

Università di Trieste
Corso di Laurea in Geologia

Anno accademico 2022 - 2023

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'**

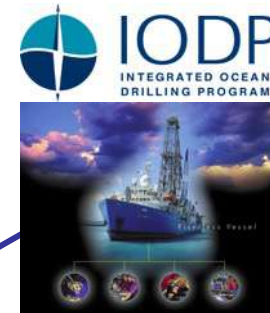
The International Ocean Discovery Program (IODP)

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 subsurface environments

<http://www.iodp.org>

End in October 2023



October 2013

**International
Ocean Discovery
Program (IODP)**

**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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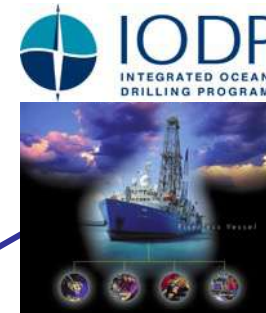
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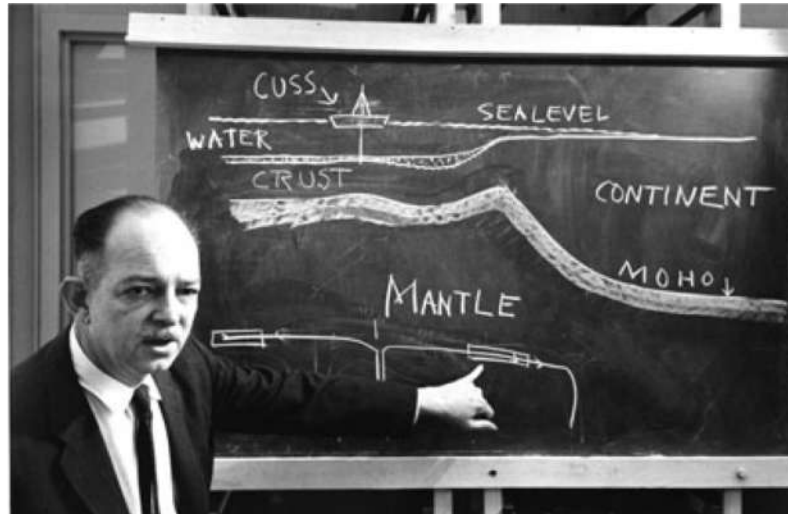


Deep Sea
Drilling
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(DSDP)
1968-1983



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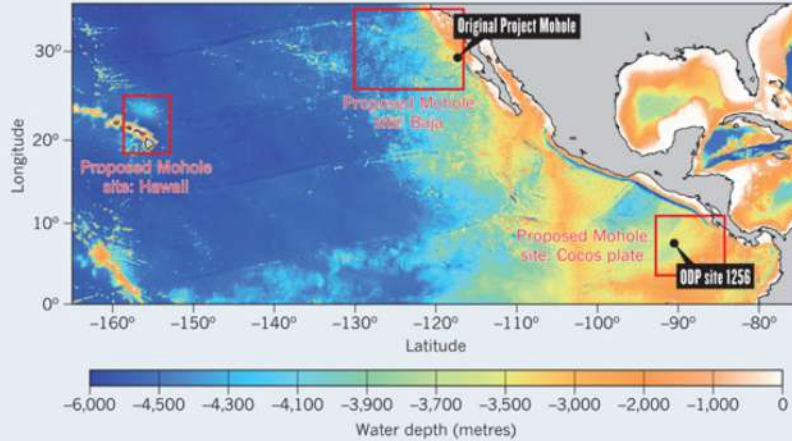
In 1961 scientific drilling took root as a feasible technology to study Earth's subseafloor geology. **Project Mohole**, a concept developed by the American Miscellaneous Society with funding from the National Science Foundation, considered the feasibility of **drilling through the Mohorovičić seismic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

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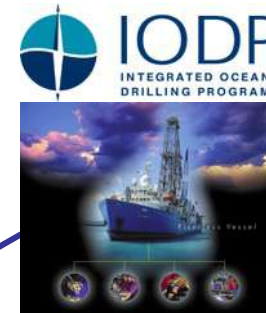
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MOHOLE
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The next phase of scientific ocean drilling, the **Deep Sea Drilling Project (DSDP)**, began in 1966 using the Drilling Vessel *Glomar Challenger*. This pioneer vessel for DSDP conducted drilling 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.



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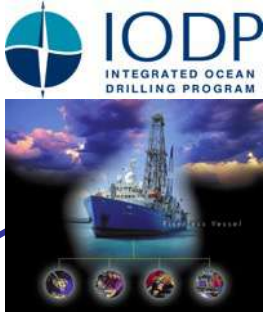
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In 1985, *JOIDES Resolution* replaced the *Glomar Challenger* at the start of a new program, the **Ocean Drilling Program (ODP)**. ODP was truly an international cooperative effort to explore and study the composition and structure of the Earth's subseafloors.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



