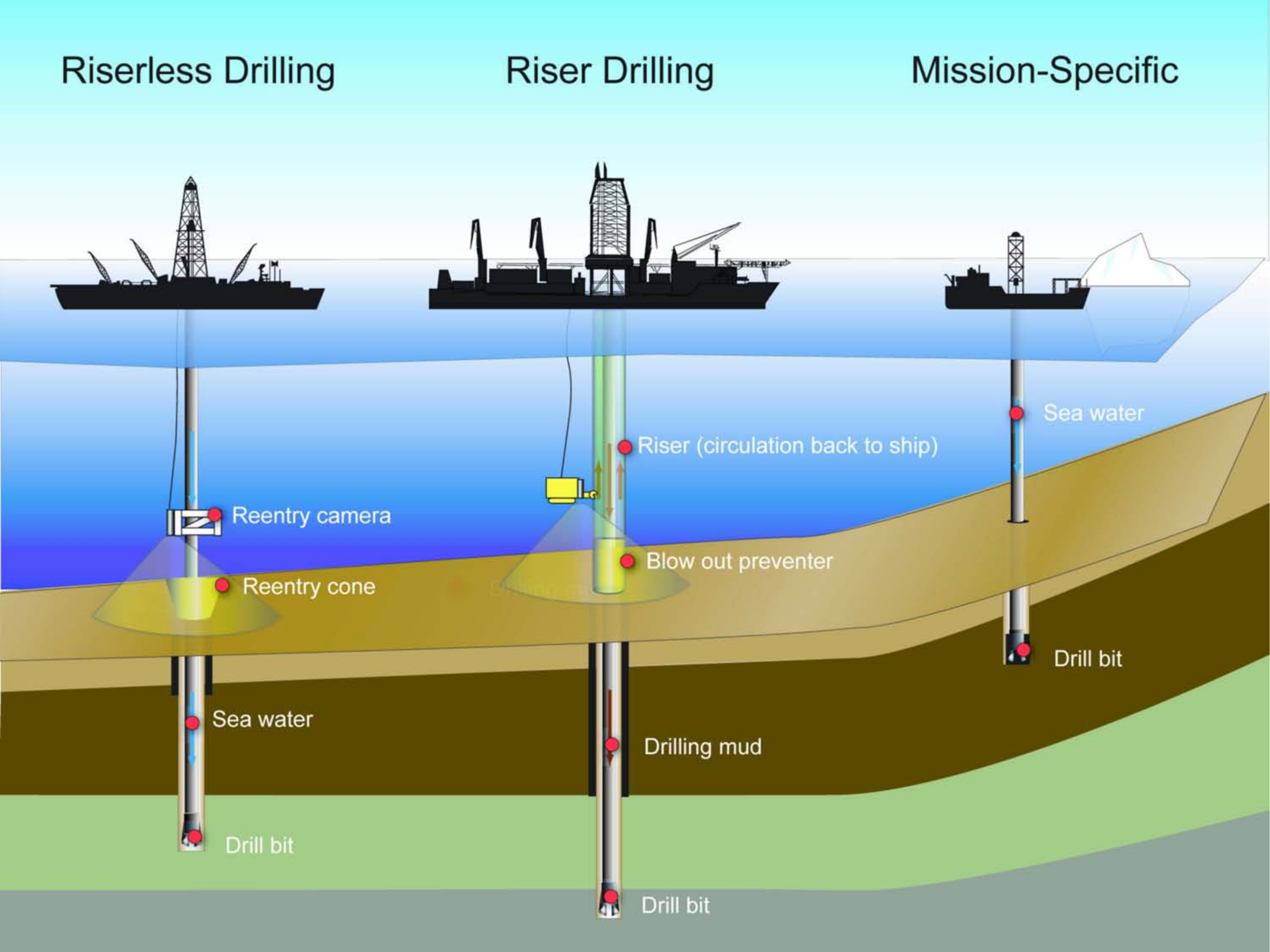
- The **British Geological Survey - BGS**, (co-ordinator) responsibile of the overall management, under contract with EMA as indicated by the ECORD Council;

- 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;

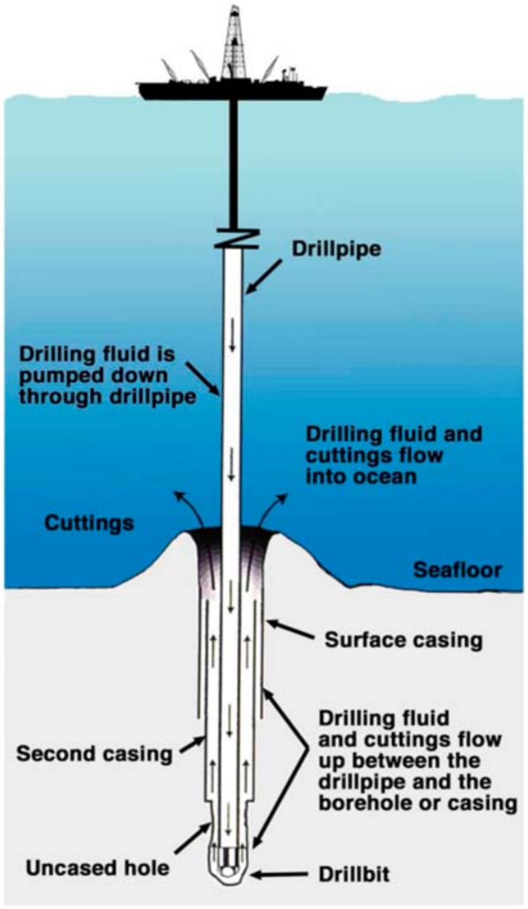
-The **European Petrophysical Consortium**, sub-contracted by BGS to manage the Wireline Logging operations and petrophysical activities. The Consortium is composd by:

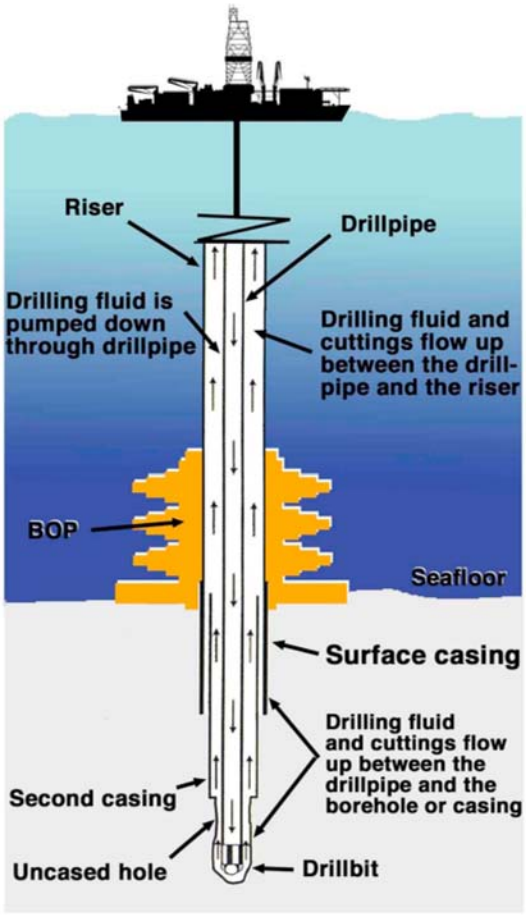
- University of Leicester (co-ordinator), U.K,
- the Université de Montpellier 2, France,
- RWTH Aachen, Germany and Vrije Universiteit of Amsterdam, Netherlands.

http://www.ecord.org/


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





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

ADVANCED PISTON CORING
APC

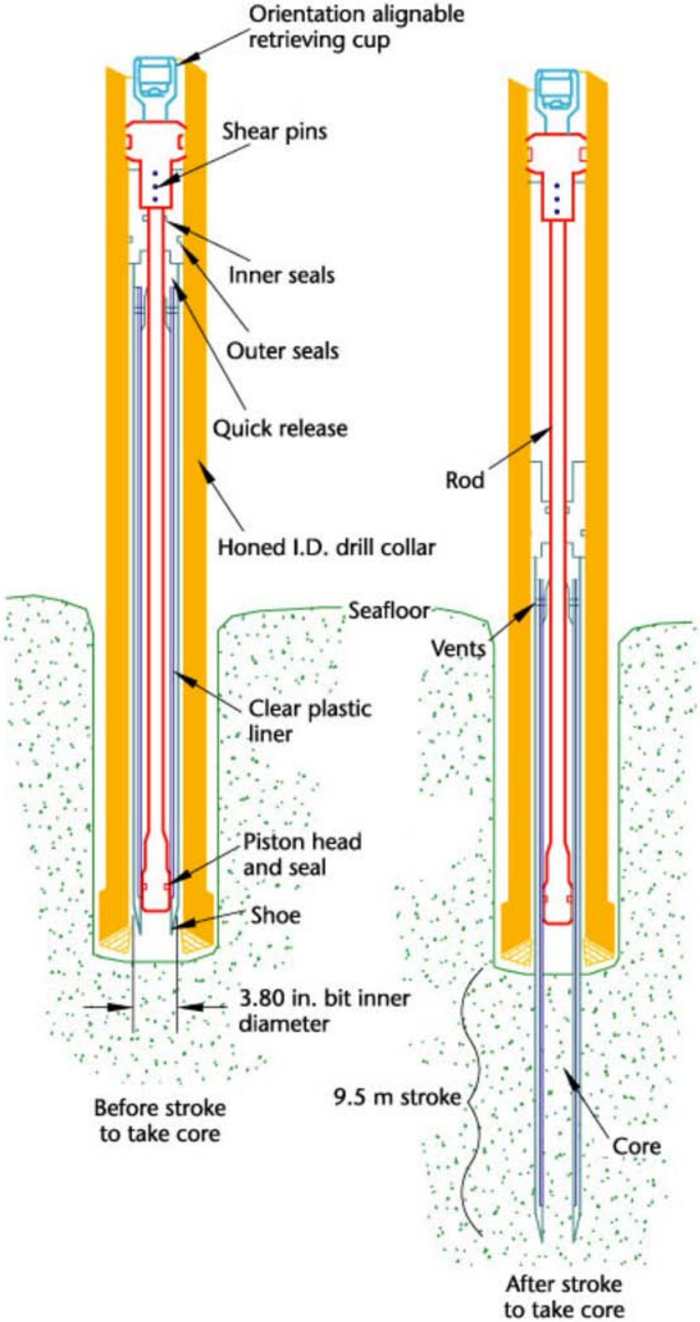
APC Specifications

Maximum Piston Stroke (Core) Length 9.5 m (31.16 ft)
APC Shoe Inside Diameter (Core Outer Diameter) 6.2 cm (2.44 in)
Piston Force 23,000 to 28,000 lbf at 2300 to 2800 psi pump pressure
Typical Operating Range
Very soft to firm sediments
Seafloor to +300 m below seafloor (mbsf)
Recovery ~100% in soft sediments

