



Università di Trieste
Corso di Laurea in Geologia

Anno accademico 2015 - 2016

Geologia Marina

Parte II

Modulo 2.4 Perforazione Oceanica

Docente

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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>



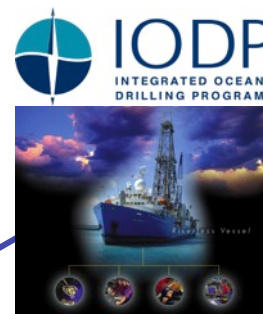
MOHOLE
1958-1966



Deep Sea Drilling Project (DSDP)
1968-1983



Ocean Drilling Program (ODP)
1985-2003



Integrated Ocean Drilling Program (IODP)
2003- 2013

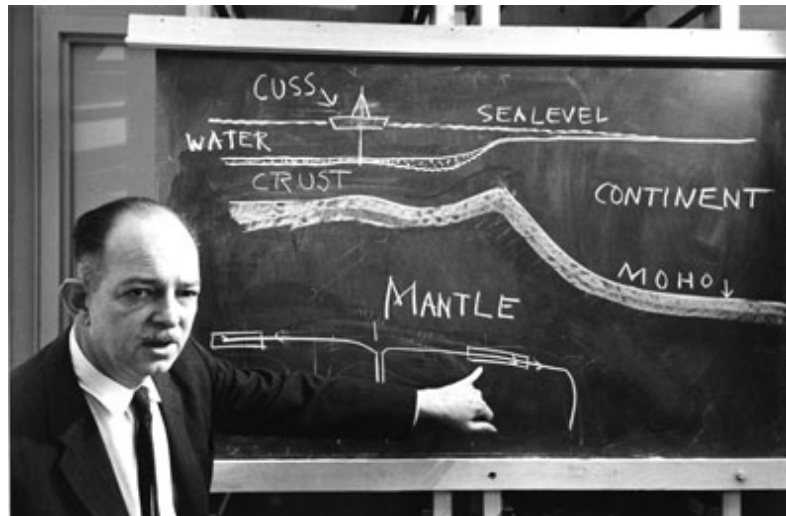


October 2013

International Ocean Discovery Program (IODP)

End in
October 2023

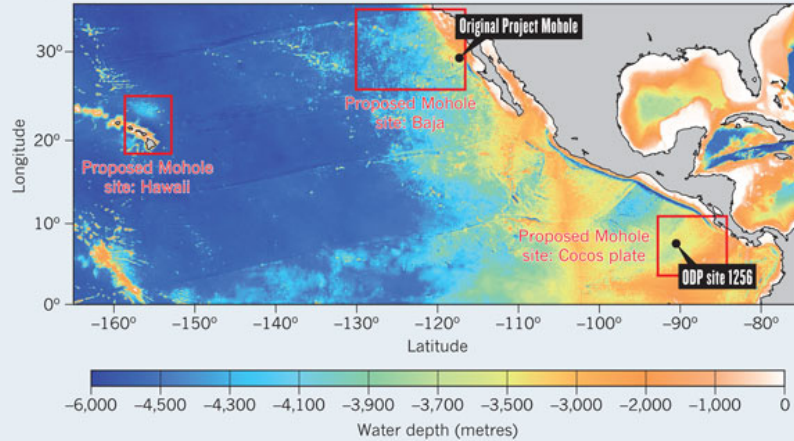
In 1961 scientific drilling took root as a feasible technology to study Earth's subseafloor geology. **Project Mohole**, a concept developed by the American Miscellaneous Society with funding from the National Science Foundation, considered the feasibility of **drilling through the Mohorovičić seismic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



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

DRILLING SITES

Three areas are under consideration for drilling into the mantle. One includes the original Project Mohole drilling site. Another includes a site (ODP site 1256) where scientists will drill this year into the lower crust.



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 phrase 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.

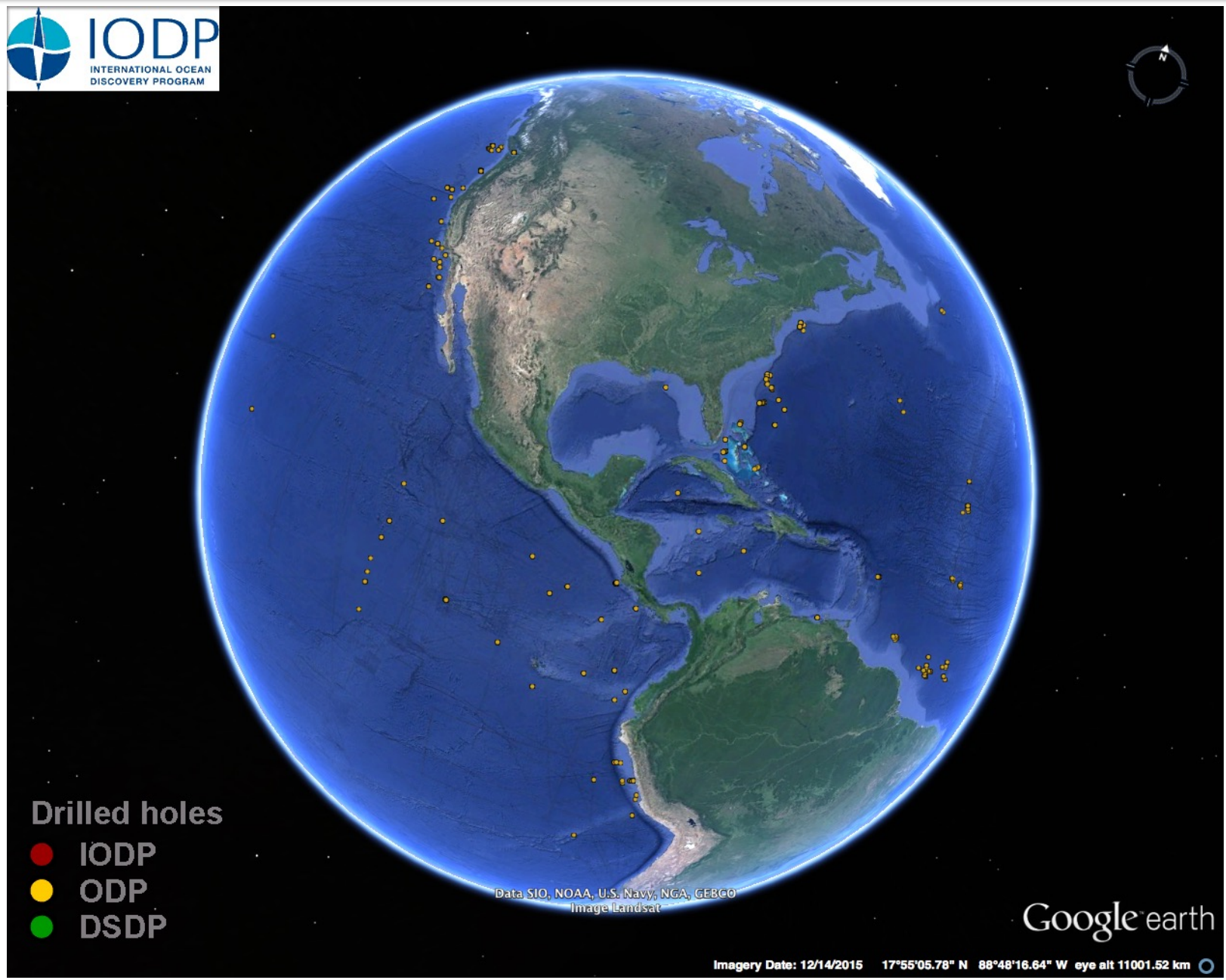


DSDP drillsites in the Mediterranean and North Atlantic



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.





Drilled holes

- IODP
- ODP
- DSDP

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat

Google earth

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 Vessel *Chikyu*, and specialized Mission-Specific-Platforms - were used to reach new areas of the global subsurface during 52 expeditions.