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



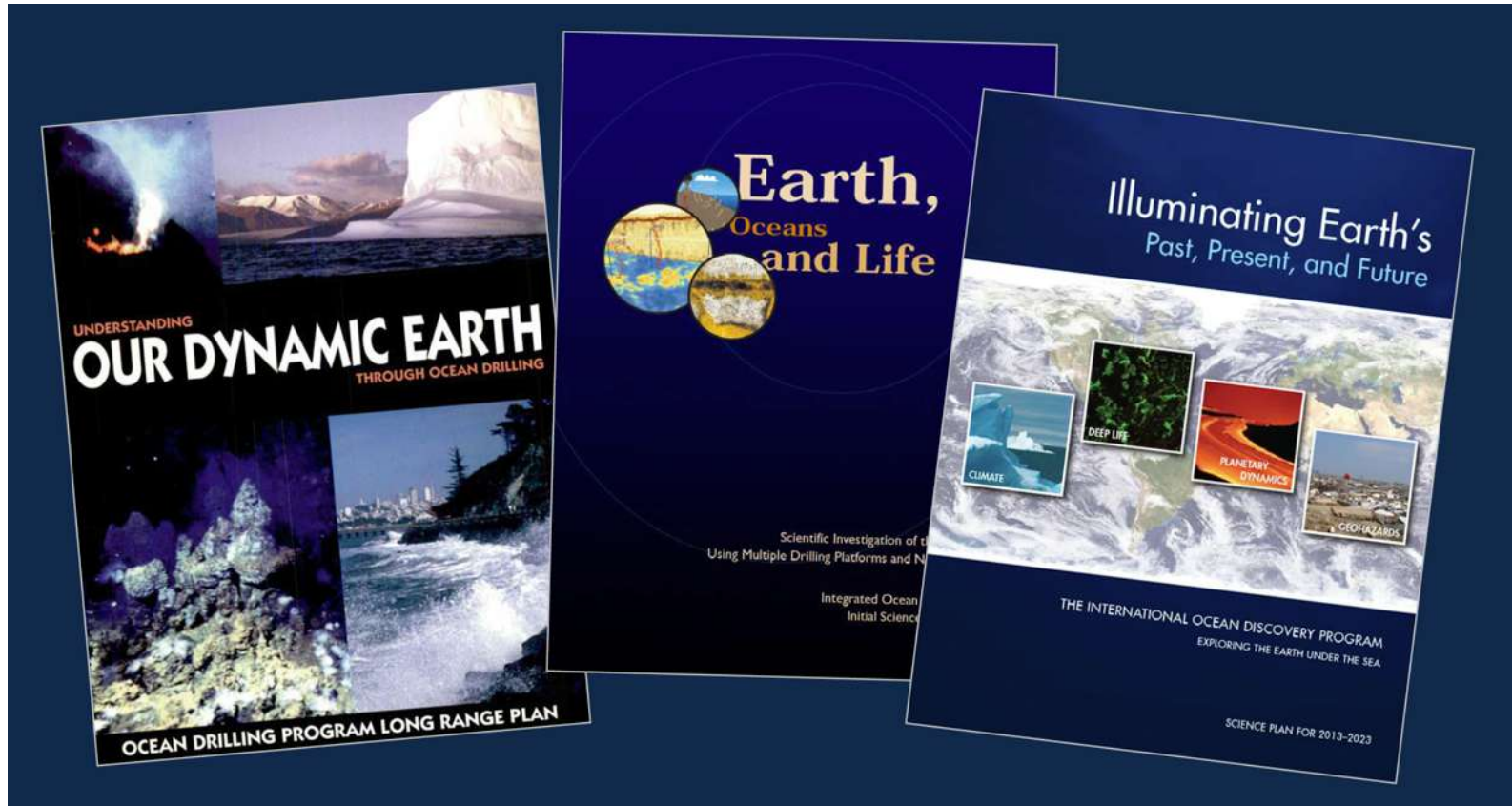


Drilled holes

- IODP
- ODP
- DSDP

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**



2020 – 2050

EXPLORING EARTH BY SCIENTIFIC OCEAN DRILLING



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

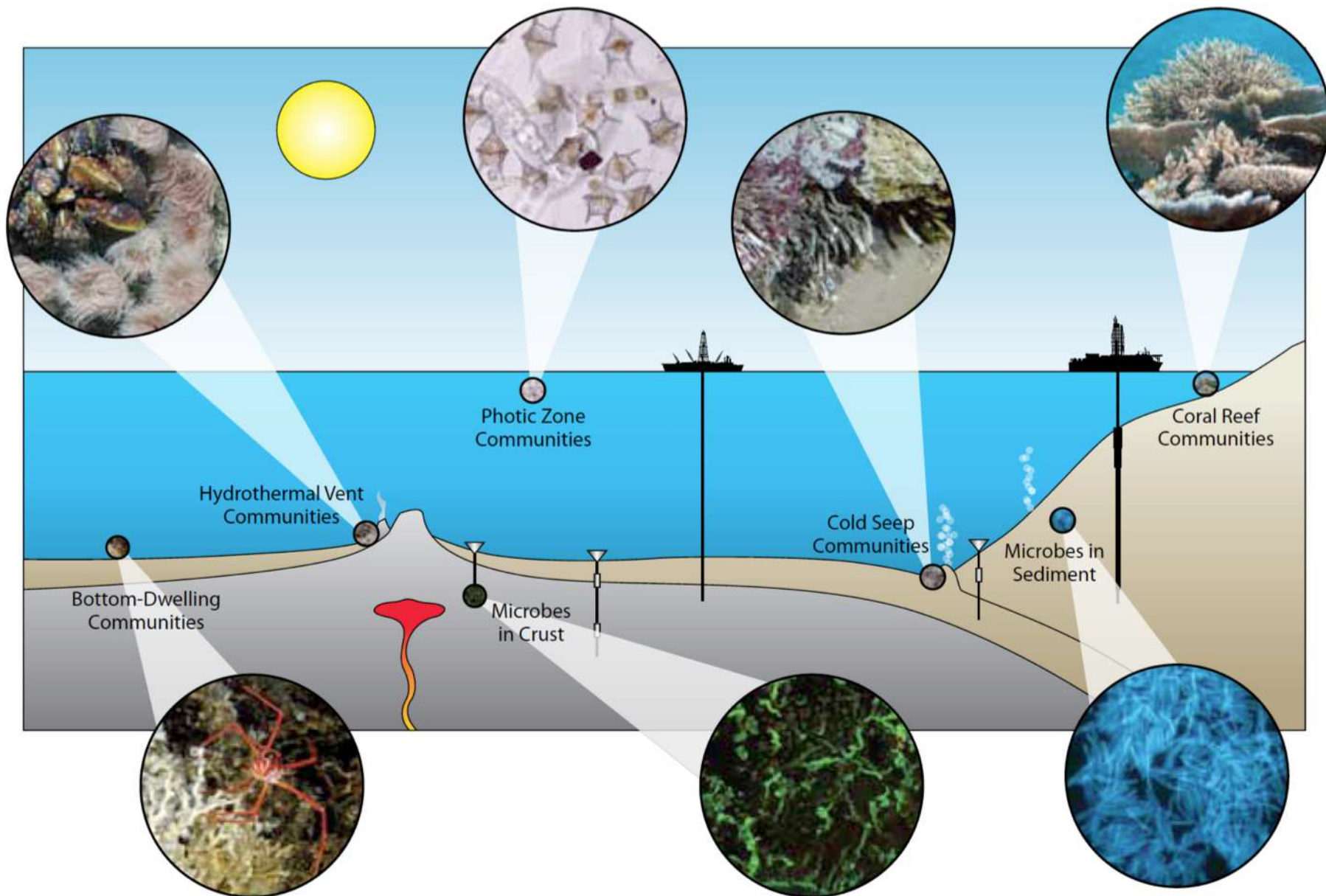
Co-lead Editor, Chair Science Framework Working Group

Rosalind Coggon

Co-lead Editor

and the Science Framework Authors and Reviewers

representing the international scientific ocean drilling community



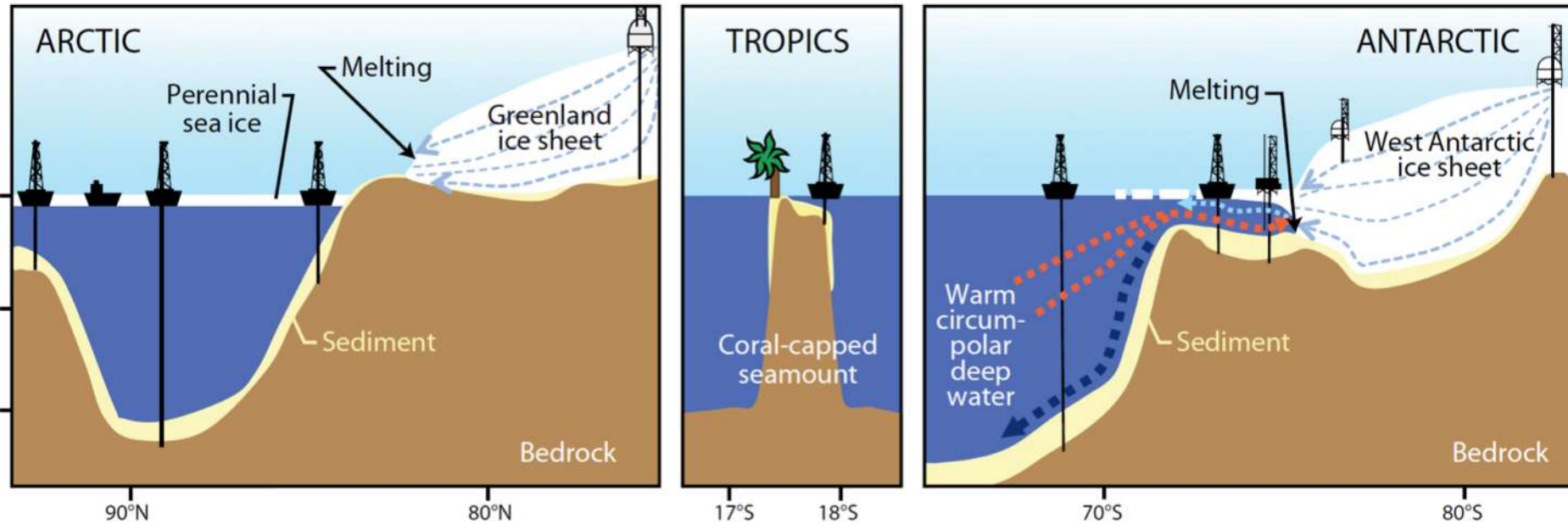
New Science Plan and as follows:

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)

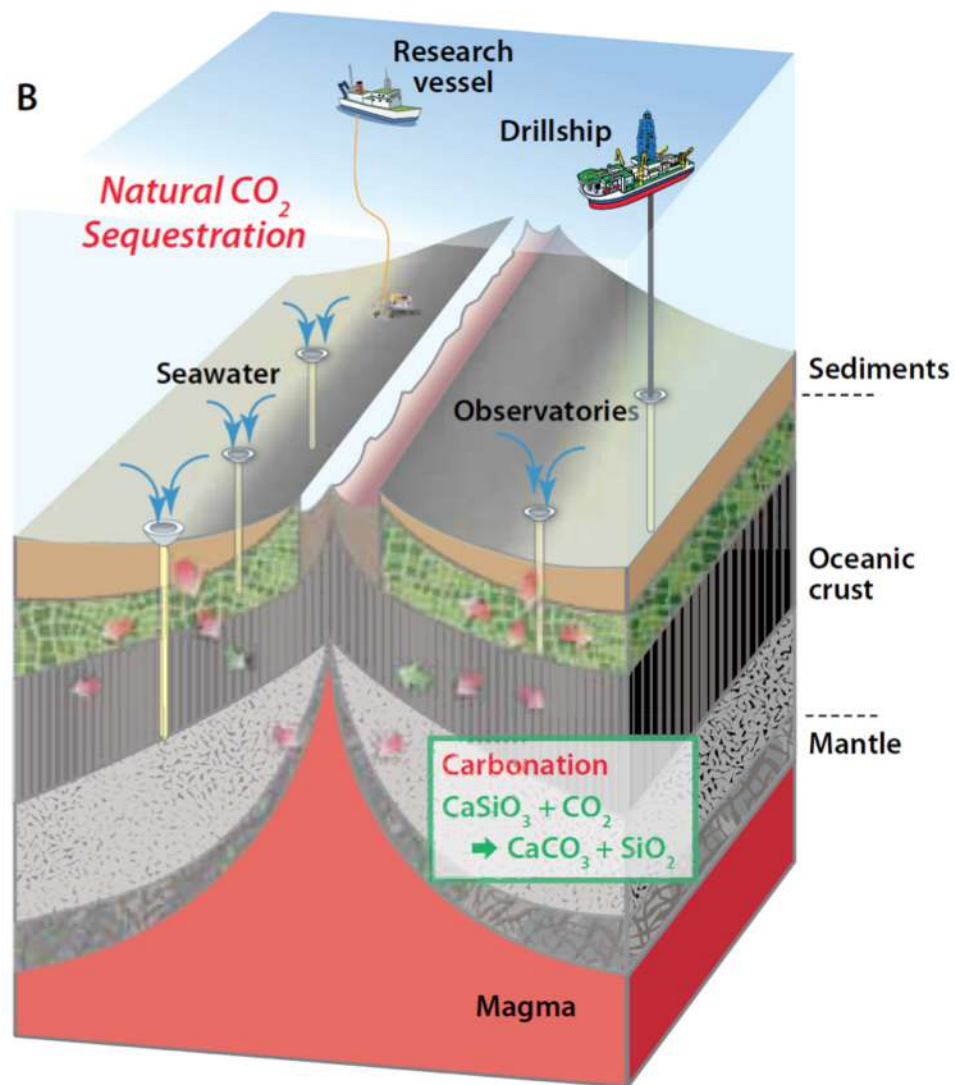
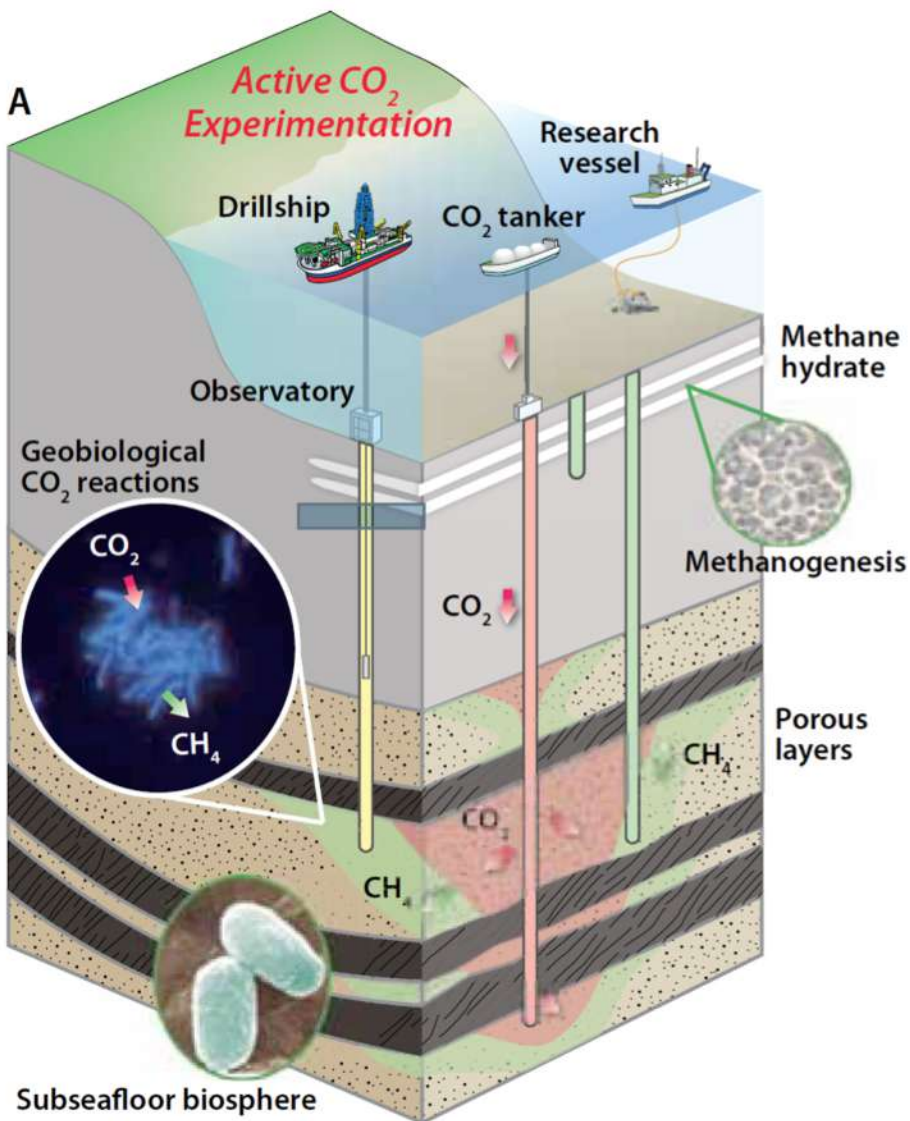
Climate and Ocean Change: Reading the Past, Informing the Future