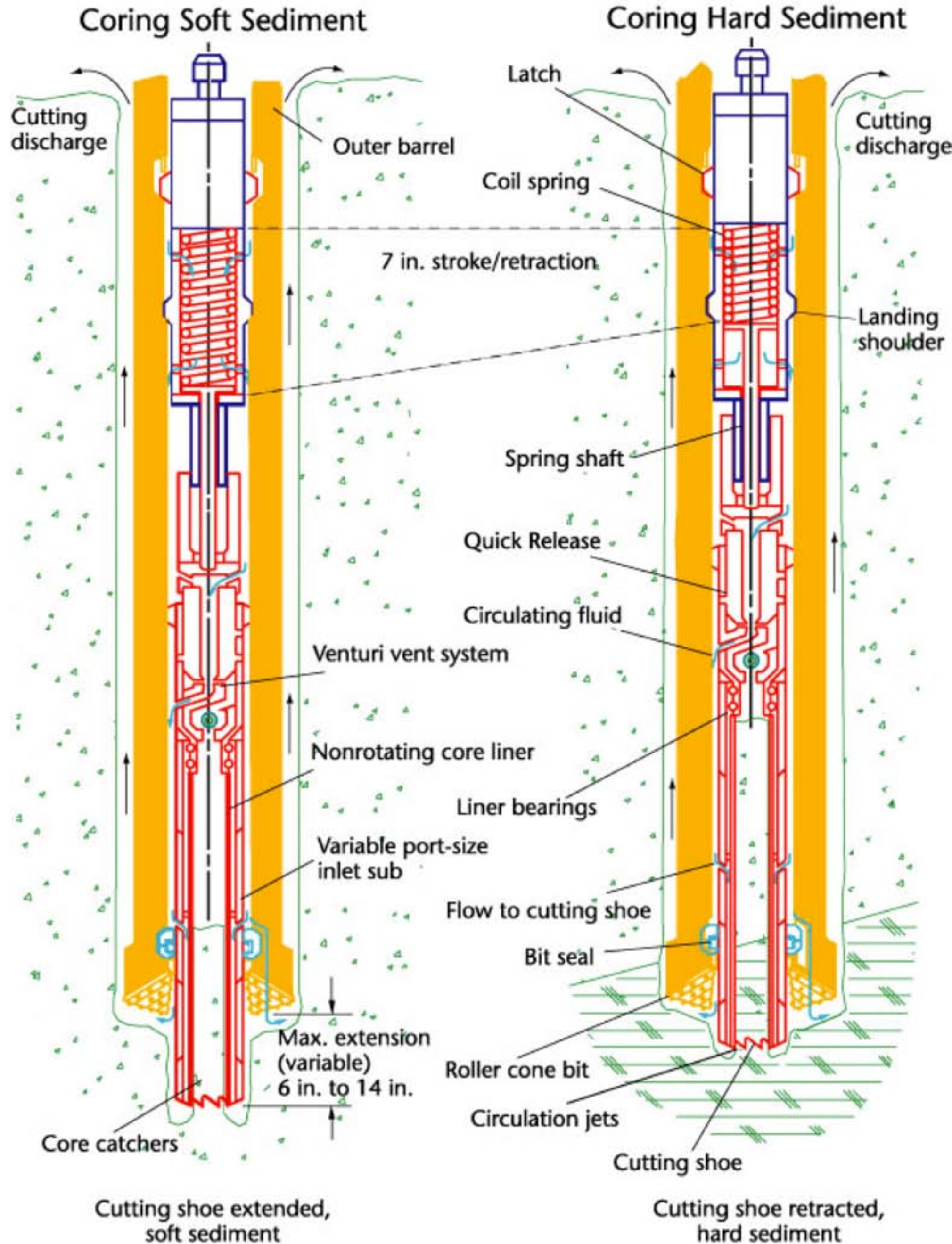
Rate of Core Recovery ~38.0 to 9.5 m of core/hr (depends on depth/wireline time). Rate of penetration typically decreases with depth.

Quantity of Cores on Deck
1 to 4 cores/hr depending on water depth and formation cored.

Limitations
Does not penetrate or recover granular formations (such as sand) or hard ground. Core barrel may stick in firm sediments and require drill-over.

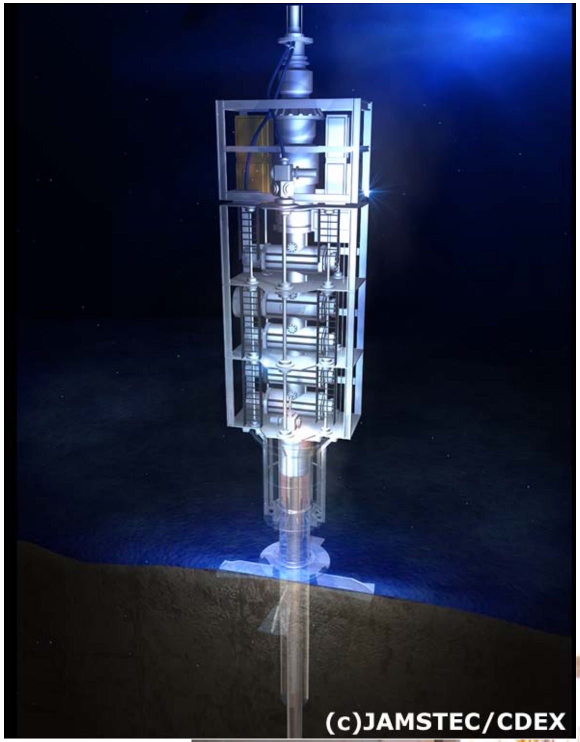


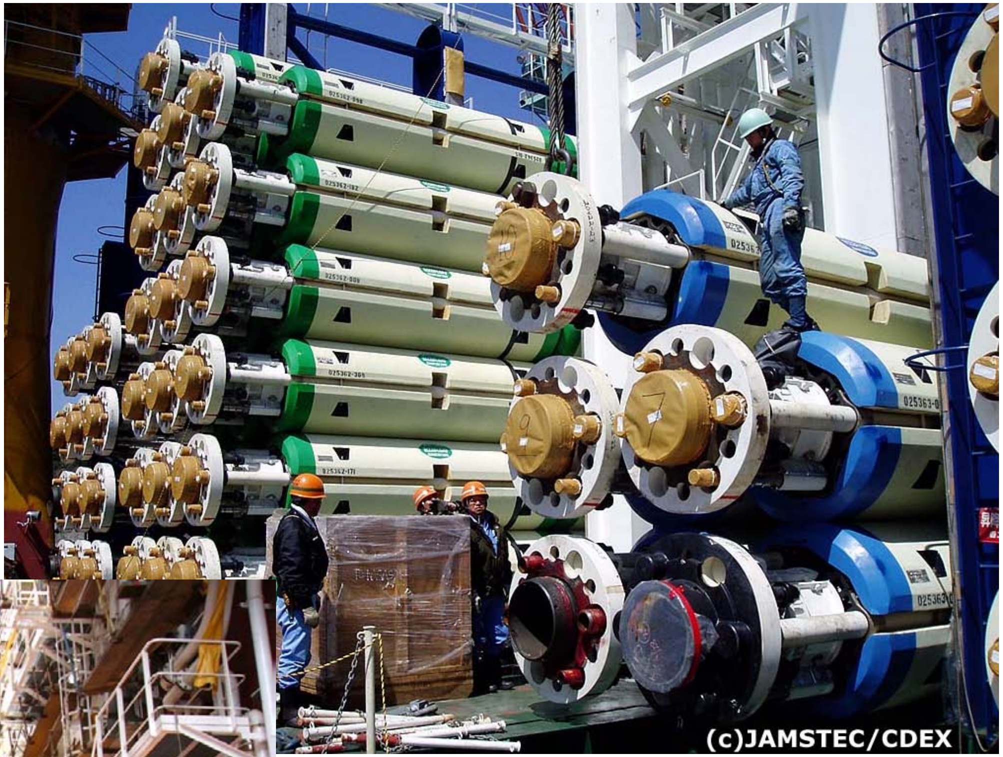
EXTENDED CORE BARREL (XCB)