Drilled holes

- IODP
- ODP
- DSDP

Image Landsat
Image U.S. Geological Survey

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

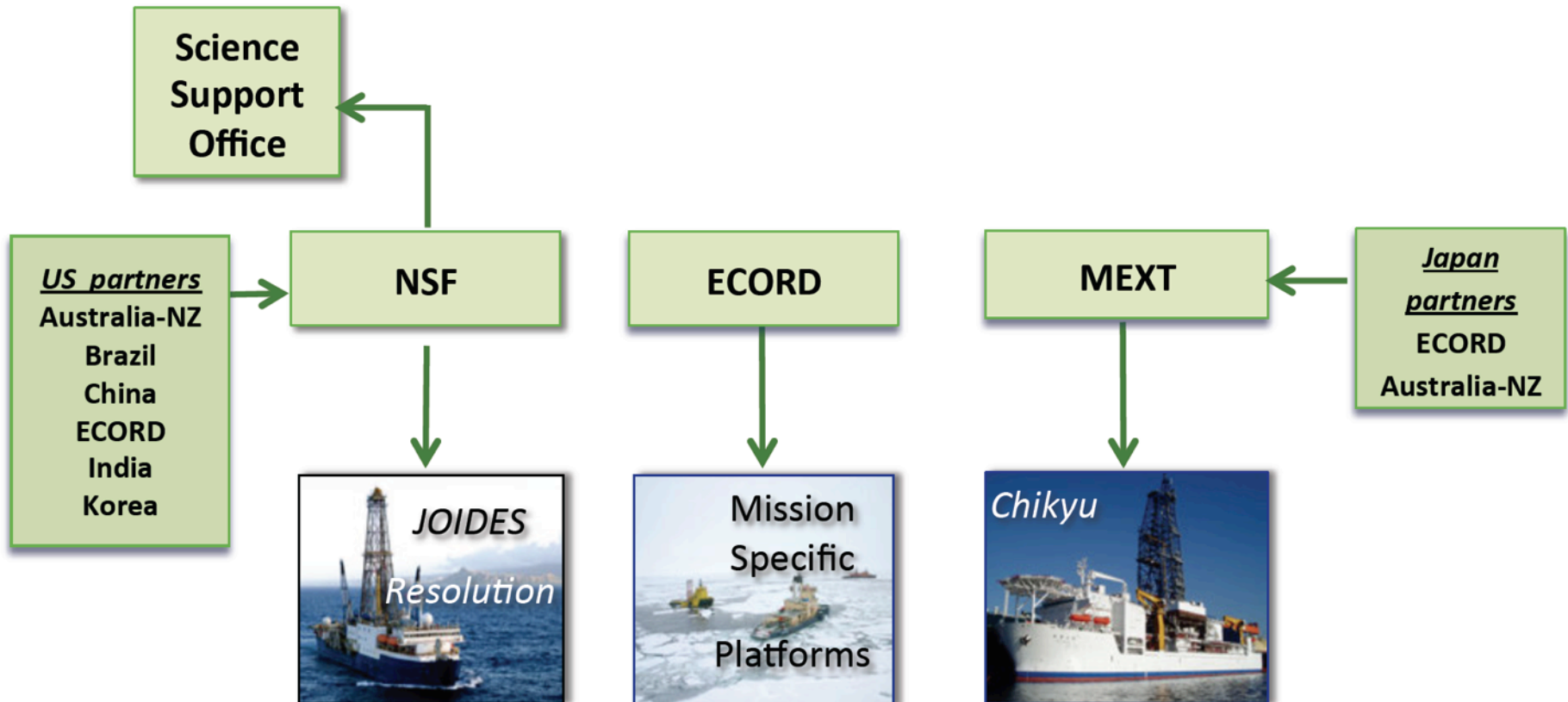
Google earth

Fundamental principles of IODP

- ***science driven project***
- ***science plan :***
*The Deep Biosphere and the Sub-seafloor Ocean
Environmental Change, Processes and Effects
Solid Earth Cycles and Geodynamics*
- ***multiple platform approach to drilling***

IODP Funding Model

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





Science Community

Support Office
and Site Survey
Data Bank

Science Evaluation Panel &
Environmental Protection and Safety Panel

US
Facility
Board

Chikyu
IODP
Board

JR partners
ANZIC
Brazil
China
ECORD
India
Korea

NSF

ECORD
Facility
Board

MEXT

Chikyu
partners
ANZIC
ECORD



ECORD

Mission
Specific
Platforms



I
O
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F
O
R
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M

→ Flow of proposals

IODP members ;
Industry ; Other countries

→ Annual funding
-→ Project-basis funding



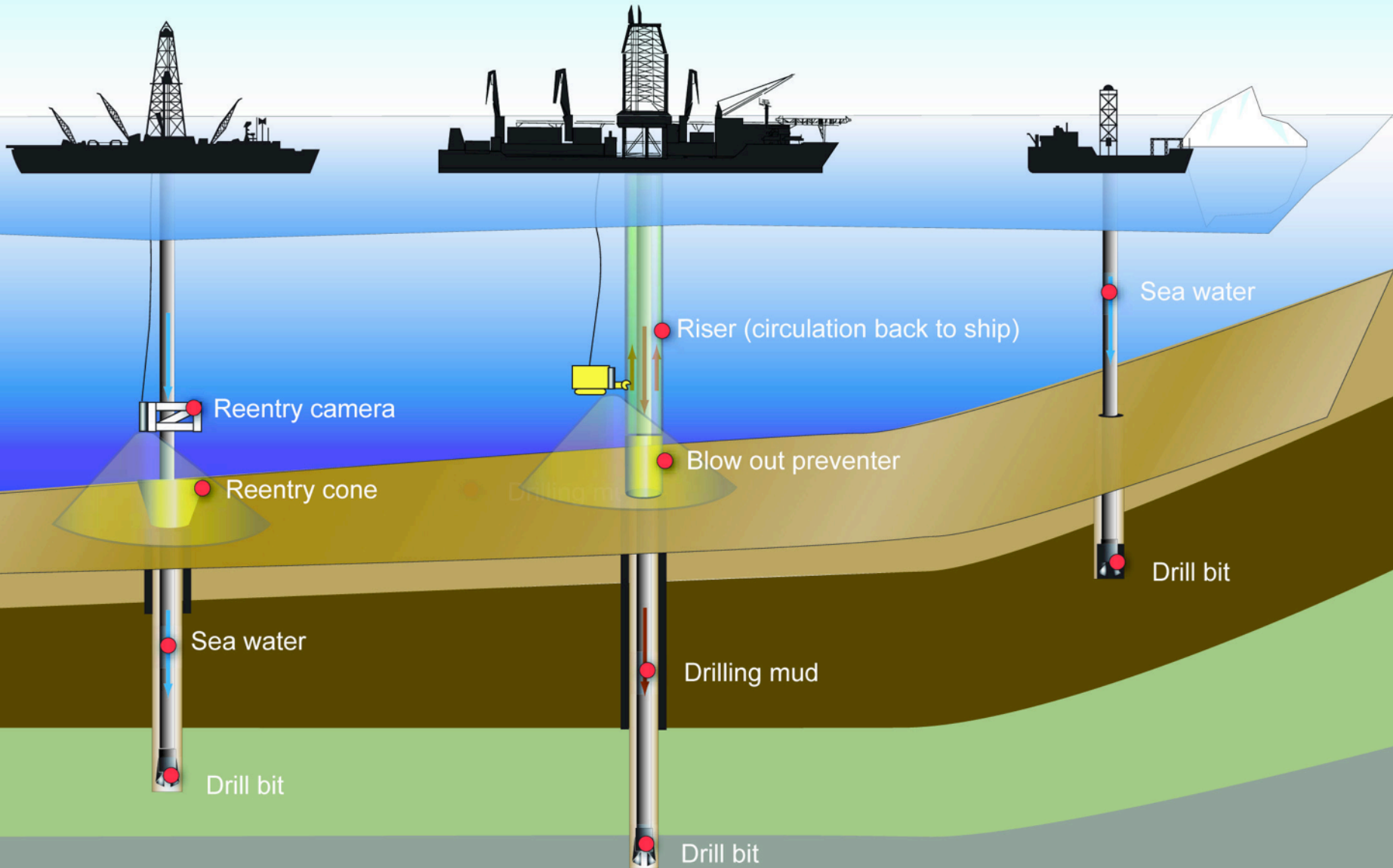
HOW MUCH DOES IT COST? Example from end of IODP phase

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)

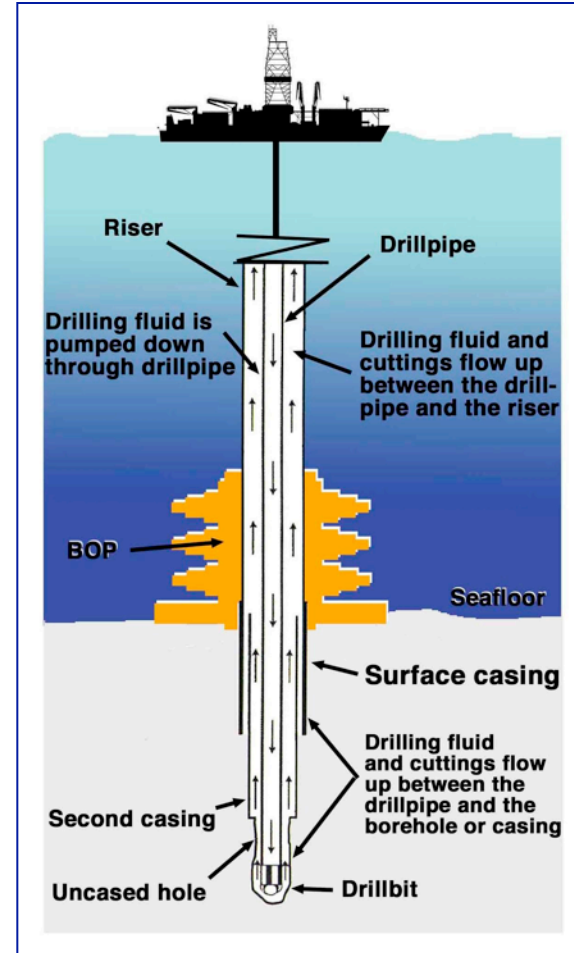
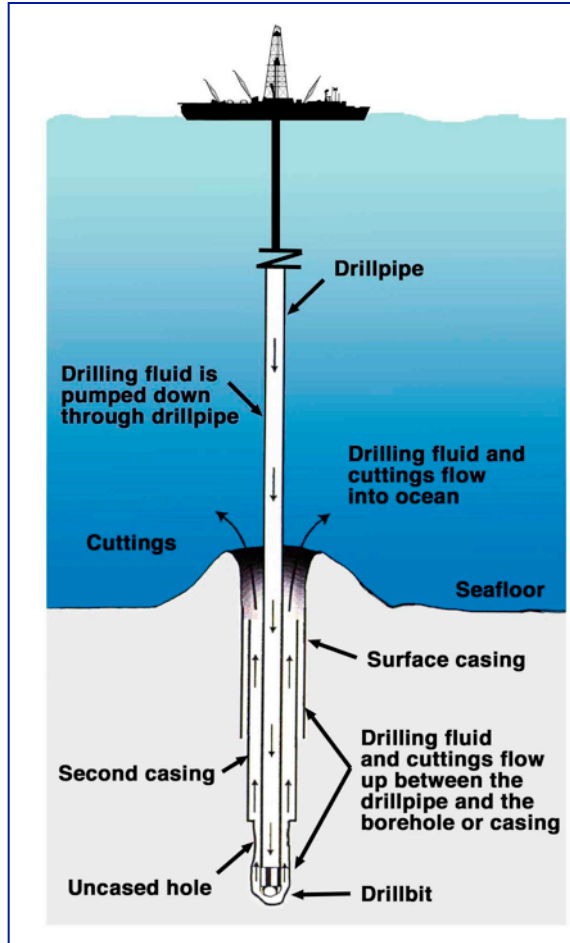
Riserless Drilling