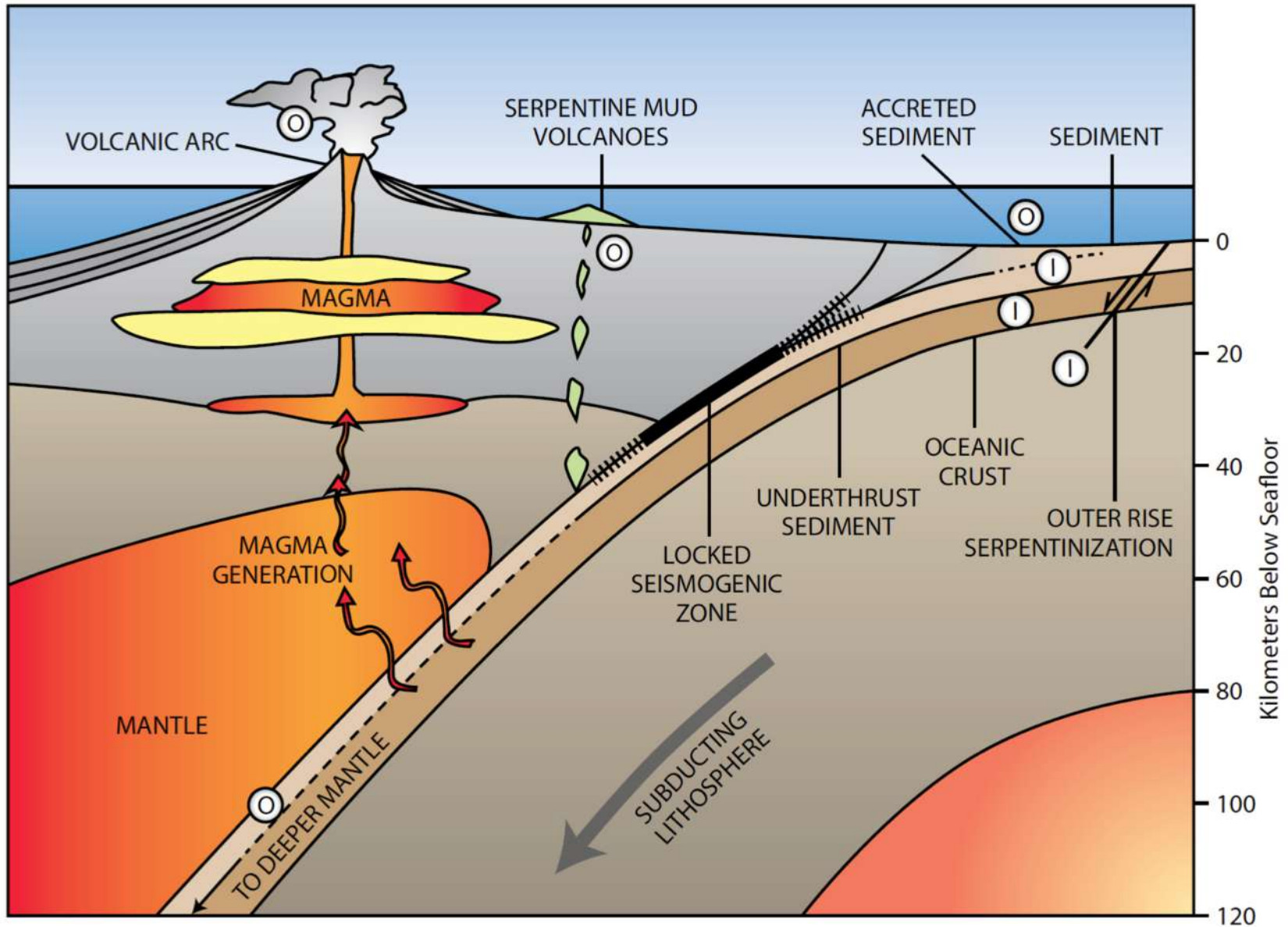
Climate and Ocean Change: Reading the Past, Informing the Future



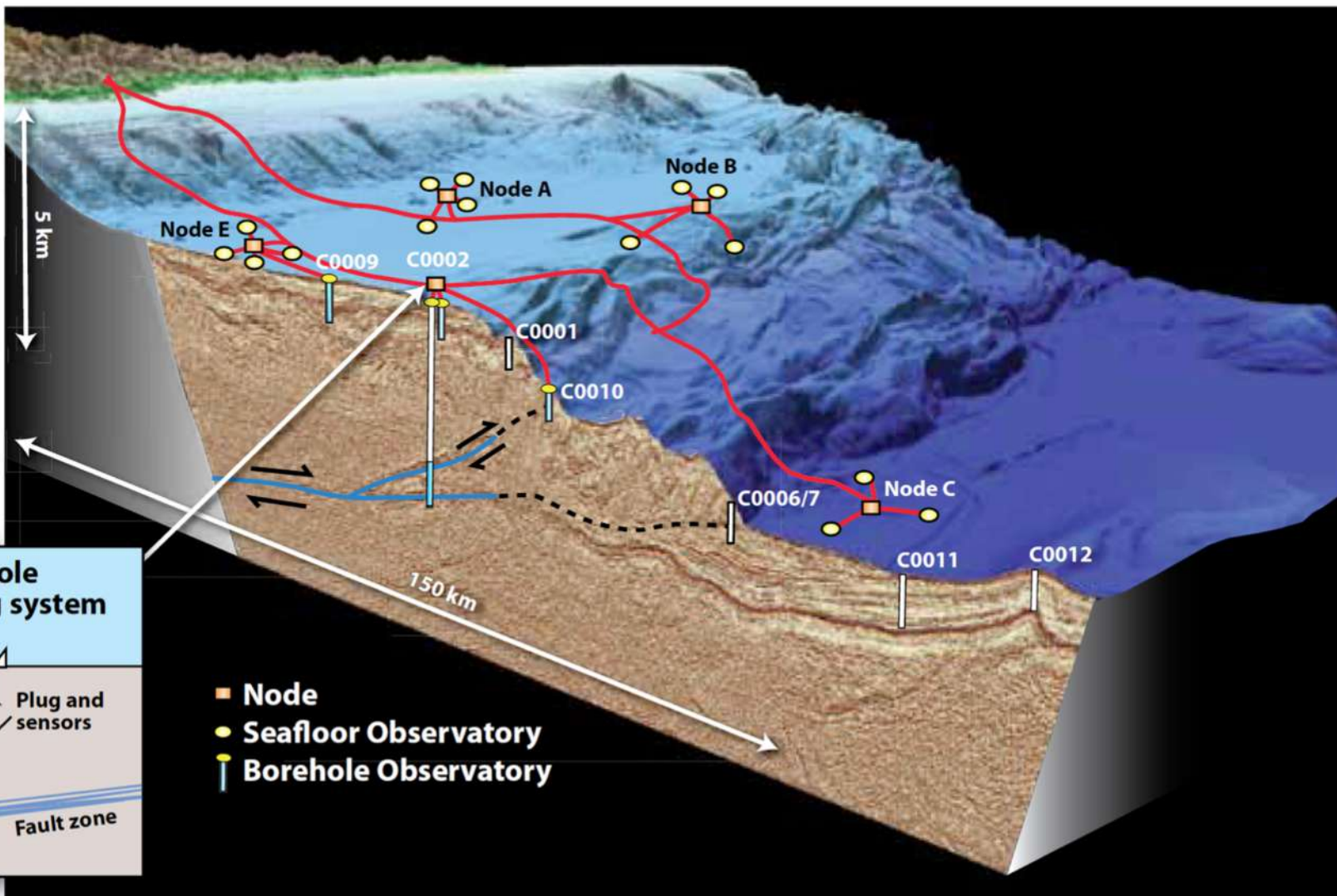
Biosphere Frontiers: Deep Life, Biodiversity, and Environmental Forcing of Ecosystems