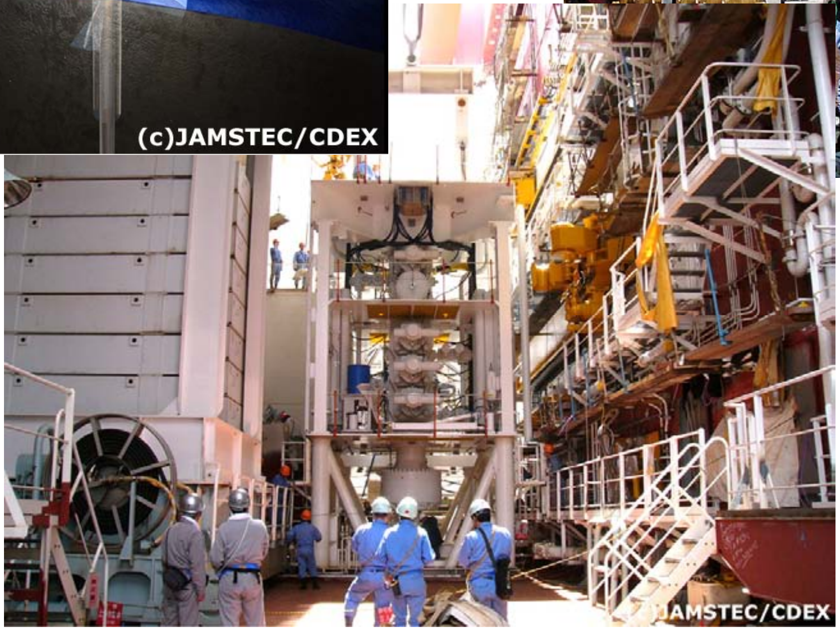


IODP	https://www.youtube.com/watch?v=0nydKlpZdIU
Chykyu animations	https://www.youtube.com/watch?v=yuu0QcnOVbo
Tripping Pipes	https://www.youtube.com/watch?v=WfR2LPeT2TI
Many more videos	https://www.youtube.com/user/theJOIDESResolution/

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







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

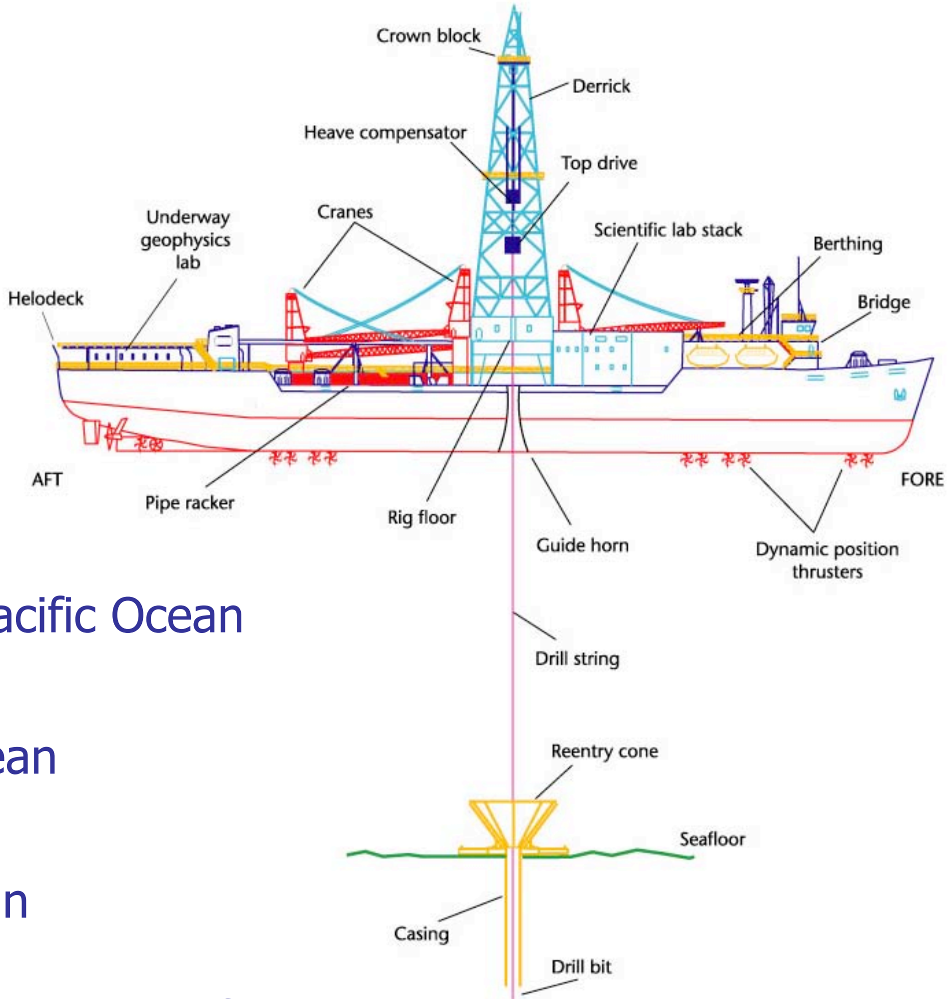
http://www.iodp.org/images/stories/swf/jamstec_english_3_riser_system.swf

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

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

JOIDES Resolution Riserless Drillship

Length	**143 m**
Width	**21 m**
Height of the rig	**61.5 m**
Crew	**111 people**
Drilling pipes	**9 km**



Deepest hole penetrated:
2,111 m Leg 148, Hole 504B, E Pacific Ocean

Shallowest water depth:
37.51 m, Leg 143, NW Pacific Ocean

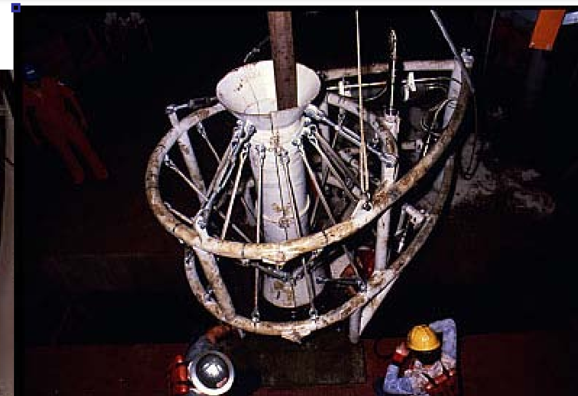
Greatest water depth:
5,980 m, Leg 129, W Pacific Ocean

Minimum water depth according to specifications: 75 m

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

IODP/USIO

Site Surveys



Dynamic Positioning

Drilling

Hole Re-entry

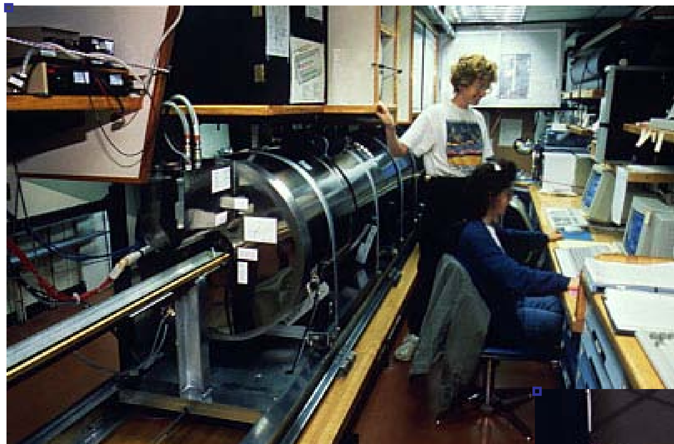
http://www.iodp-usio.org/

Core Handling

Core Logging

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

Geomagnetic logging



Microbiology

Micropaleontology

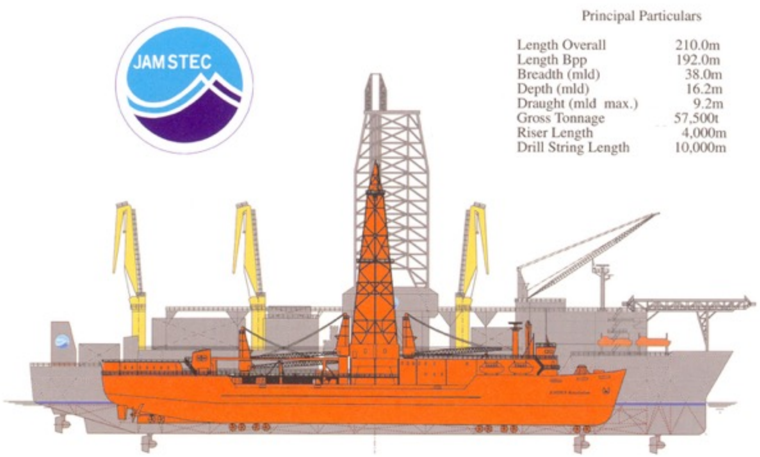
Geochemistry

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

Downhole Logging

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

Chikyu Riser Drillship



JAPAN (MEXT)

Japan invests in the new deep sea riser drilling vessel Chikyu. The vessel will then be offered to IODP as drilling platform.

http://www.mext.go.jp

Chikyu Riser Drillship

Length	**210 m**
Width	**38 m**
Draft	**9.2 m**
Weight	**57000 Ton**
Crew	**150 people**
Pipes	**10 km**
Riser length	**4 km**

The ship is built and operated by **JAMSTEC**, The Japan Agency for Marine-Earth Science and Technology

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

IODP/CDEX


http://www.jamstec.go.jp/chikyu/
(c)JAMSTEC/CDEX


http://www.jamstec.go.jp/chikyu/
(c)JAMSTEC/CDEX

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

The **U.S.A**. (trough the National Science Foundation, NSF) will re-fit and improve the drilling and laboratory capability of the JOIDES RESOLUTION, and will cover manage the operations of the **non-riser deep water drilling.**