Riser Drilling

Mission-Specific

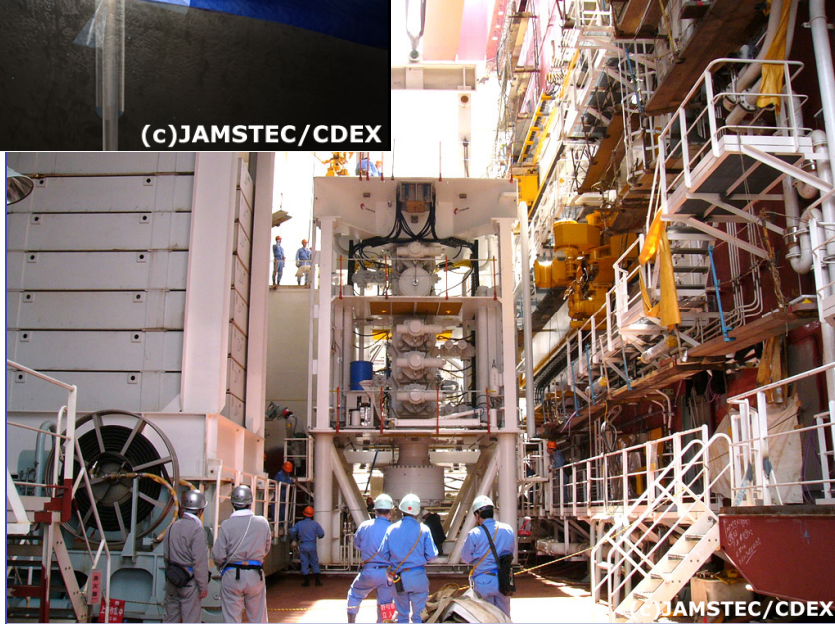
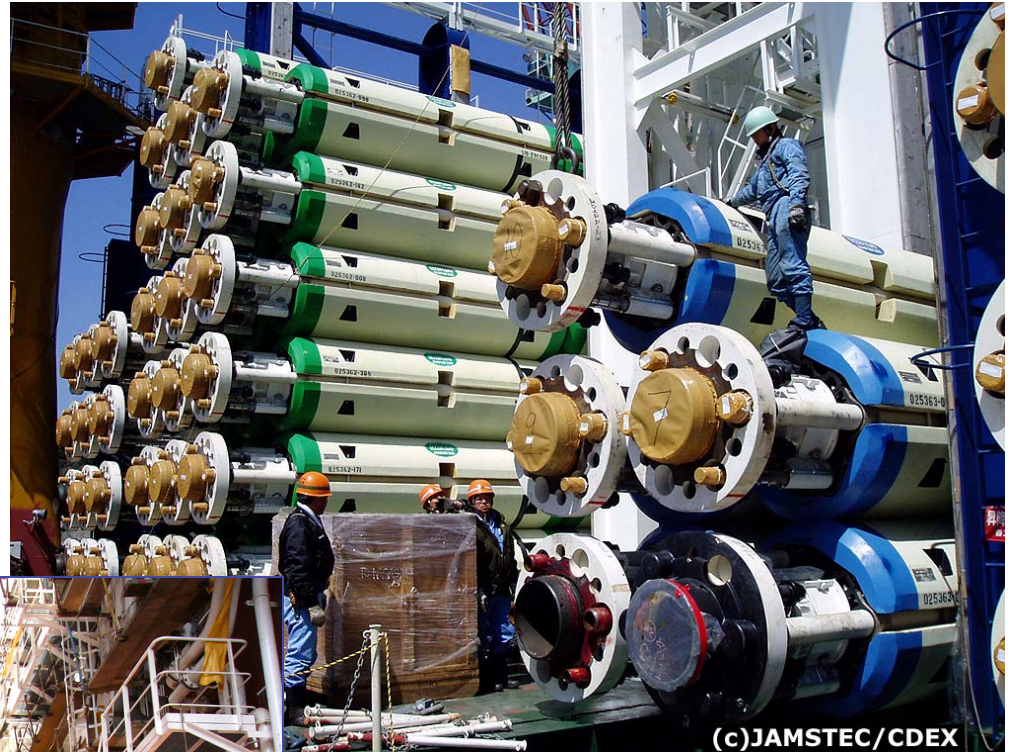
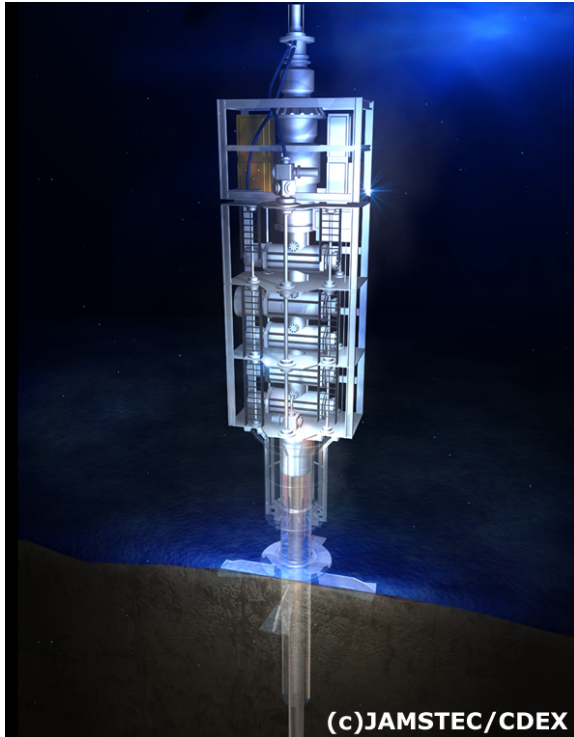


THE 'RISER' DRILLING SYSTEM





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



CORE ON DECK

[http://www.youtube.com/watch?
feature=player_embedded&v=wC9IDPvvze0](http://www.youtube.com/watch?feature=player_embedded&v=wC9IDPvvze0)

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

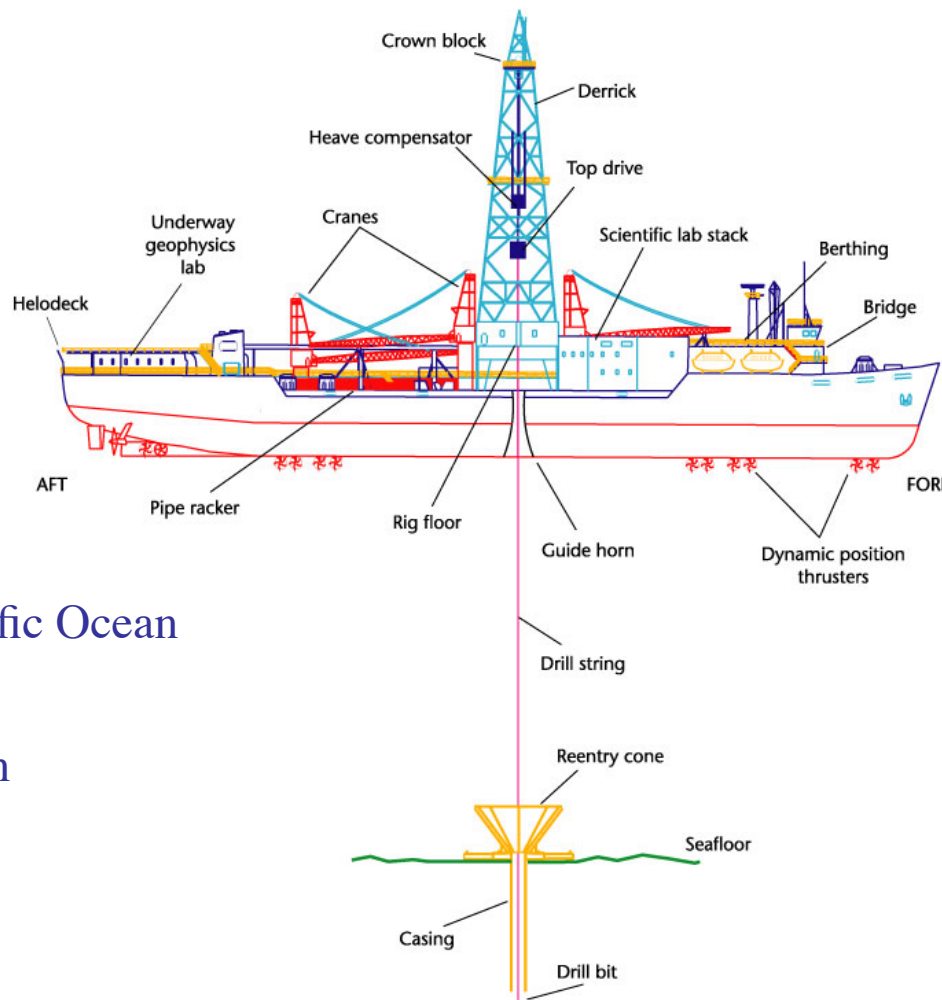
Shallowest water depth:

37.51 m, Leg 143, NW Pacific Ocean

Greatest water depth:

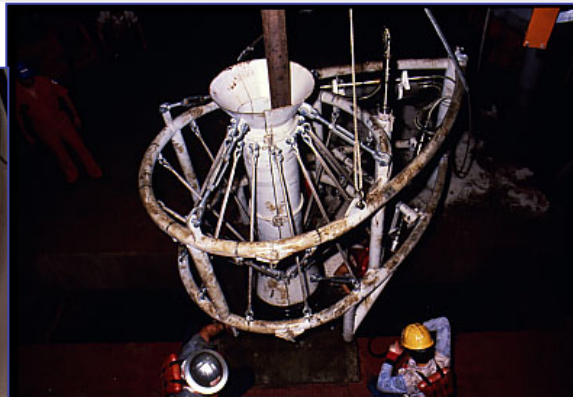
5,980 m, Leg 129, W Pacific Ocean

Minimum water depth according to specifications: 75 m





Site Surveys



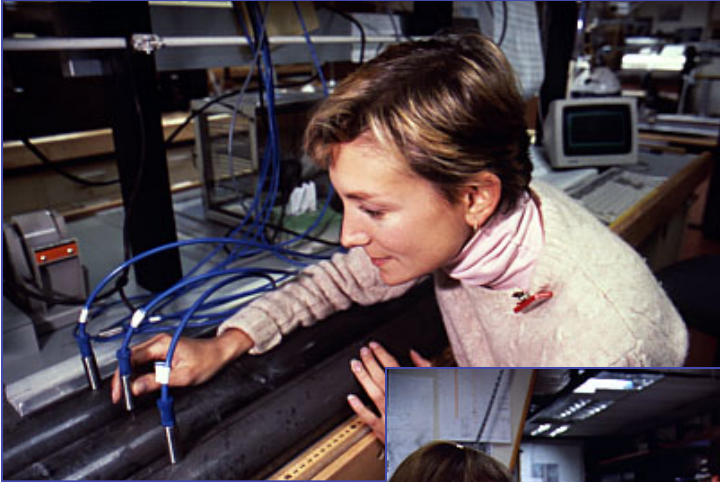
Dynamic Positioning



Drilling



Hole Re-entry

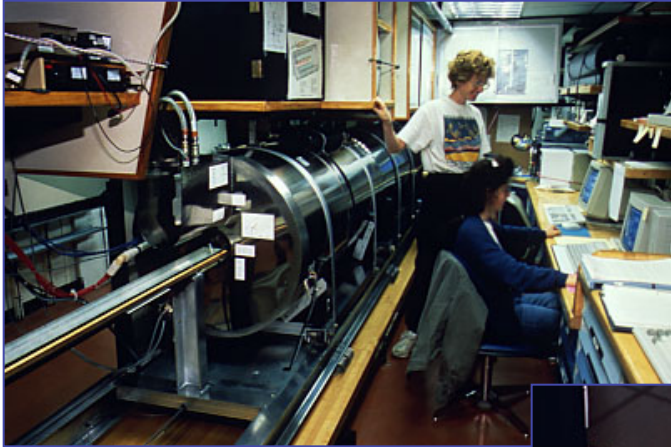


Core Handling

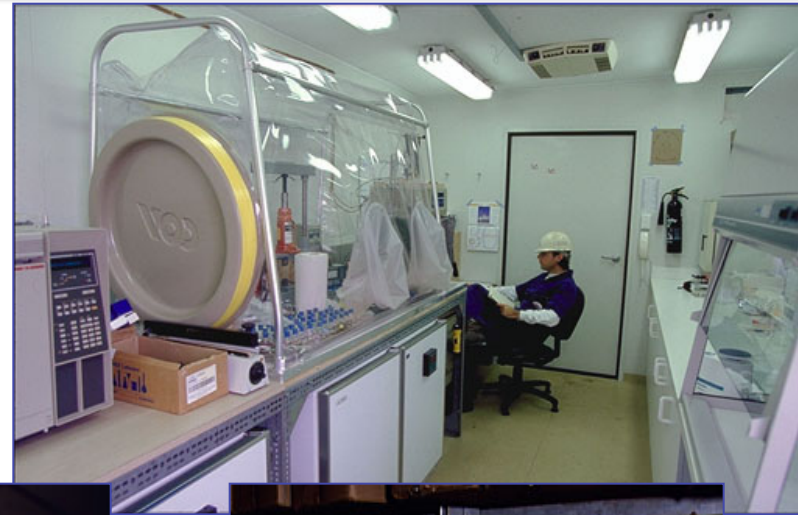


Core Logging

Geomagnetic logging



Microbiology



Micropaleontology

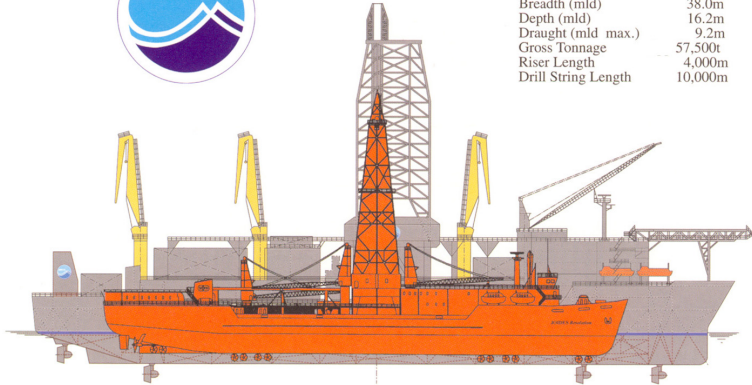


Geochemistry



Downhole Logging

Chikyu Riser Drillship



Principal Particulars

Length Overall	210.0m
Length Bpp	192.0m
Breadth (mld)	38.0m
Depth (mld)	16.2m
Draught (mld max.)	9.2m
Gross Tonnage	57,500t
Riser Length	4,000m
Drill String Length	10,000m

JAPAN (MEXT)

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



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/>

(c)JAMSTEC/CDEX





The **U.S.A.** (through 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**.

JOIDES Resolution Riserless Drillship



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



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





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



Vidar Viking: the drill ship

<http://www.ecord.org/>

Swedish Ice Breaker Oden

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



Russian Ice breaker **Sovietsky Soyuz**

ACEX (Arctic Coring Expedition)

IODP Exp. 203 (year 2004)