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



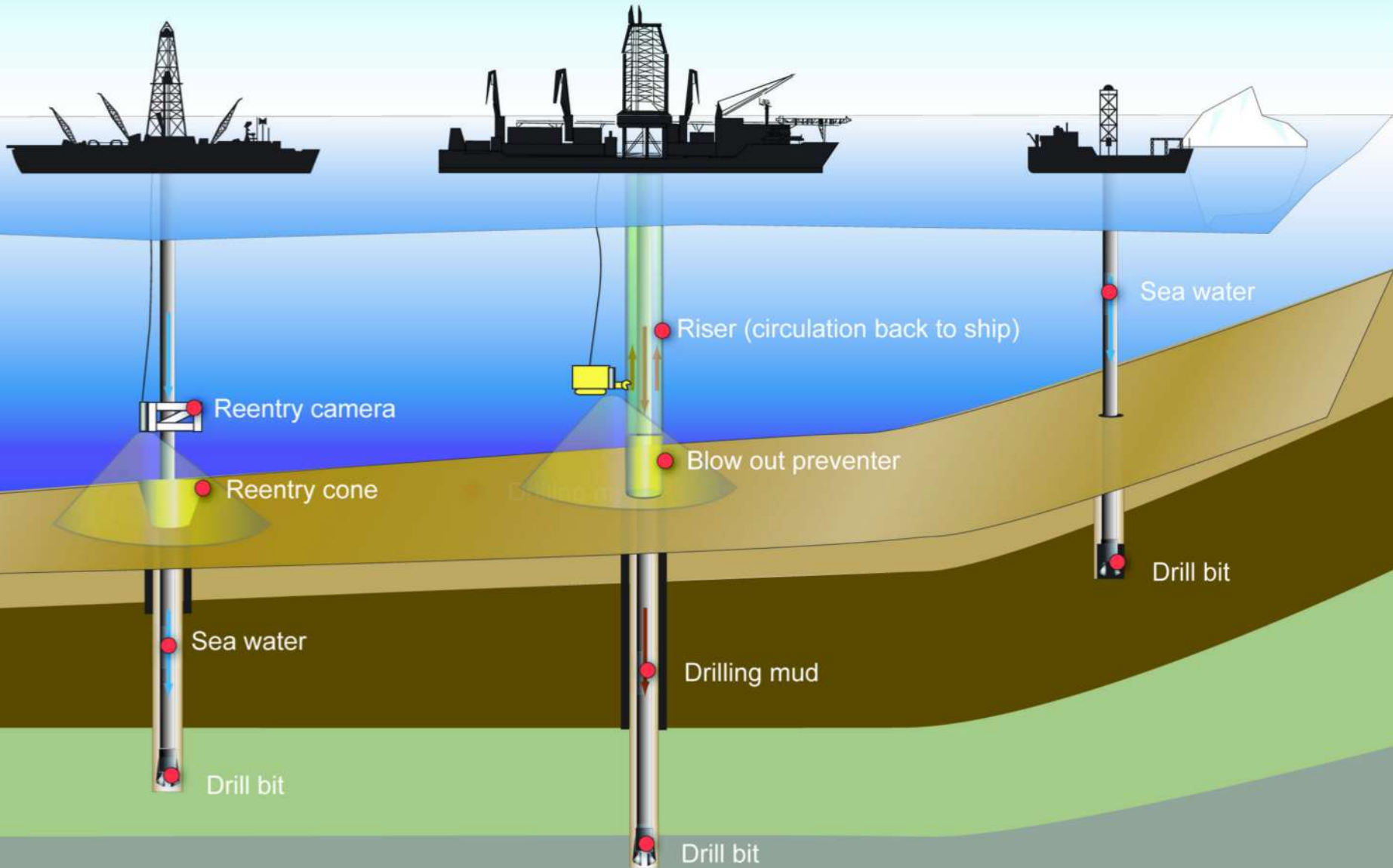
Earth in Motion: Processes and Hazards on Human Time Scales



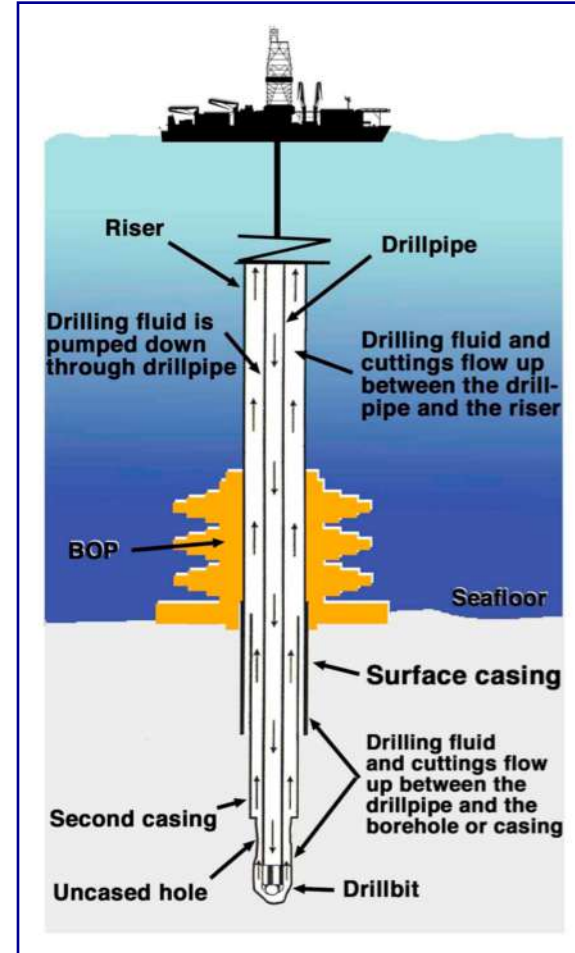
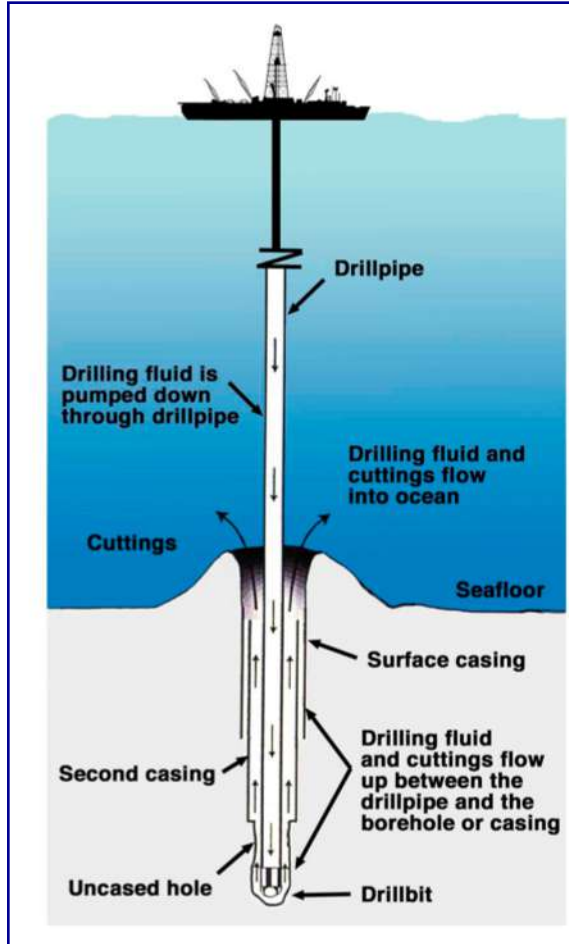
Riserless Drilling

Riser Drilling

Mission-Specific

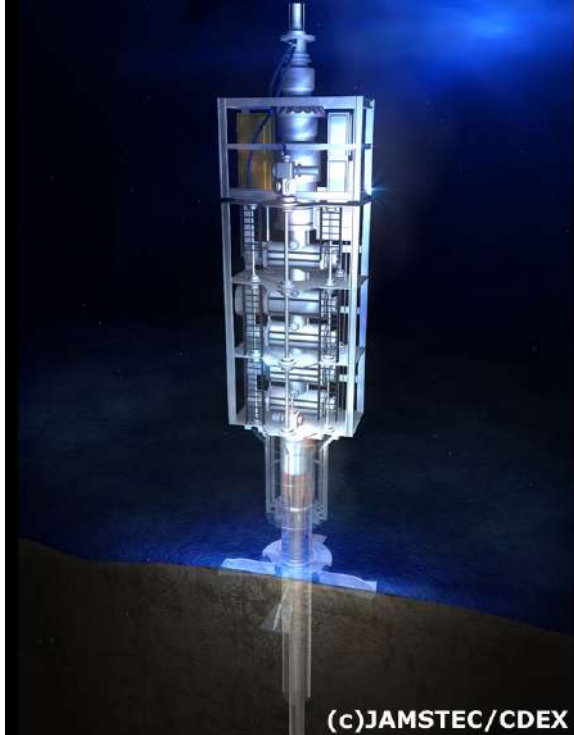


THE 'RISER' DRILLING SYSTEM





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



CORE ON DECK

http://www.youtube.com/watch?feature=player_embedded&v=wC9IDPvvze0

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

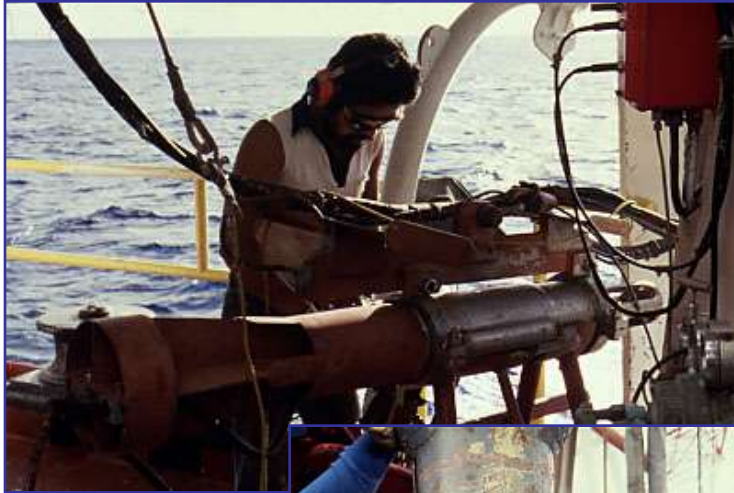
http://www.iodp.org/images/stories/swf/jamstec_english_2_rotary_drilling.swf