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

Europe + Canada (ECORD) manages drilling operations that neither the JOIDES Resolution nor the Chikyu can do (ice-covered seas, shallow water).

http://www.ecord.org/

ACEX (Arctic Coring Expedition)
IODP Exp. 203 (year 2004)

http://www.ecord.org/


IODP/ECORD
VIDAR VIKING

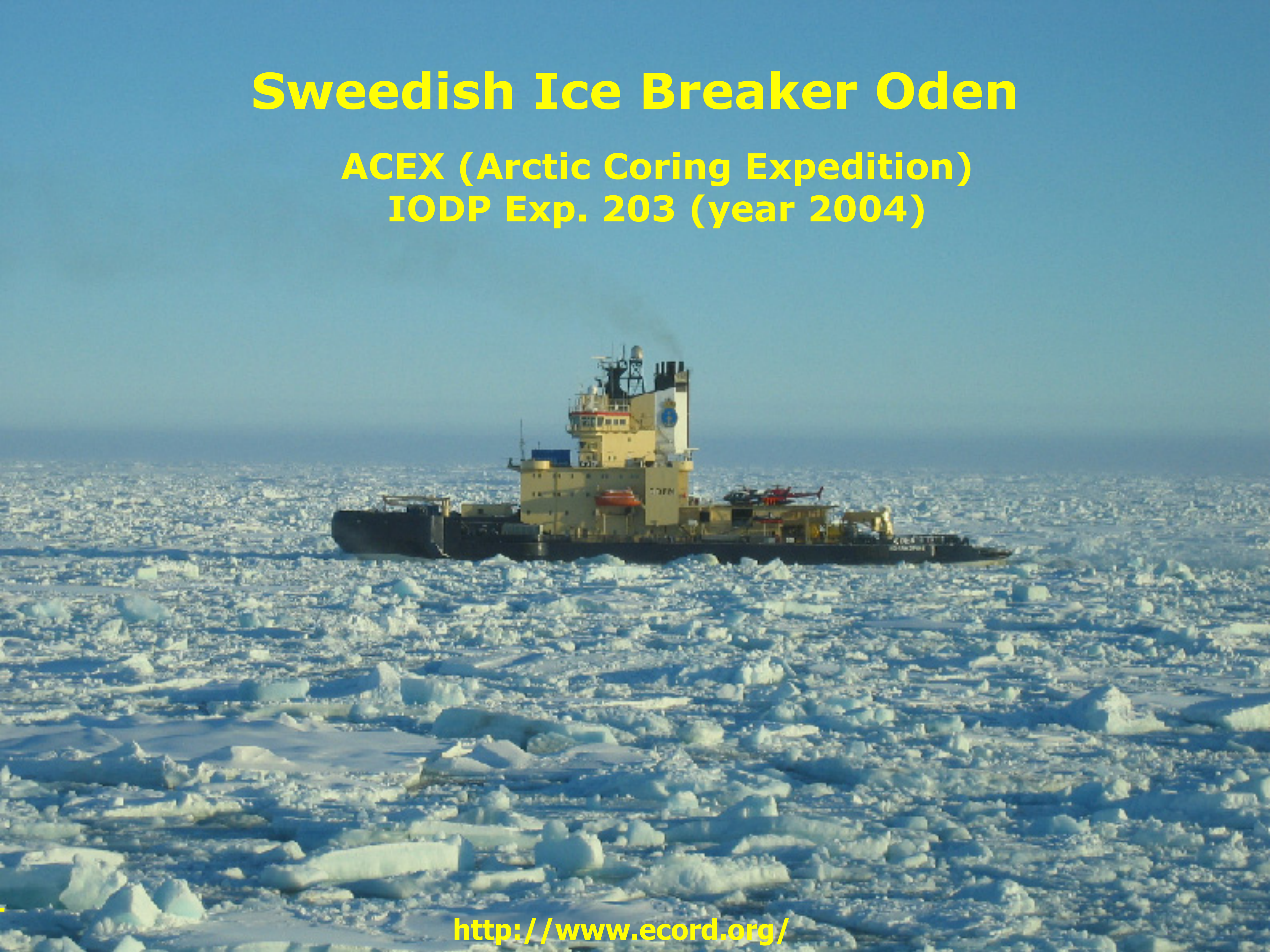
ACEX (Arctic Coring Expedition)
IODP Exp. 203 (year 2004)

Vidar Viking: the drill ship

http://www.ecord.org/

Sweedish Ice Breaker Oden

ACEX (Arctic Coring Expedition)
IODP Exp. 203 (year 2004)



http://www.ecord.org/

Russian Ice breaker Sovietsky Soyuz

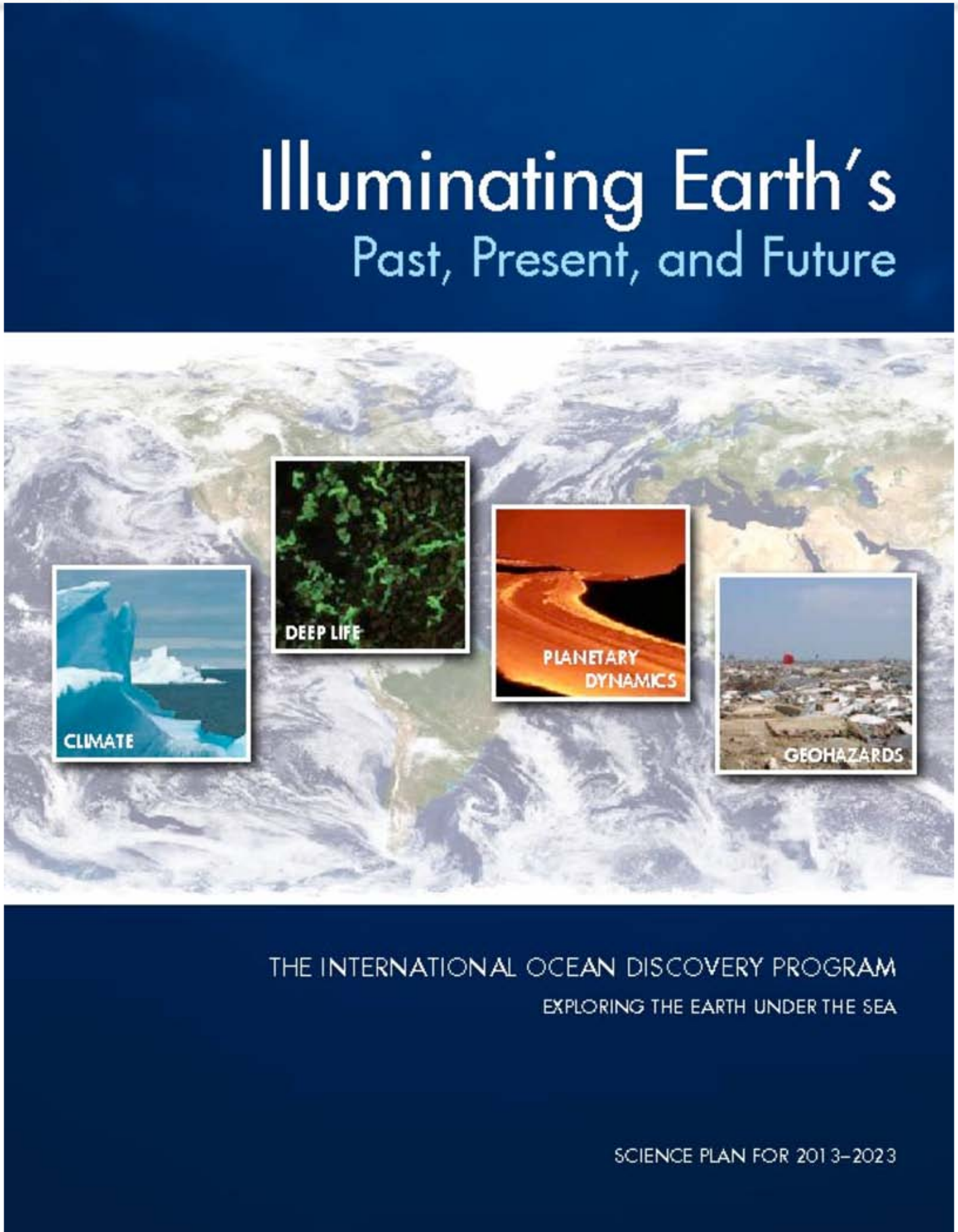
ACEX (Arctic Coring Expedition)
IODP Exp. 203 (year 2004)

DP Hunter, IODP Tahiti Sea Level Expedition (IODP Expedition- 310)

http://www.ecord.org/

DP Hunter, IODP Tahiti Sea Level Expedition (IODP Expedition- 310, year 2005)