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



photo A. Skinner © NERC for ECORD Science Operator

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



Illuminating Earth's Past, Present, and Future

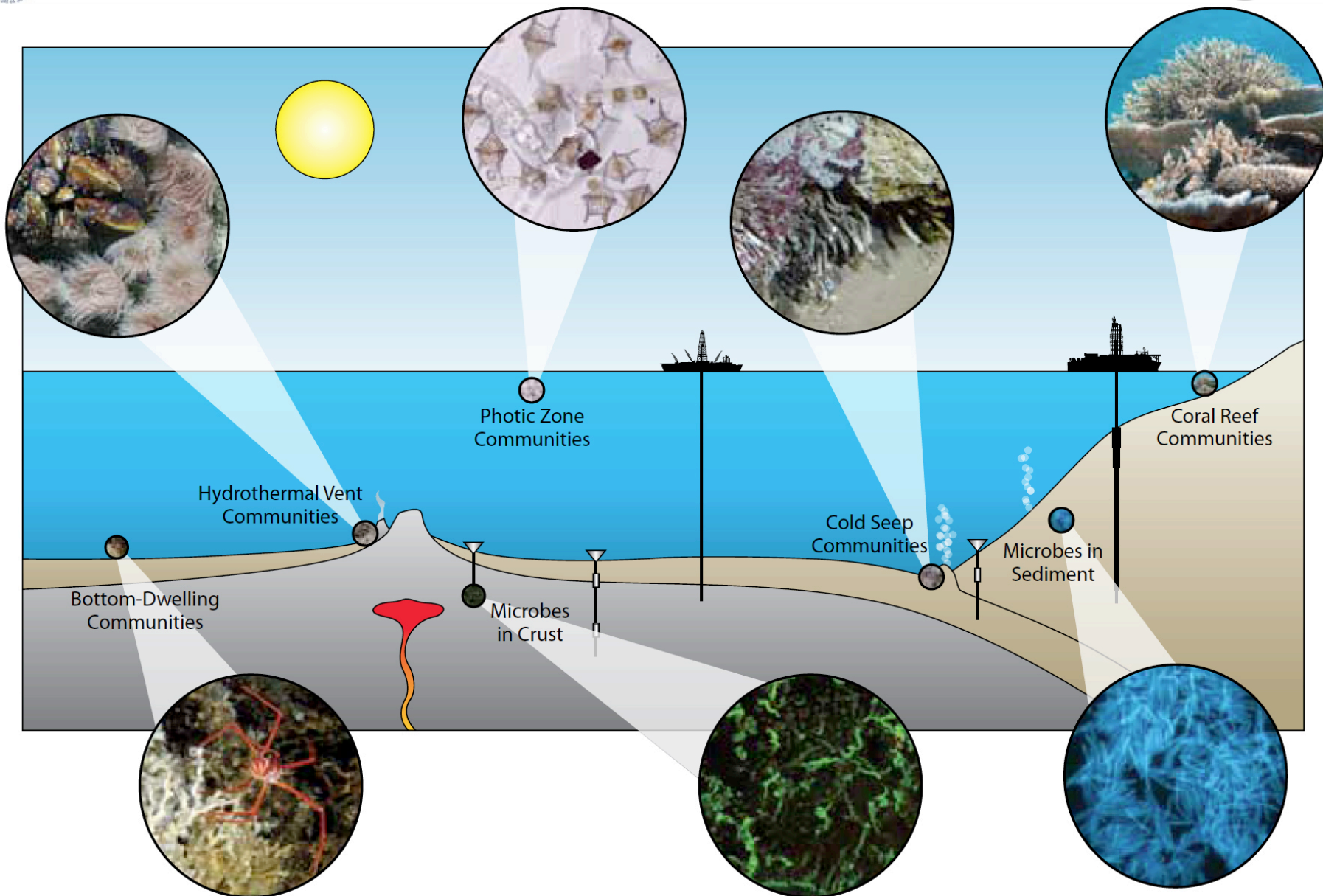


Research Themes

- 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

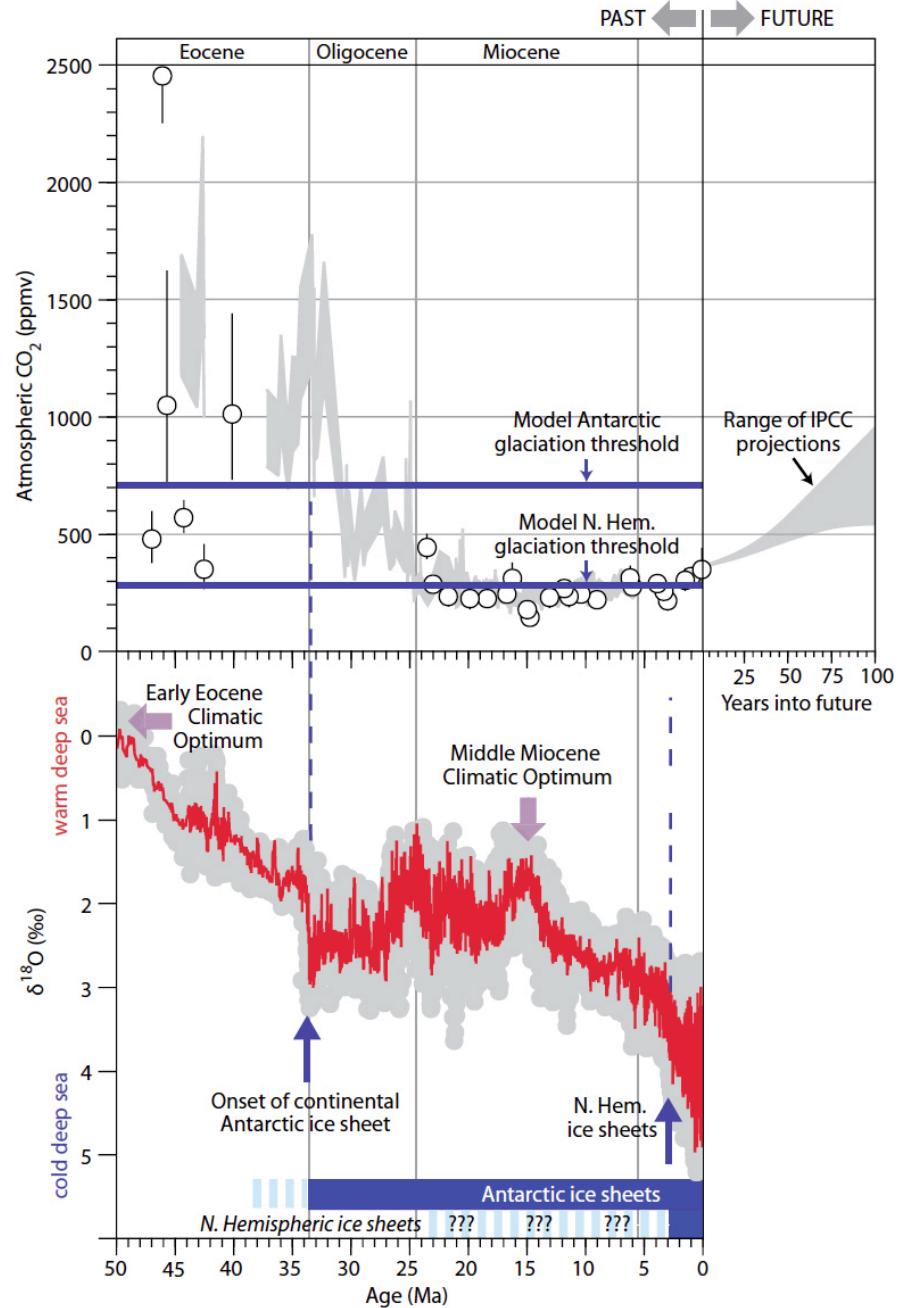
THE INTERNATIONAL OCEAN DISCOVERY PROGRAM
EXPLORING THE EARTH UNDER THE SEA



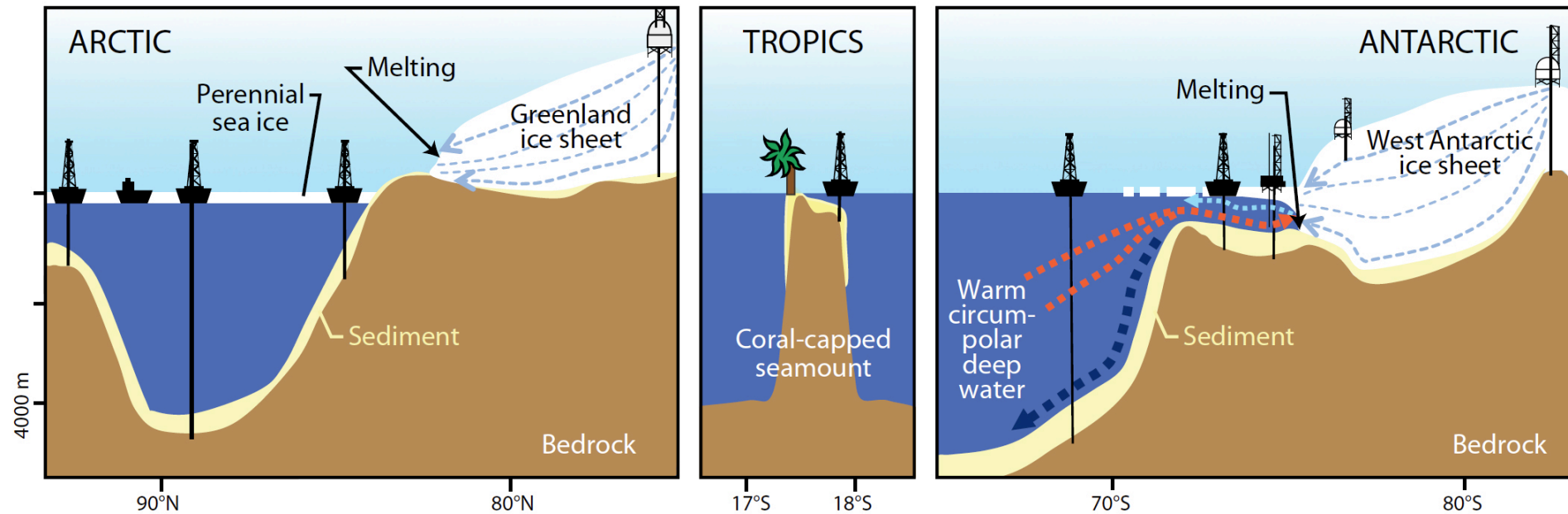
New Science Plan and as follows:

Bottom Dwelling: Ross (2007; Figure 3), Hydrothermal Vents: Devey et 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)

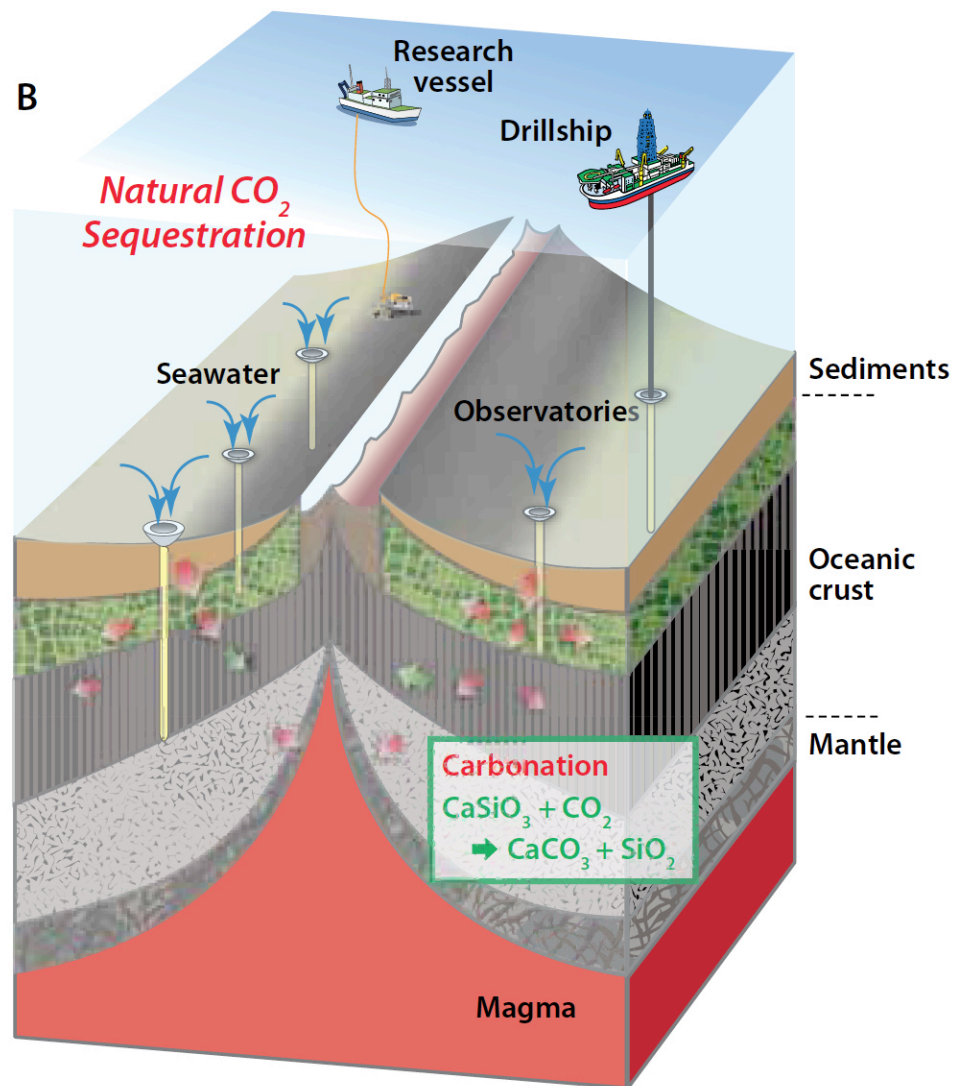
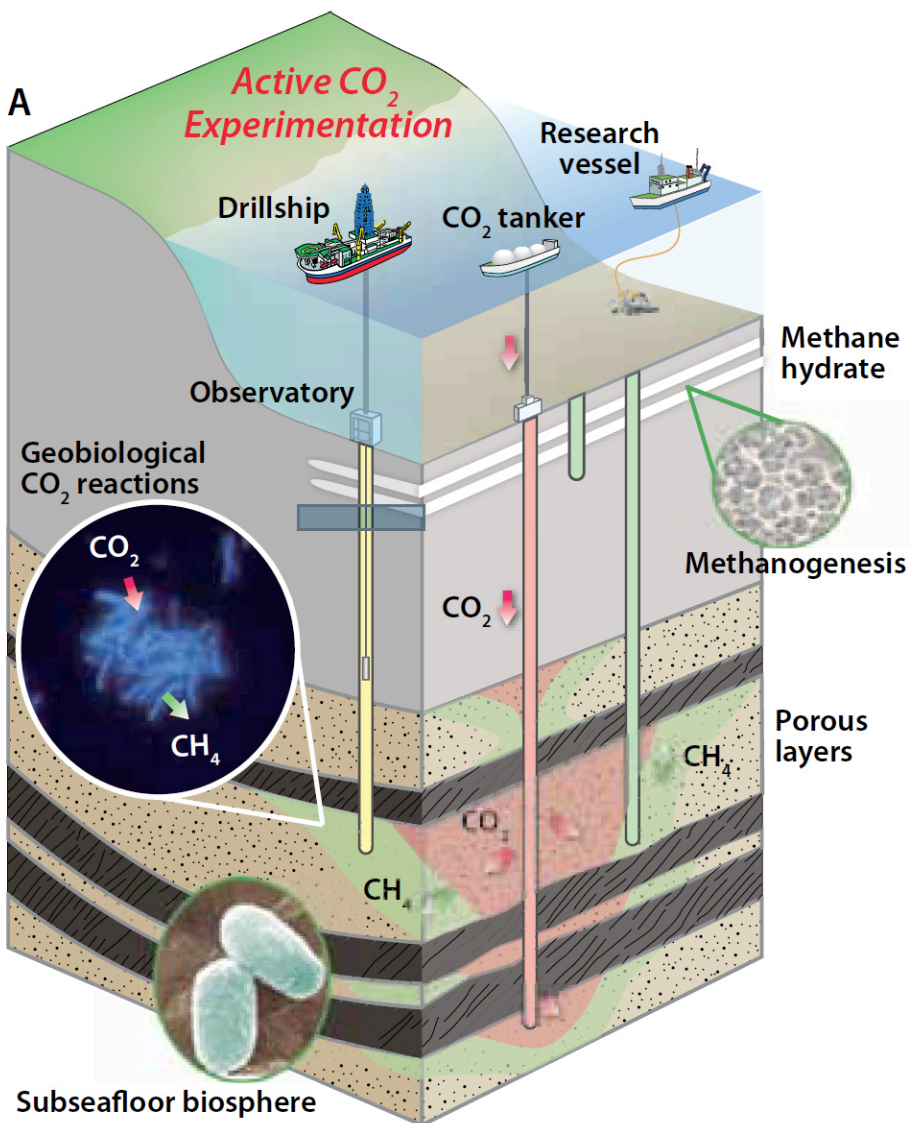
Climate and Ocean Change: Reading the Past, Informing the Future