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



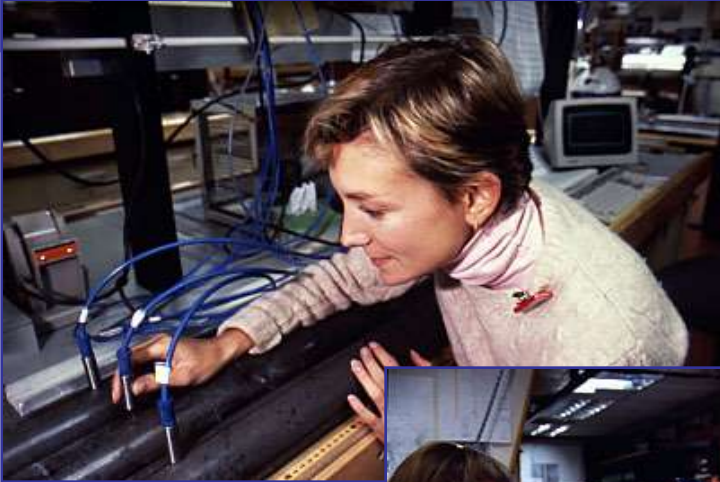
Dynamic Positioning



Drilling



Hole Re-entry

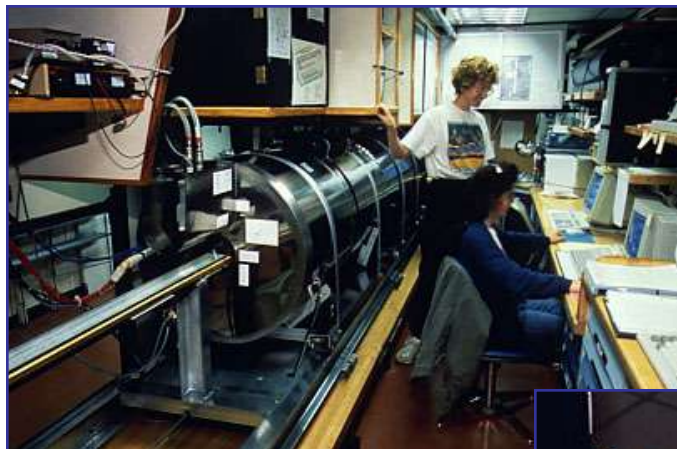


**Core
Handling**



Core Logging

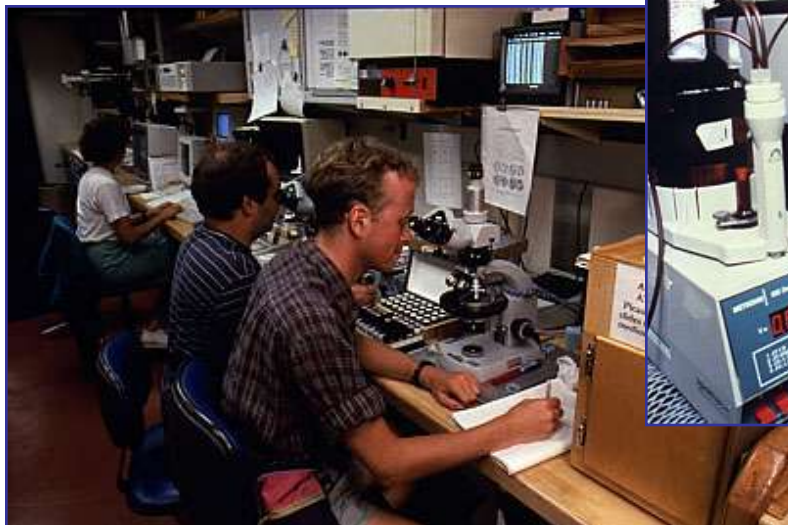
Geomagnetic logging



Microbiology



Micropaleontology



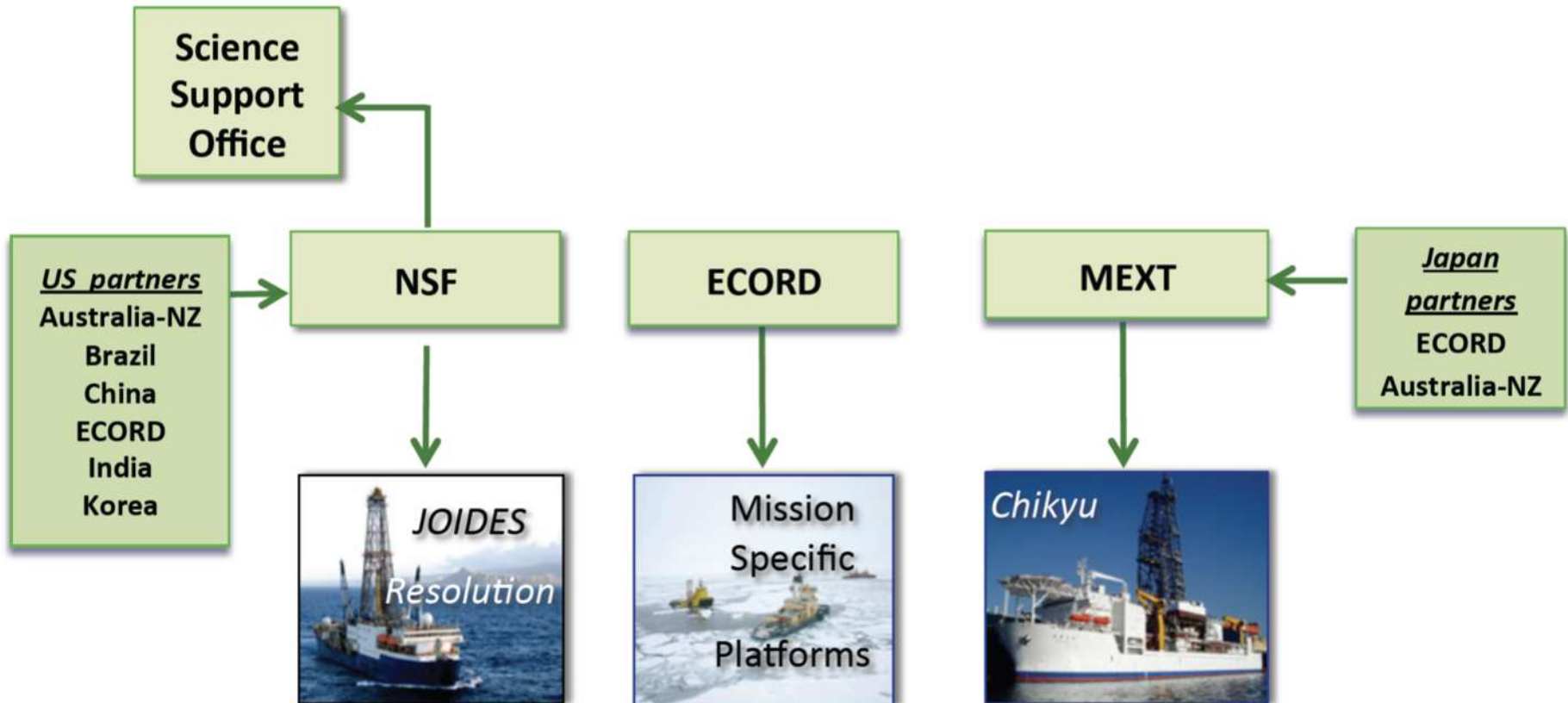
Geochemistry



Downhole Logging

IODP Funding Model

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



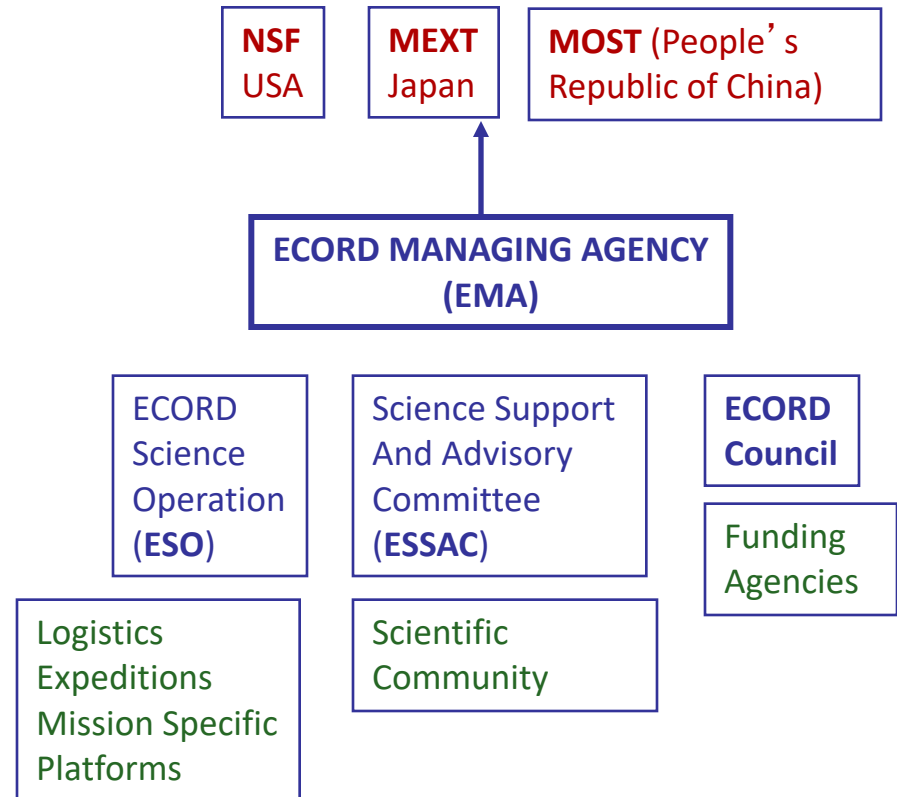
ECORD

(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	



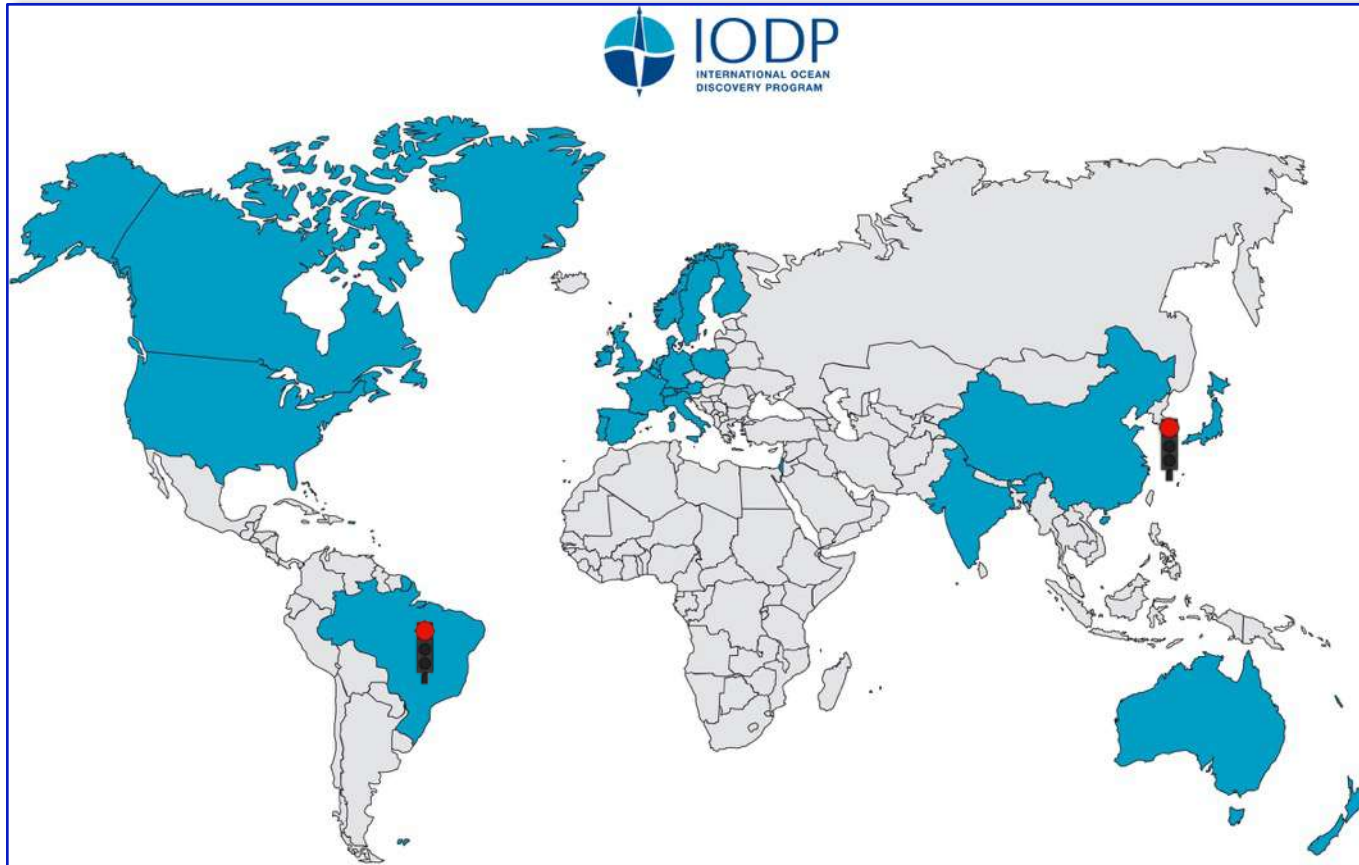
Prevision 2005: *ECORD 12.5 Million USD, ~ 17 % of IODP*

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) responsabile 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.



USA (--> 2023)

ANZIC (--> 2022)

China (--> 2023)

India (--> 2023)

Japan (--> 2023)

ECORD (--> 2023)

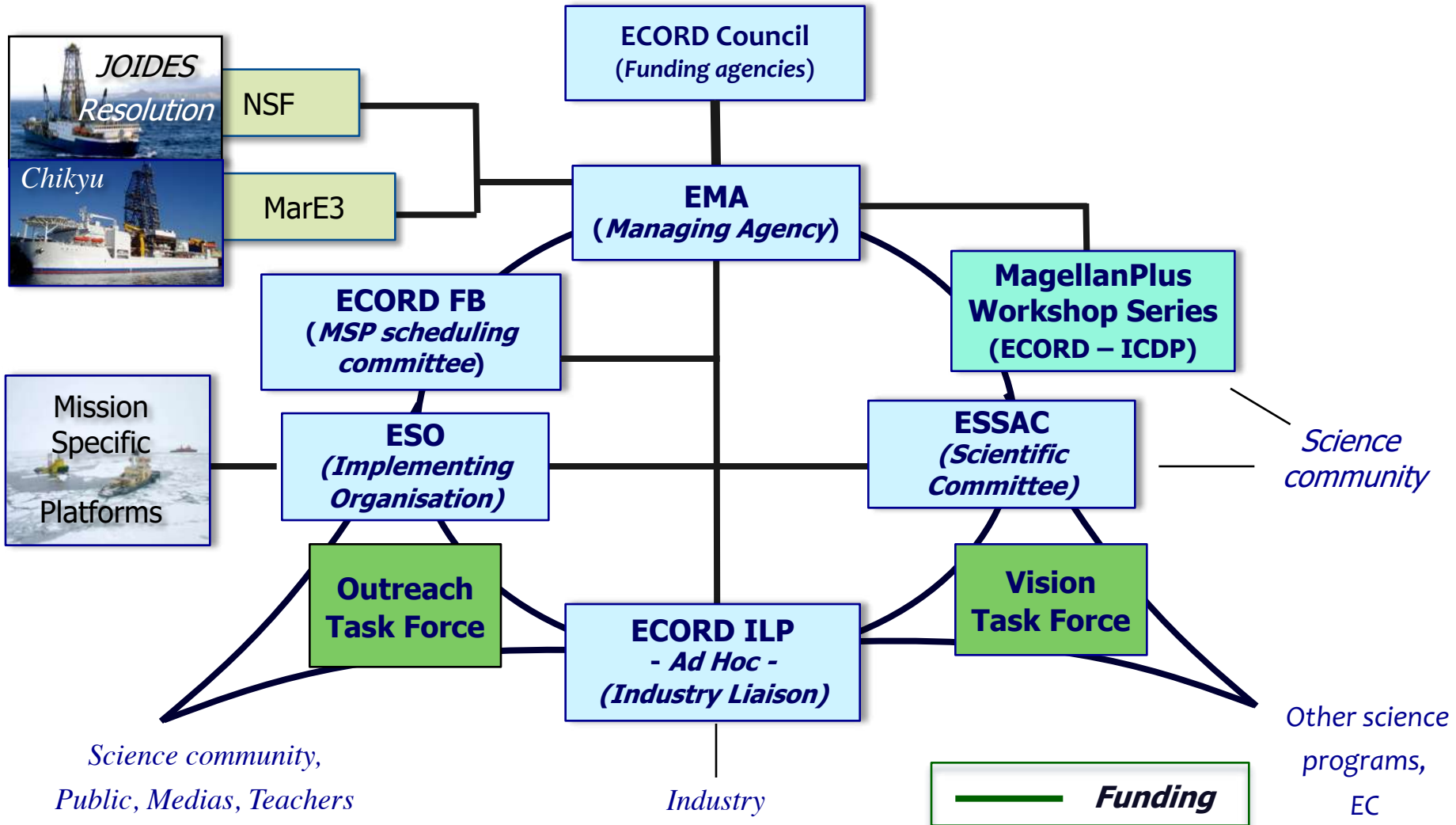
S-Korea (*On hold*)

Brazil (*On hold*)



Budget \pm 130-140 M\$/yr

23 member countries





Credit: Simone Sauer / ECORD / IODP

ECORD
Science Operator

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