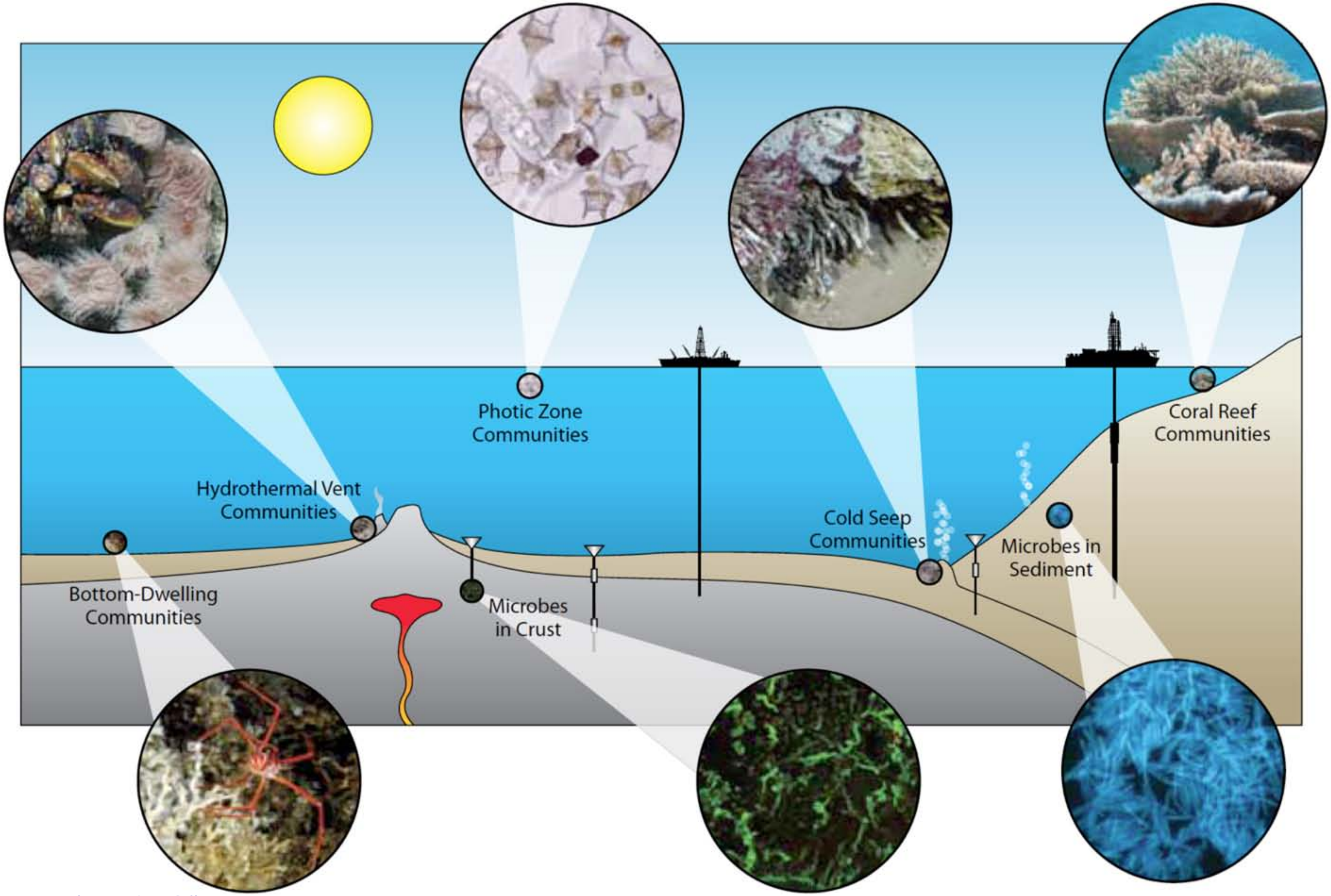
http://www.ecord.org/



Research Themes

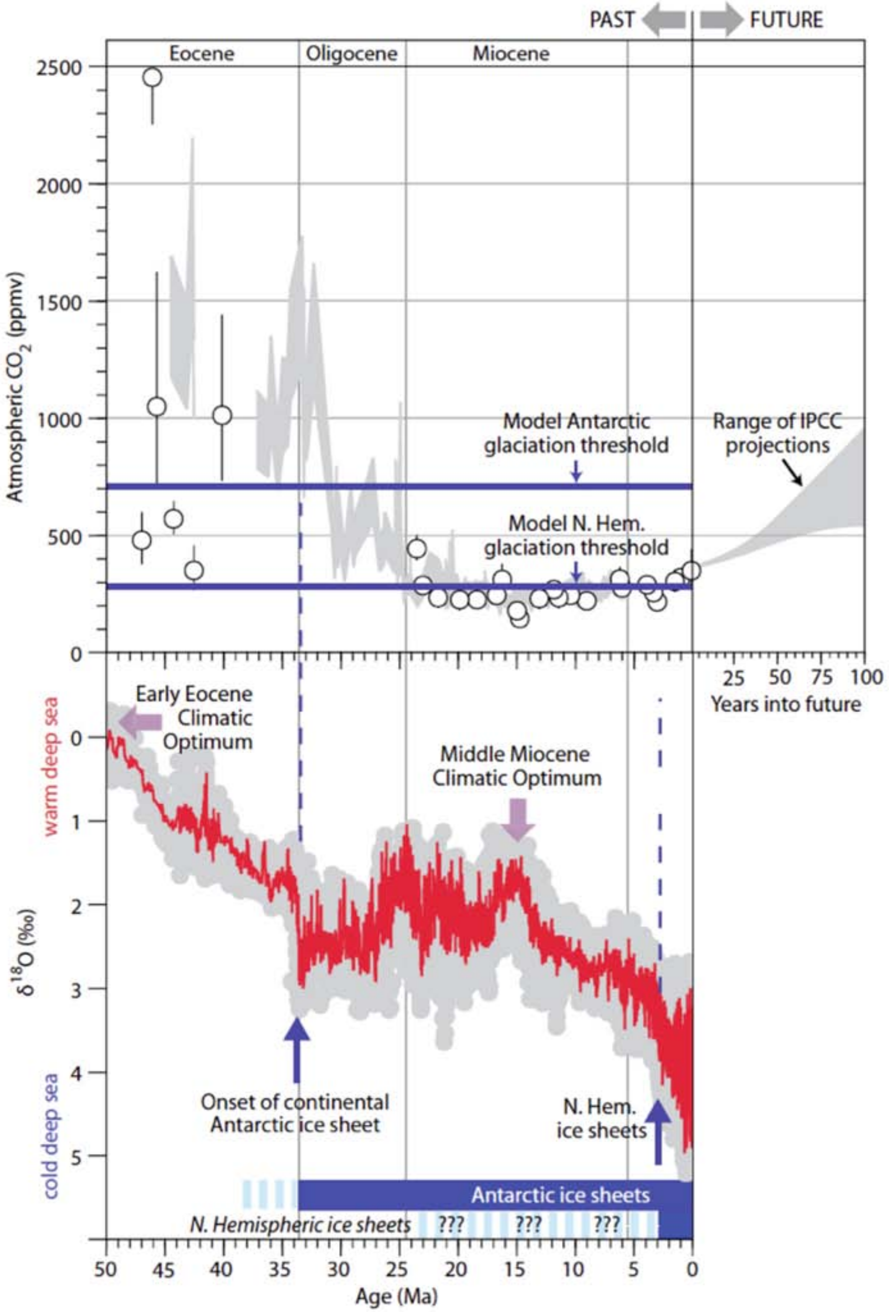
- Climate and Ocean Change: Reading the Past, Informing the Future
- Biosphere Frontiers: Deep Life, Biodiversity, and Environmental Forcing of Ecosystems
- Earth Connections: Deep Processes and Their Impact on Earth's Surface Environment
- Earth in Motion: Processes and Hazards on Human Time Scales

Education AND OUTREACH

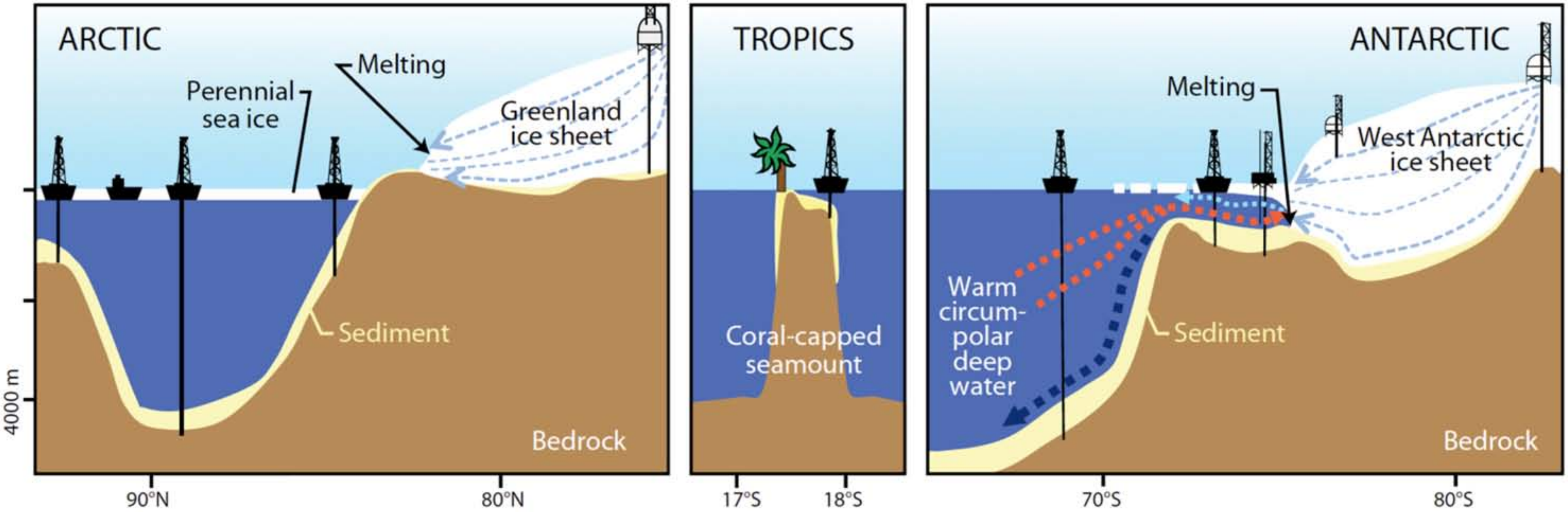


New Science Plan and as follows:
Bottom Dwelling: Ross (2007; Figure 3), Hydrothermal Vents: Devey at al. (2007, Figure 2), Microbes in Crust: Orcutt et al. (2010), Photic Zone: M. Montresor, SZN/Alfred Wegener Institute, Cold Seep Communities: Vanreusel et al. (2009, Figure 6A), Microbes in Sediment: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