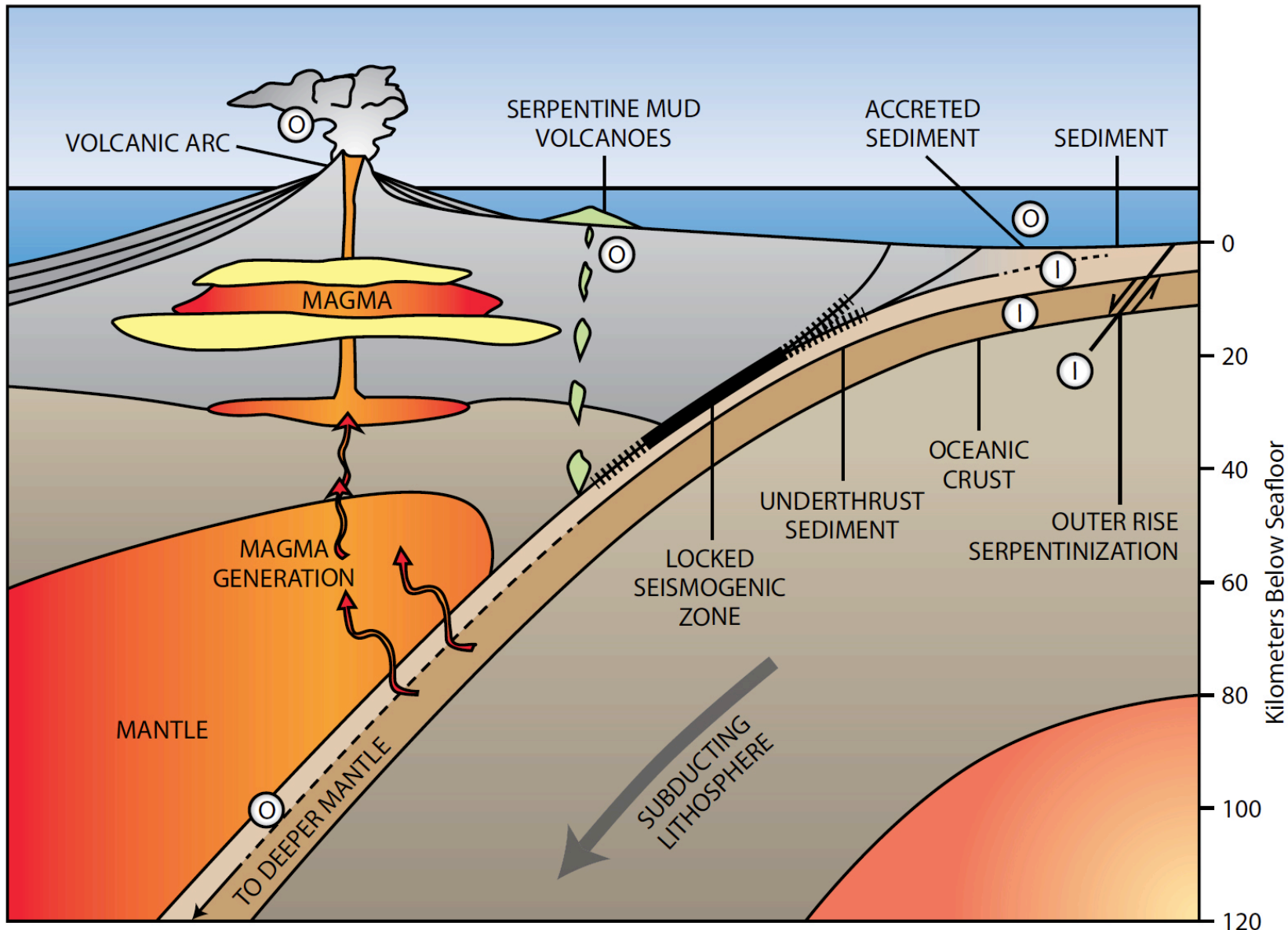
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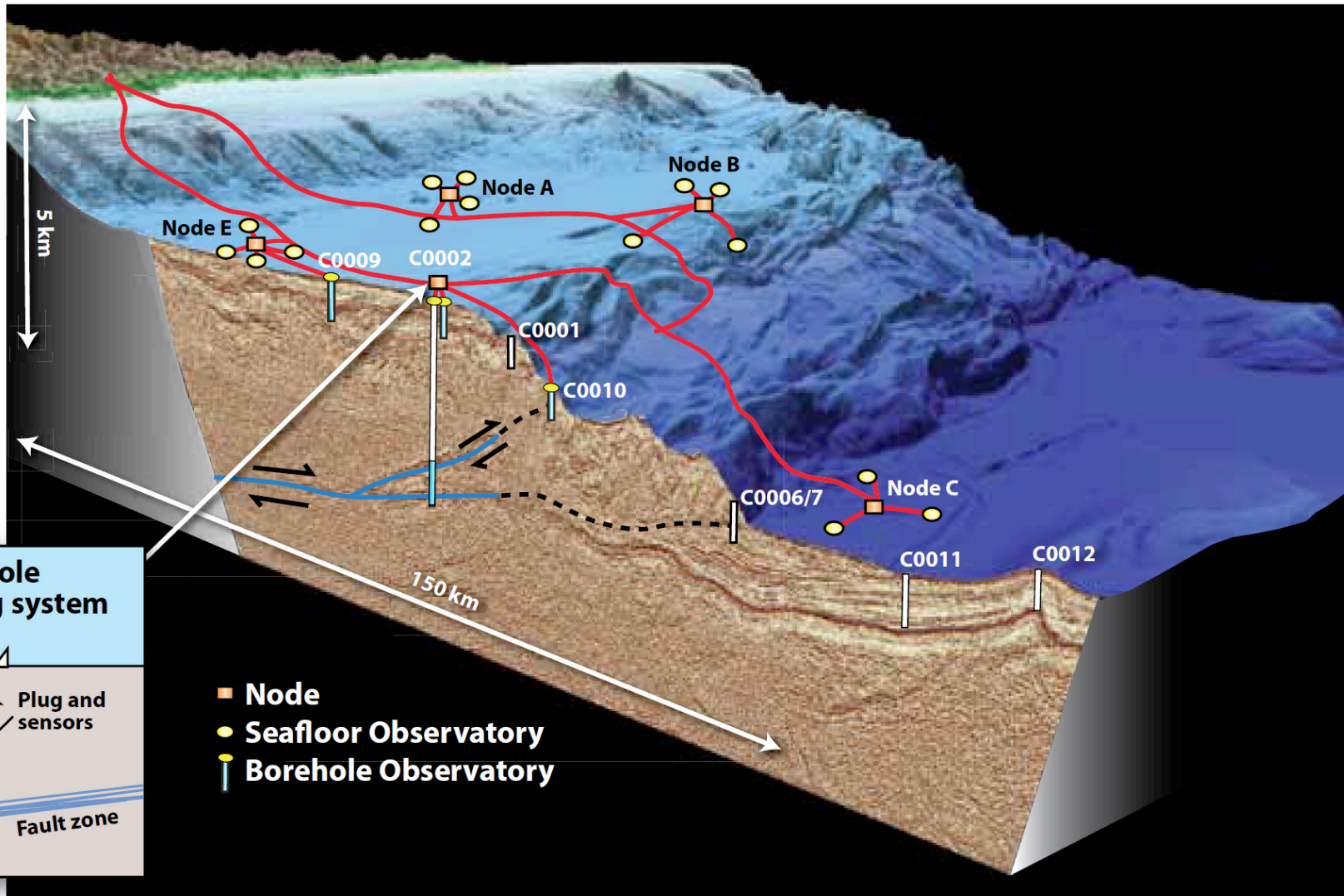
Biosphere Frontiers: Deep Life, Biodiversity, and Environmental Forcing of Ecosystems



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



Earth in Motion: Processes and Hazards on Human Time Scales



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)
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**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

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



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)

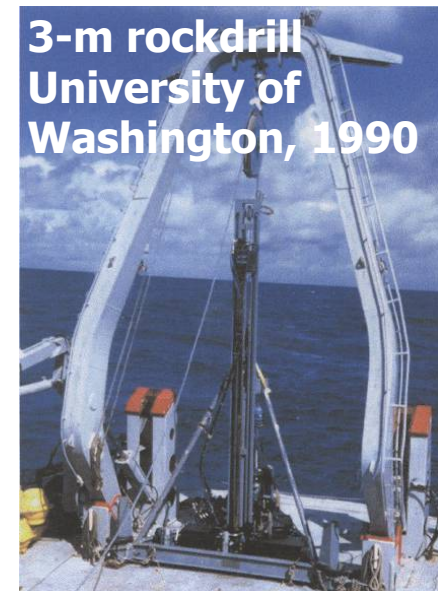
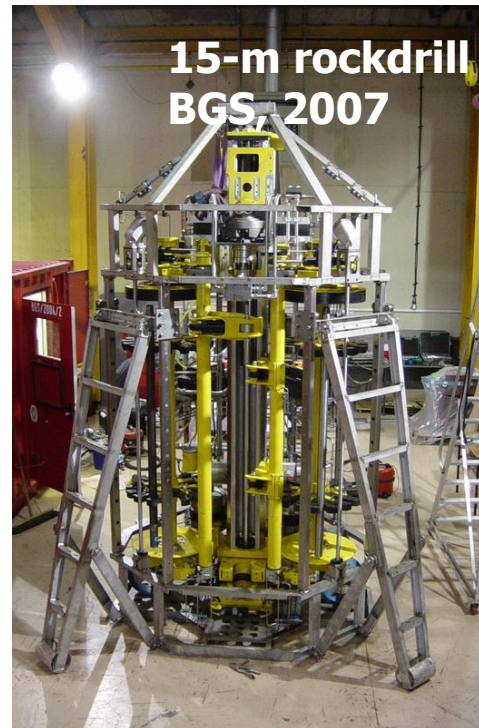
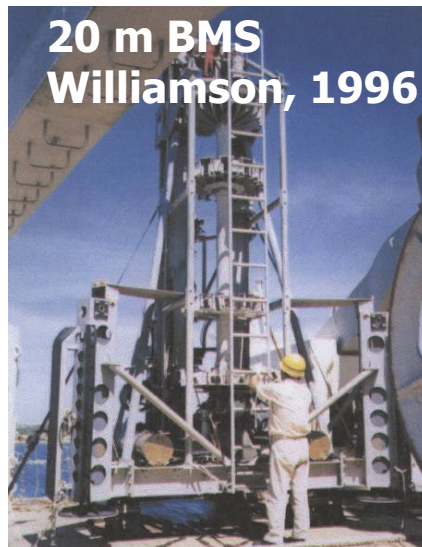
Advantages of sea bed drill rigs