THANKS TO DAVID MCINRE



British
Geological
Survey

dbm@bgs.ac.uk

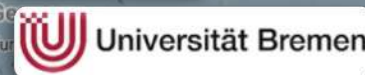
Why are MSPs needed?



- 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





X313
New Jersey
Shelf



1



2

X347 Baltic Sea

X302
Central Arctic



2



3

X364 Gulf of Mexico
(Chicxulub)



4

X357
Central North Atlantic



5

X381
Gulf of Corinth



6

X386 Japan Trench (planning)



7

X310 Tahiti

IODP Mission Specific Platforms 2004-2021



8

X325
Great Barrier Reef



X313
New Jersey
Shelf



1



2

X347 Baltic Sea

X302
Central Arctic



2



3

X364 Gulf of Mexico
(Chicxulub)



4

X357
Central North Atlantic



5

X381
Gulf of Corinth



6

X386 Japan Trench (planning)



7

X310 Tahiti

**Dynamically positioned
geotechnical vessels,
multipurpose vessels, and
converted supply vessels**



8

X325
Great Barrier Reef



X313
New Jersey
Shelf



1



2

X347 Baltic Sea

X302
Central Arctic



2



3

X364 Gulf of Mexico
(Chicxulub)



4

X357
Central North Atlantic



5

X381
Gulf of Corinth



6

X386 Japan Trench (planning)



7

X310 Tahiti

Lift boats
(and other small-scale
elevating platforms)