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

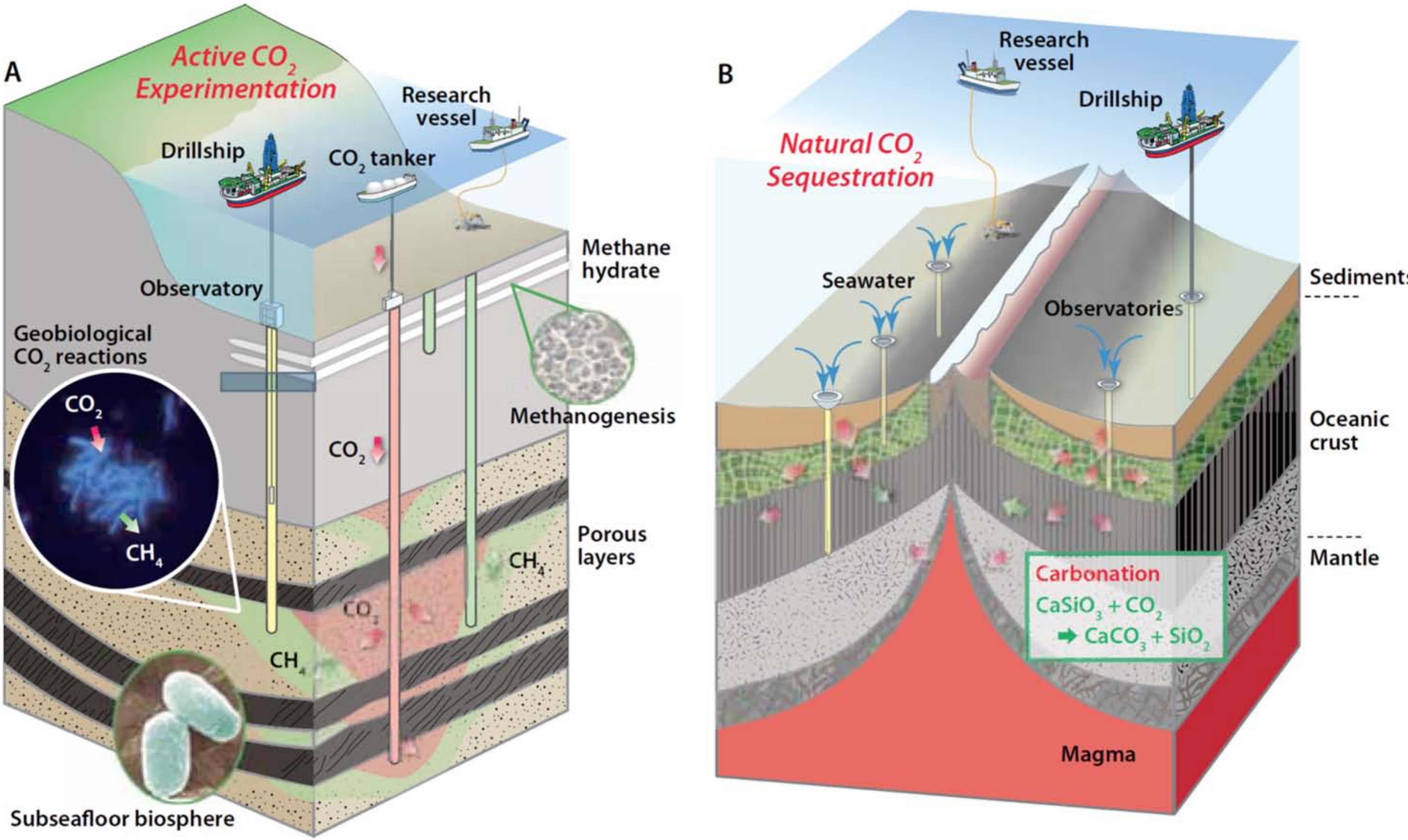


Climate and Ocean Change: Reading the Past, Informing the Future



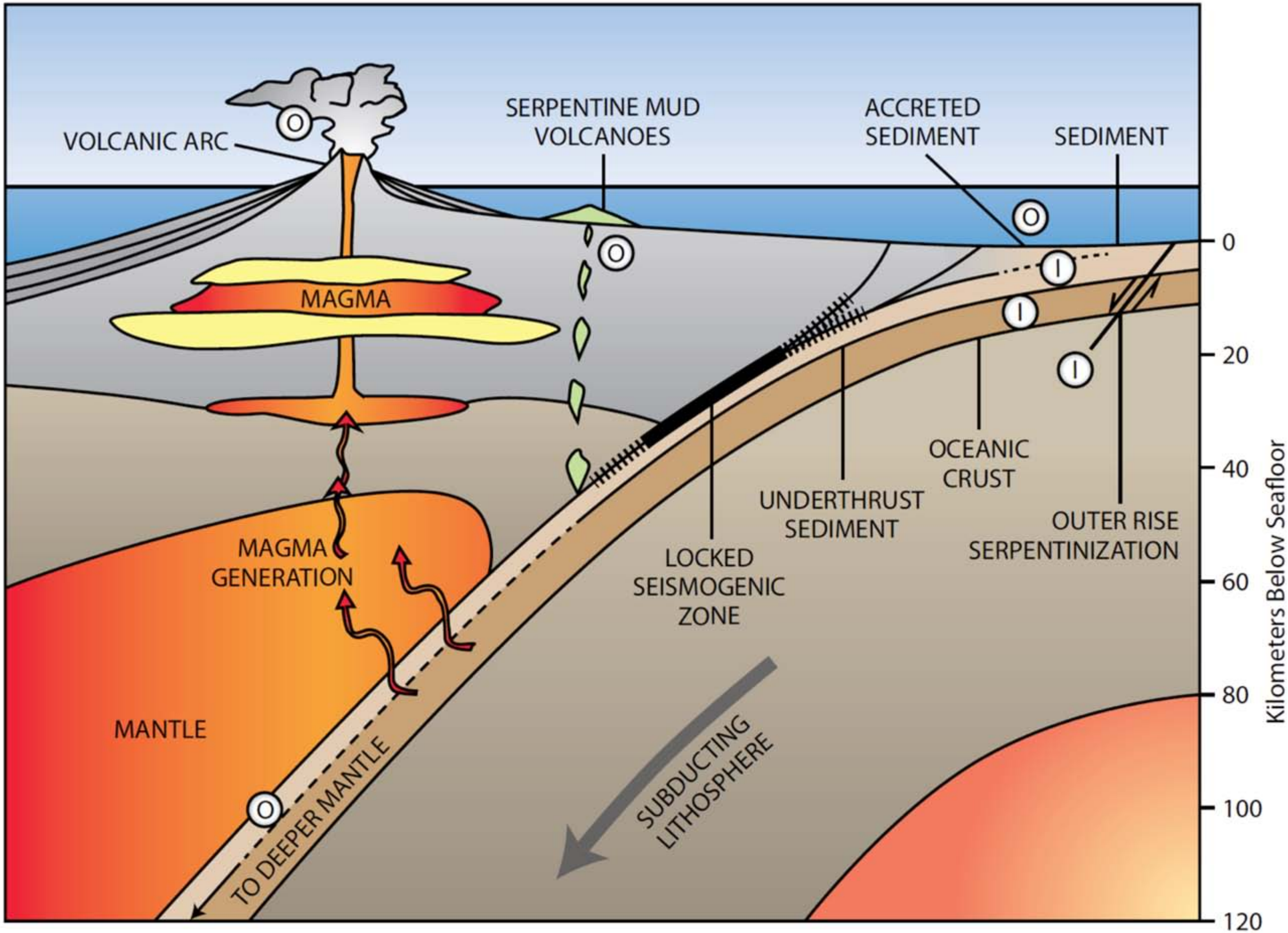
Elements of this figure were adapted from Schoof (2010)