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



Seabed Rig AS

Existing seabed drill rigs



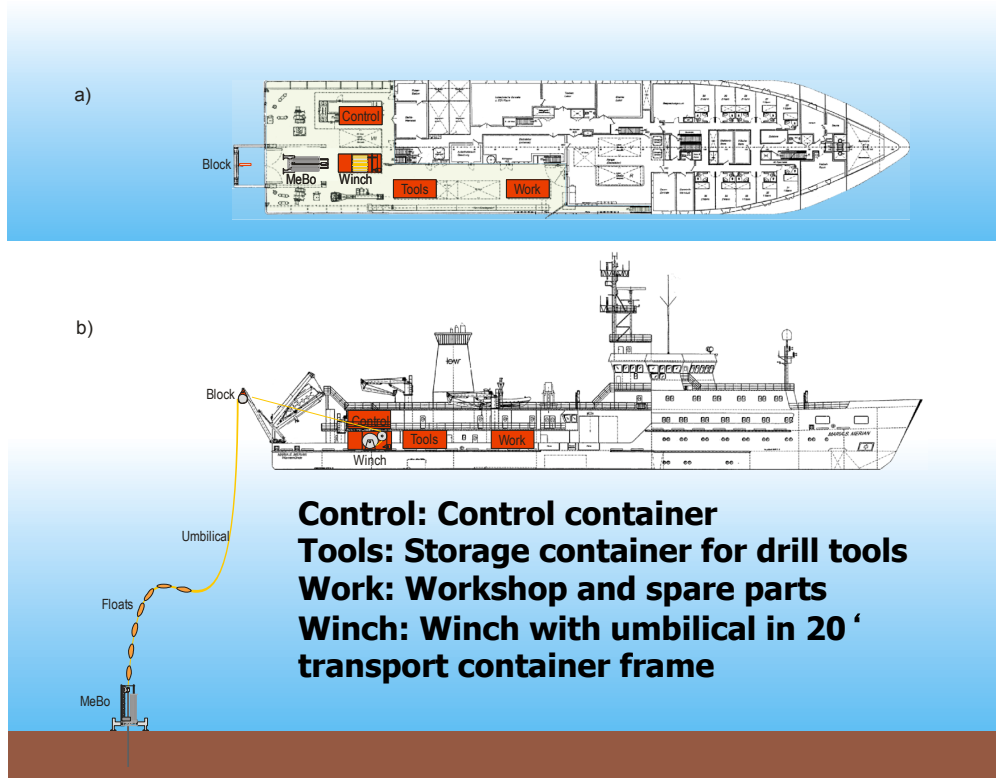


MeBo specifications

- 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

Concept of MeBo

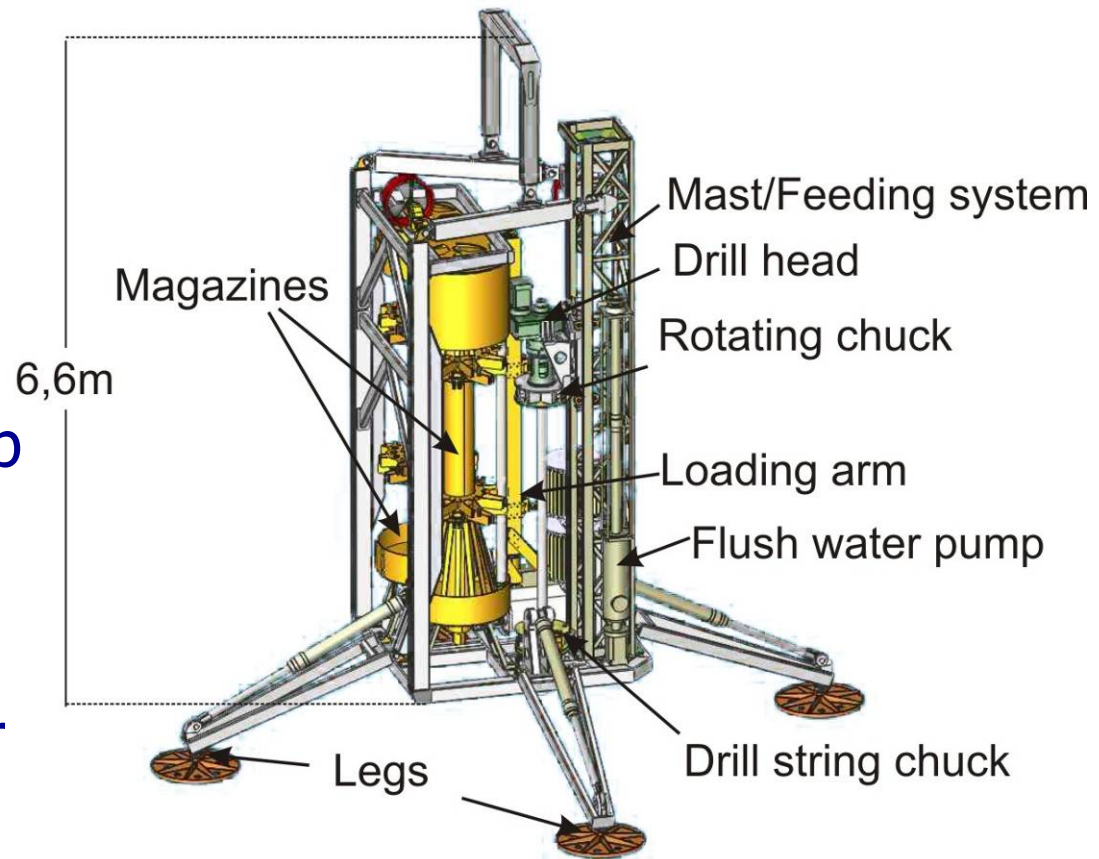
- Umbilical is used to lower the drill rig to the sea floor
- Umbilical is used for energy supply and remote control from the vessel



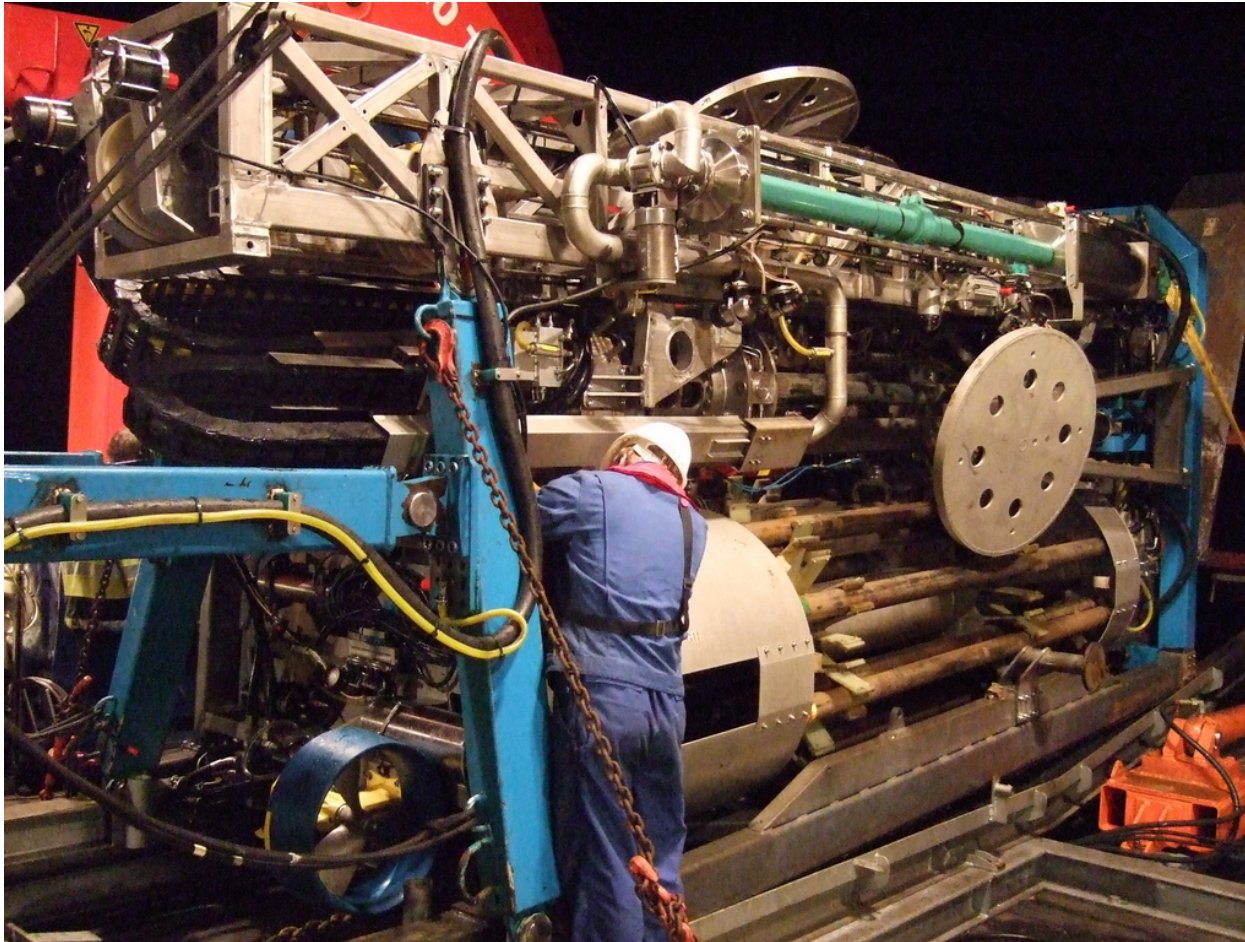
- Transport of the System within 20' shipping containers, that are mounted on the working deck of the research vessel

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.

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.

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)