8

X325
Great Barrier Reef

X313
New Jersey
Shelf



1



2

X347 Baltic Sea

X302
Central Arctic



2



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X364 Gulf of Mexico
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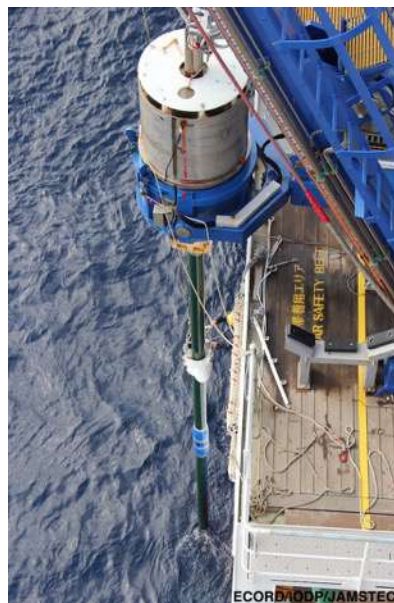
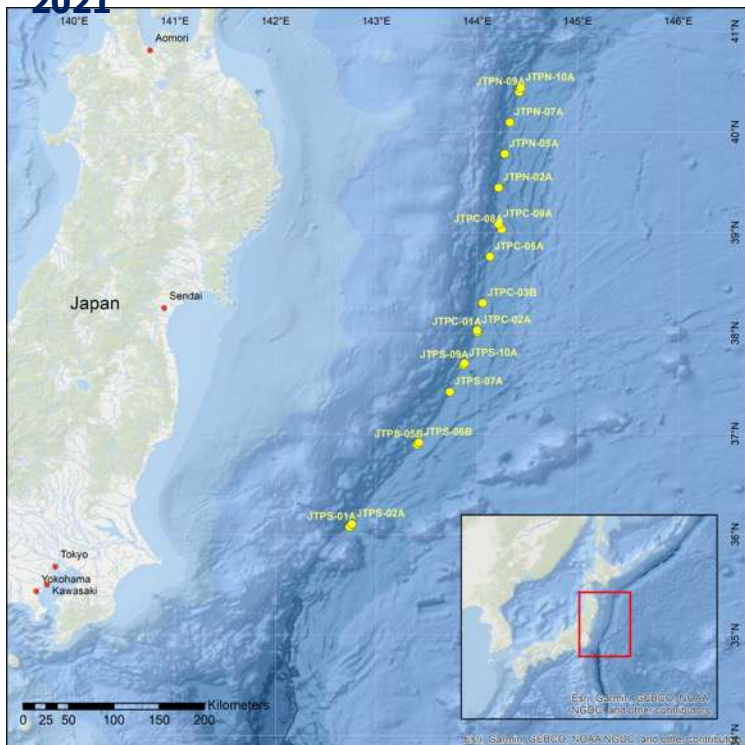


8

X325
Great Barrier Reef

Research vessels

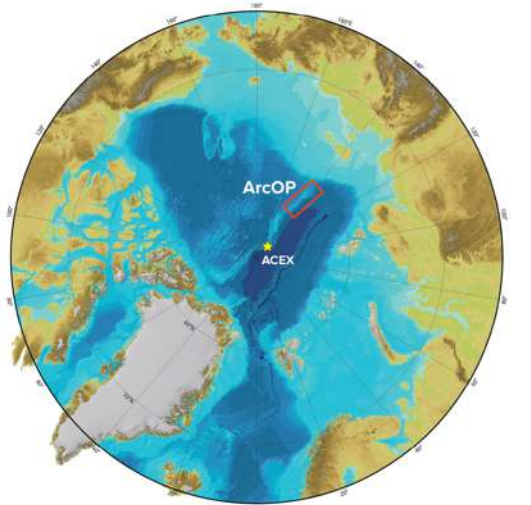
IODP Expedition 386: Japan Trench Paleoseismology, April – June 2021



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.

Drillship: *Dina Polaris*



Summary of MSP coring methods 2004-2021



Offshore wireline



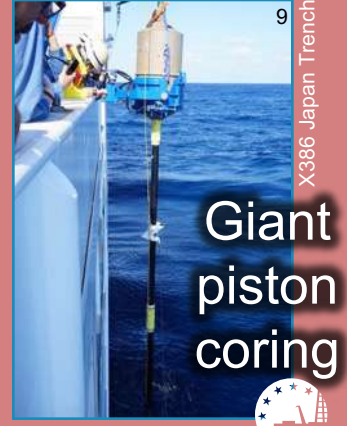
Mining-style wireline



Seafloor drills



Rumohr
cores
(gravity
cores)