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



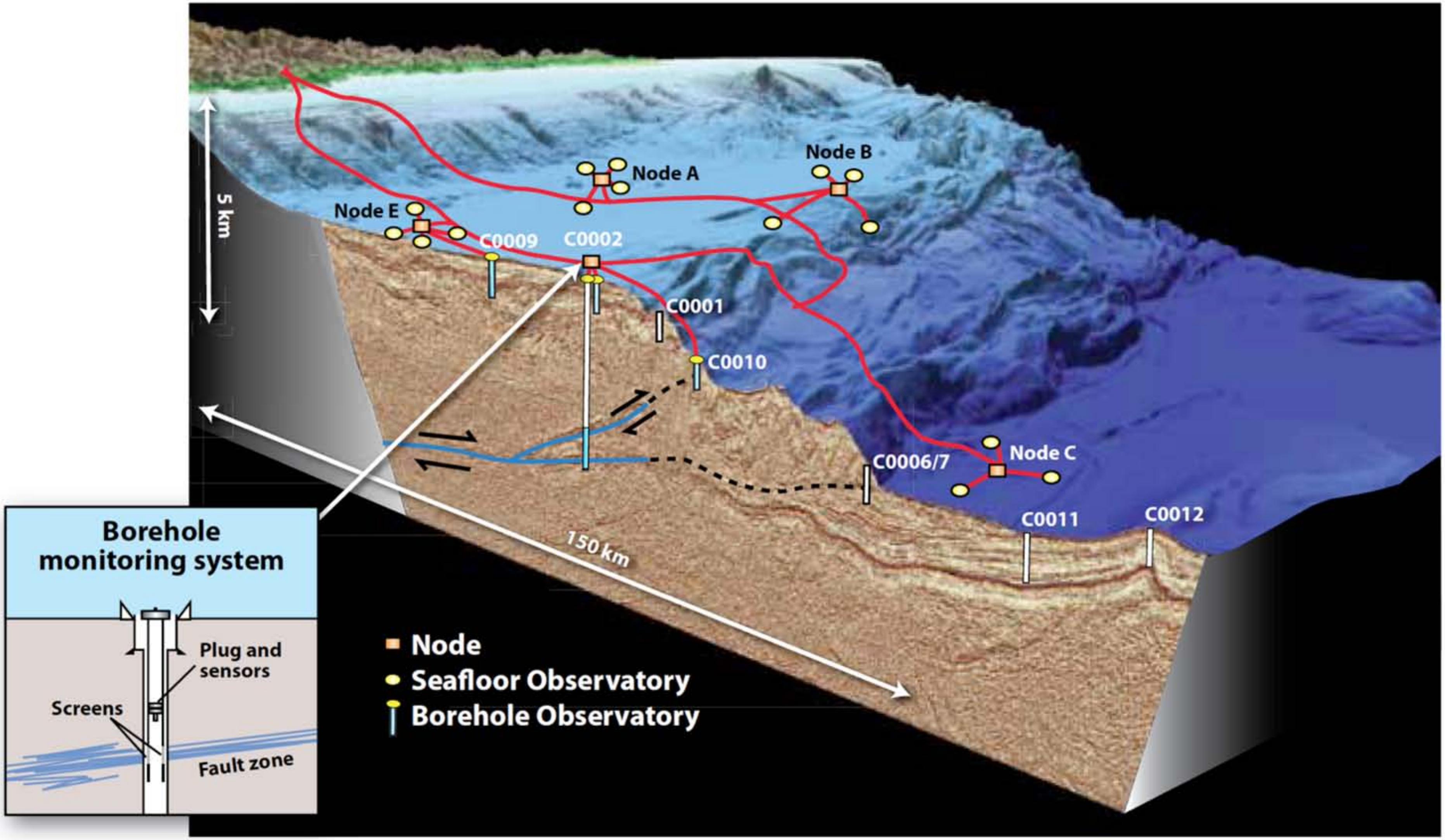
F. Inagaki, JAMSTEC

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



New Science Plan

Earth in Motion: Processes and Hazards on Human Time Scales



Inset from Expedition 319 Scientists (2010)

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)

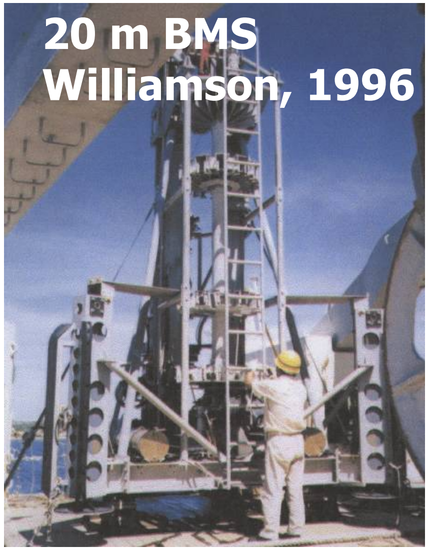
Advantages of sea bed drill rigs

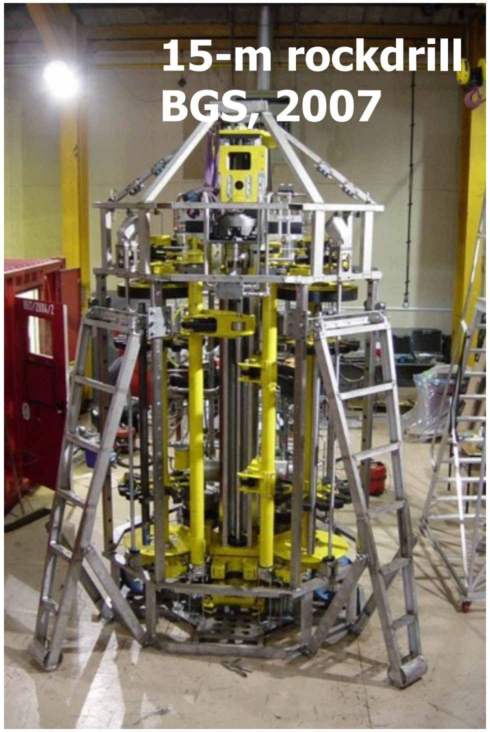
- Stable platform – optimal drill bit control
- No need for drill pipe through the water column
- Operation from multipurpose research vessels

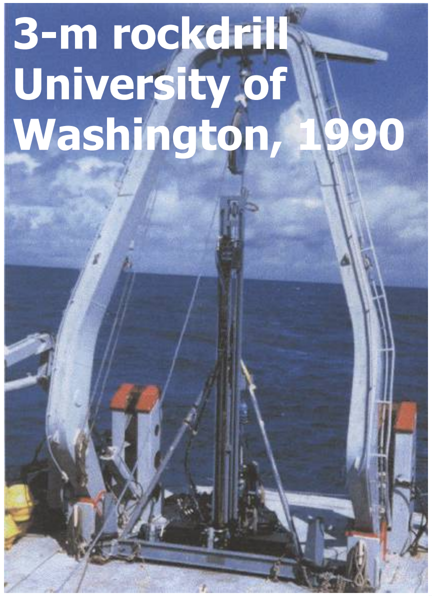
Seabed Rig AS

Courtesy Tim Freudenthal, MARUM, Bremen

Existing seabed drill rigs







Courtesy Tim Freudenthal, MARUM, Bremen

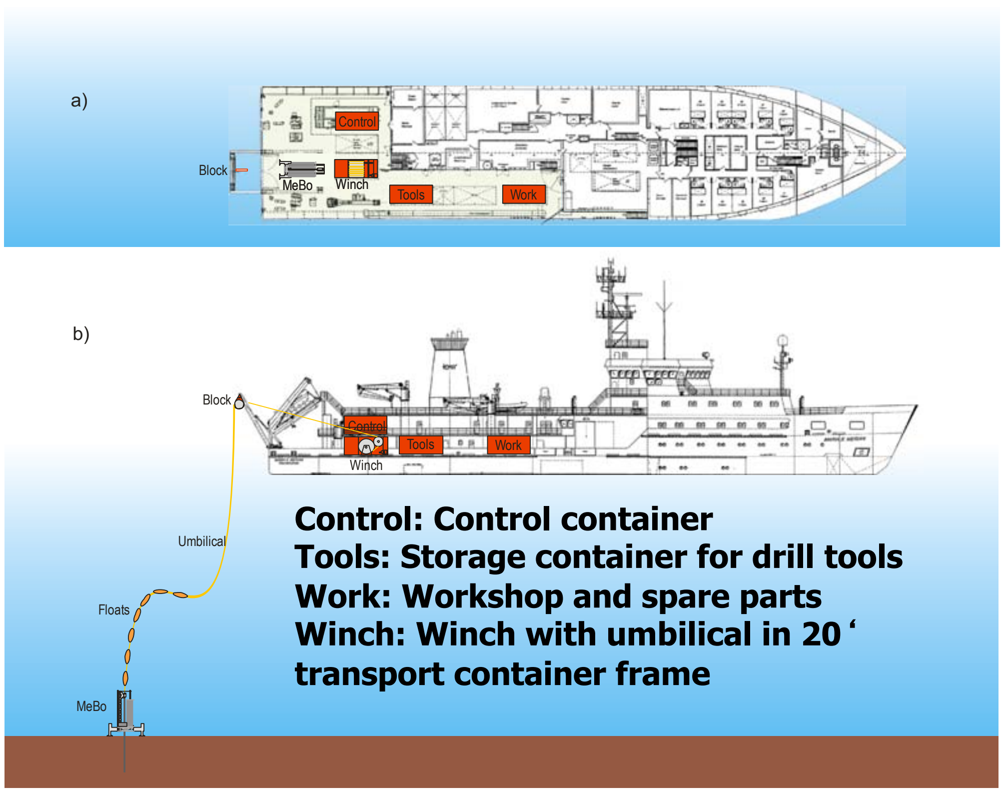
marum

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 Tim Freudenthal, MARUM, Bremen

Concept of MeBo



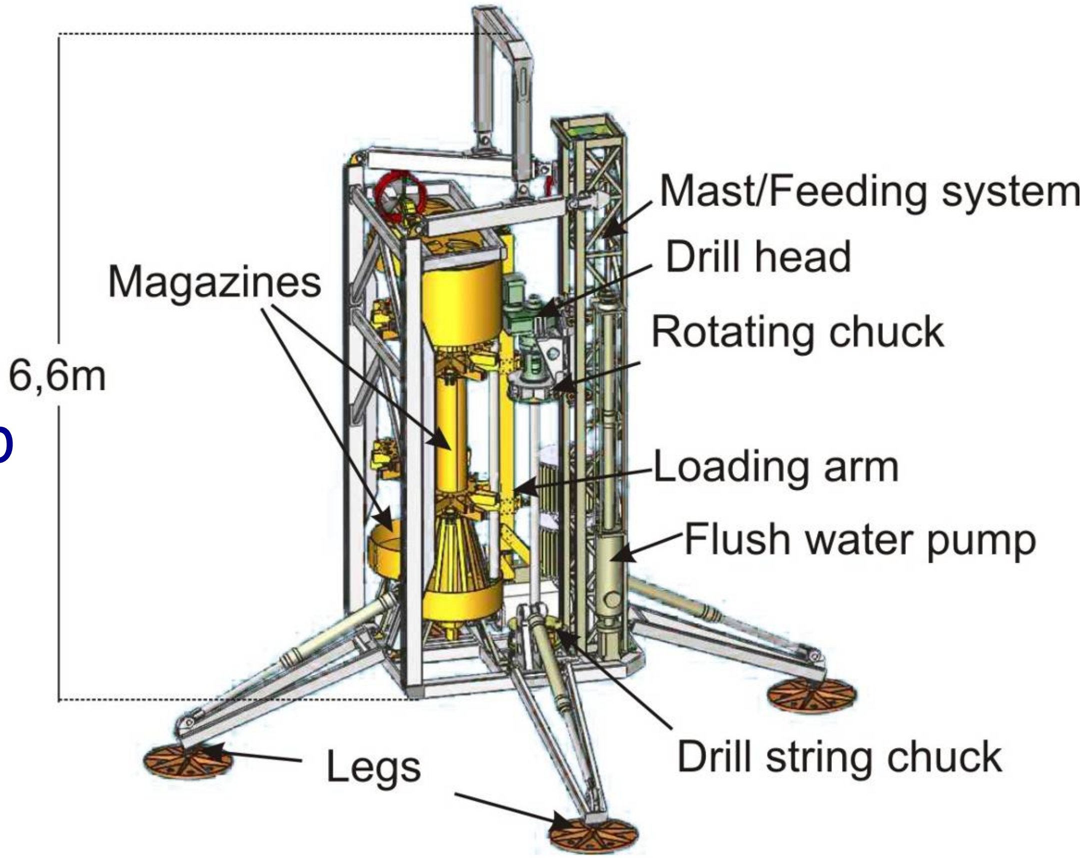
- Umbilical is used to lower the drill rig to the sea floor
- Umbilical is used for energy supply and remote control from the vessel

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

Courtesy Tim Freudenthal, MARUM, Bremen

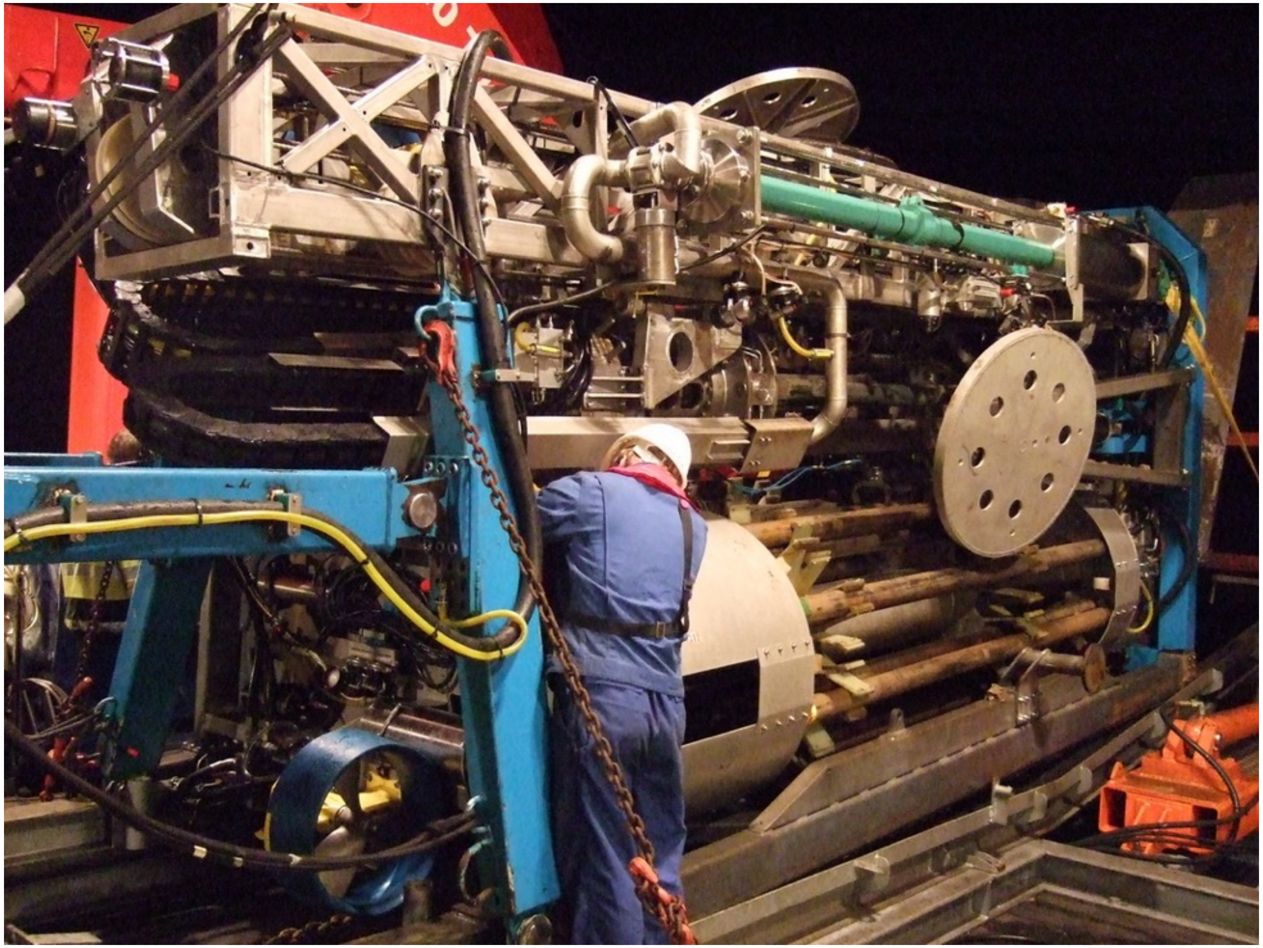
Concept

- 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



Courtesy Tim Freudenthal, MARUM, Bremen

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.

System

Winch

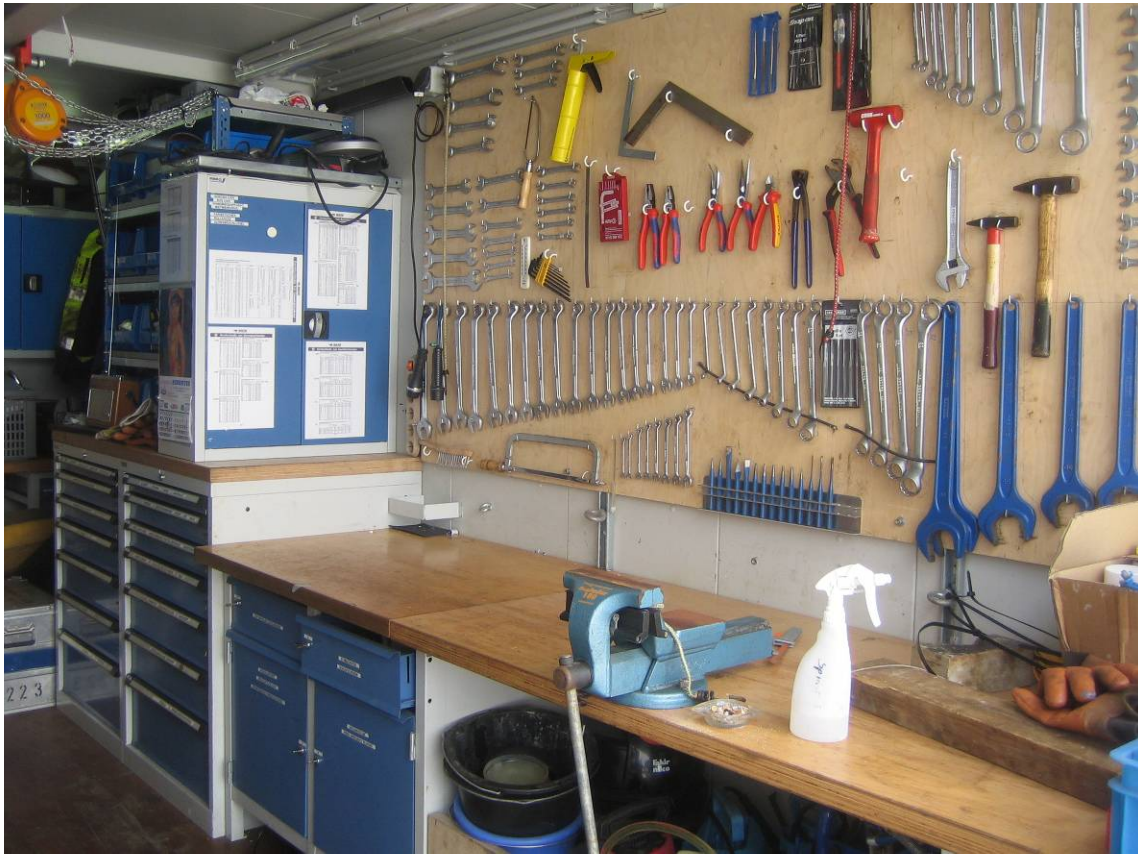
The winch stores 2500 m of the umbilical. The pull force of the winch in the upper layer is 12 tonnes.

System

Control Unit

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

System



Workshop

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

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.

Courtesy Tim Freudenthal, MARUM, Bremen

MeBo 2004/2005 (HBFG)

Wire-line 2007/2008 (HBFG)

Pressure Core Barrel 2008/2010 (BMBF, SUGAR)

Borehole Logging (2010)