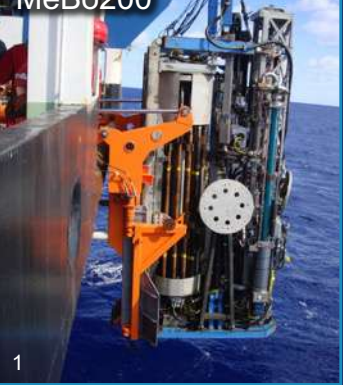


Giant
piston
coring



Seafloor drill technology

MARUM MeBo70 & MeBo200



BGS RD2



Benthic Geotech PROD 1, 2, 3 & 4



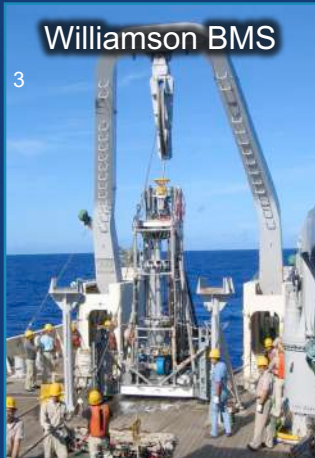
Williamson A-BMS



Cellula CRD100



Williamson BMS



Fugro SFD & SFDII



Helix RovDrill 2



Royal IHC SWORD

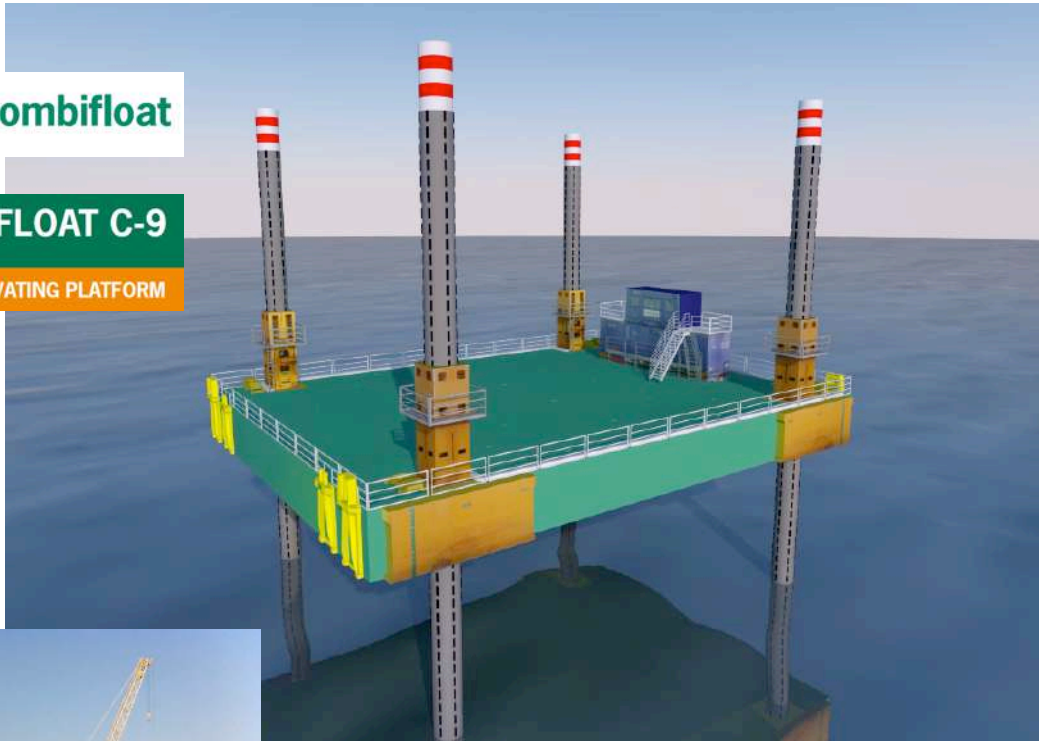


Possible future MSP platforms

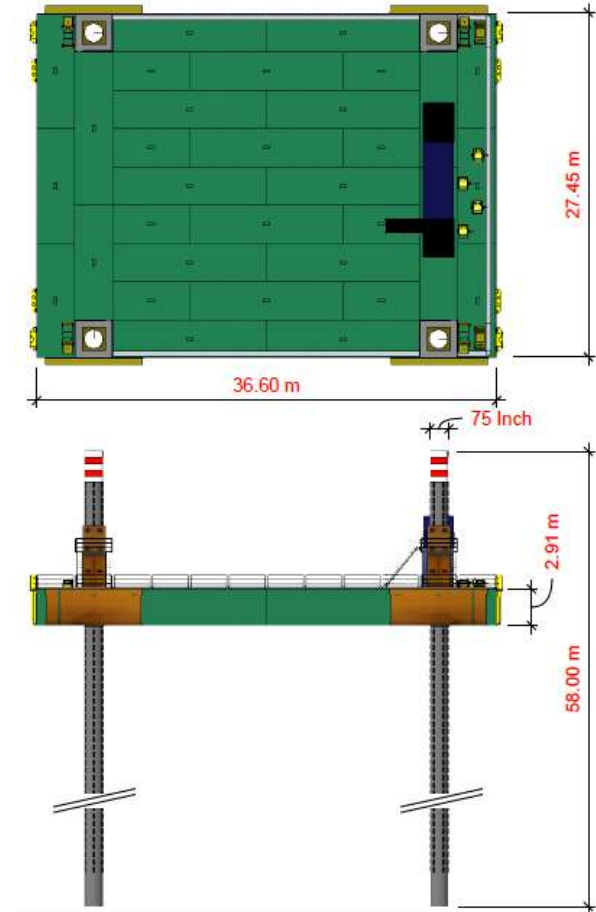


COMBIFLOAT C-9

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

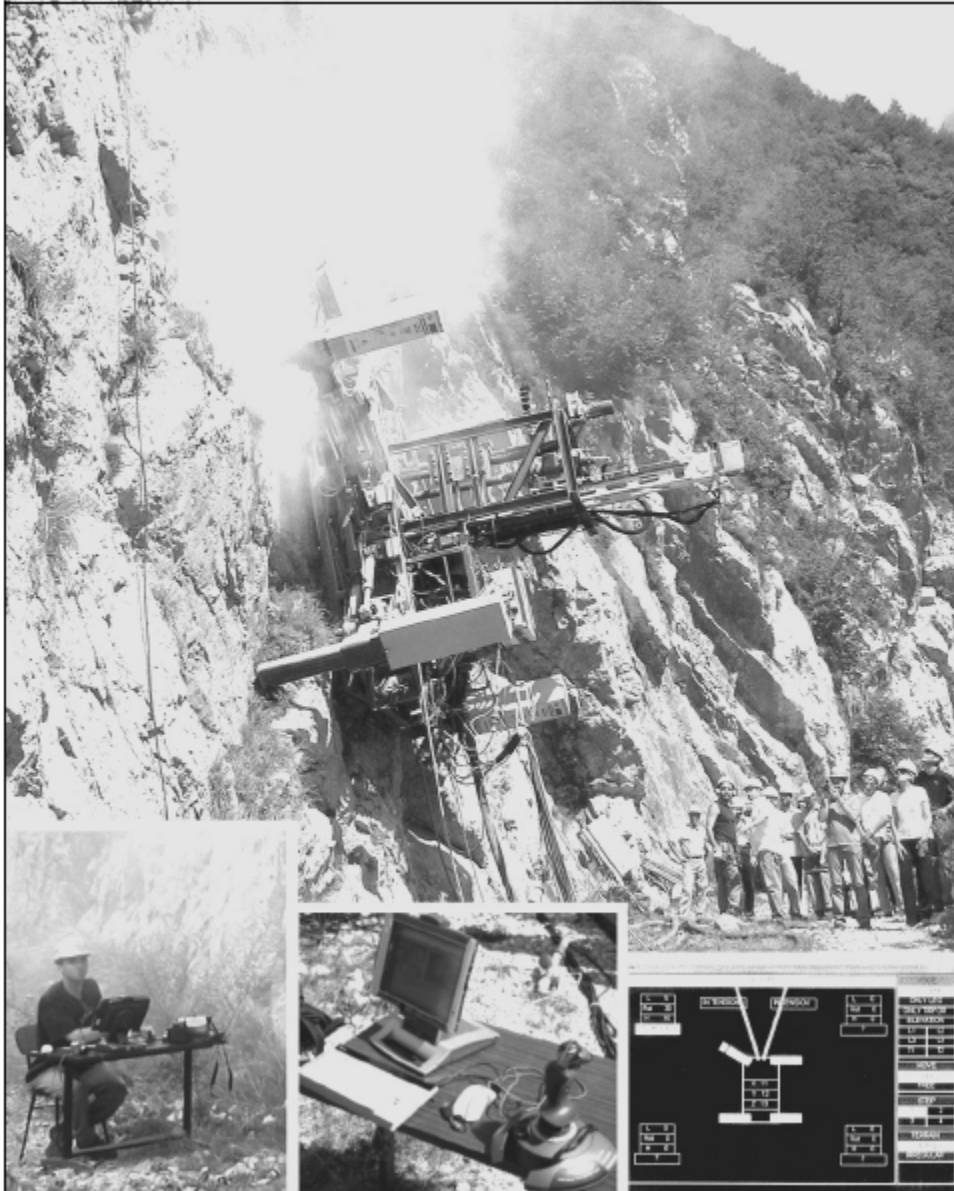


Credit: UKRI / Natural Environment Research Council



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)

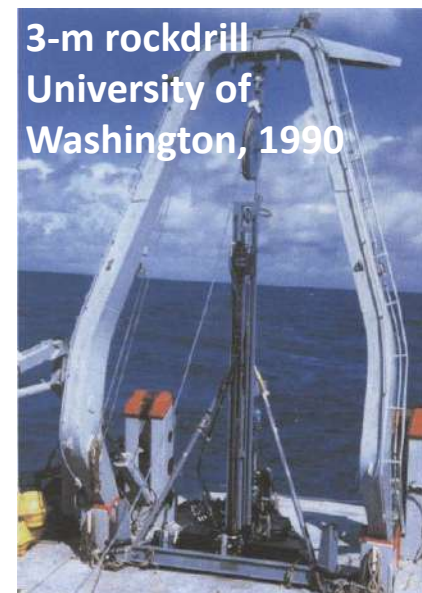
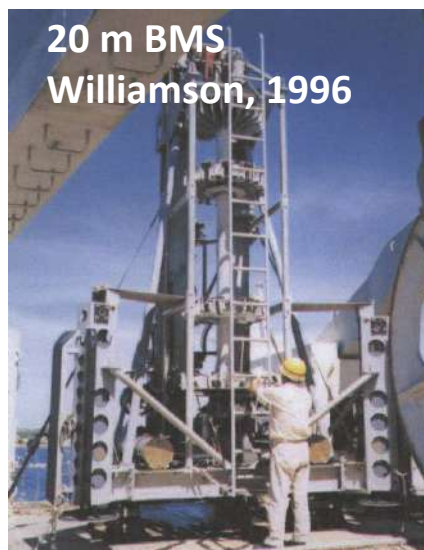
Advantages of sea bed drill rigs

- 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



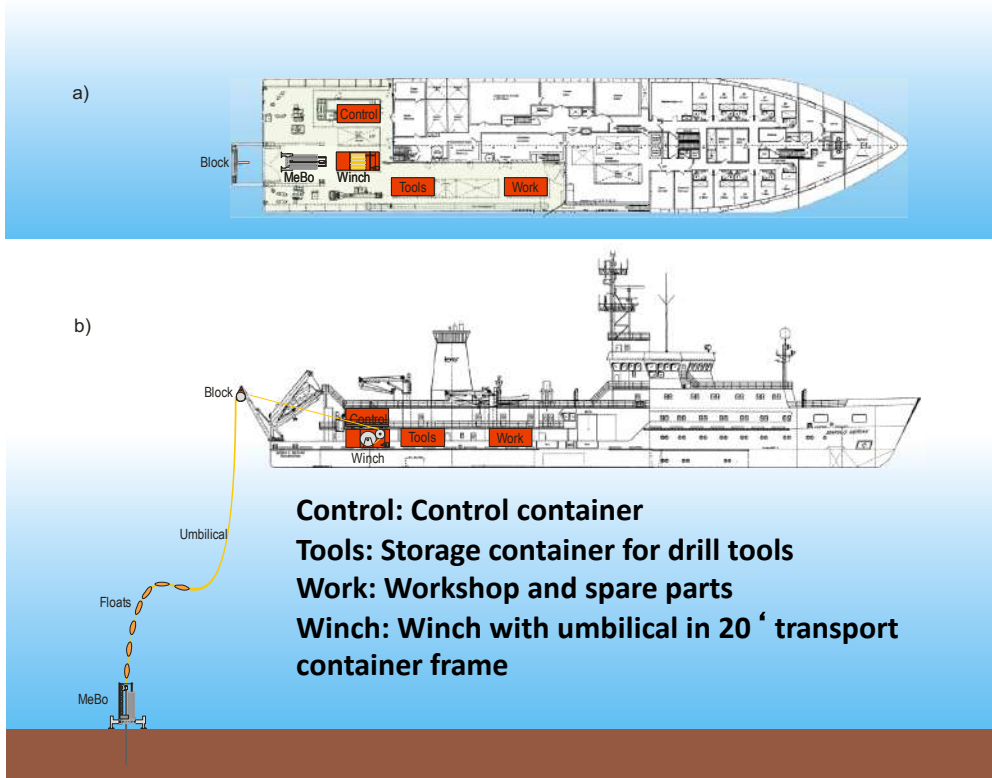


MeBo specifications

- 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

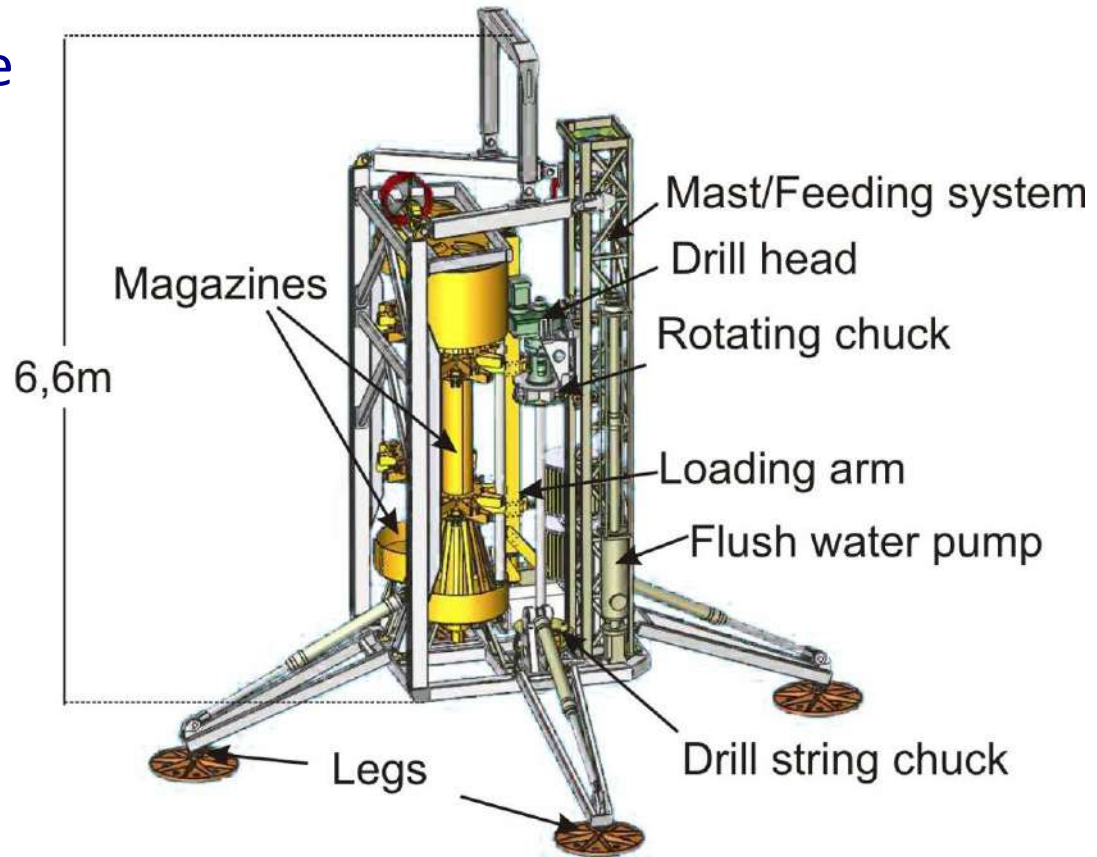
- Umbilical is used to lower the drill rig to the sea floor
- Umbilical is used for energy supply and remote control from the vessel



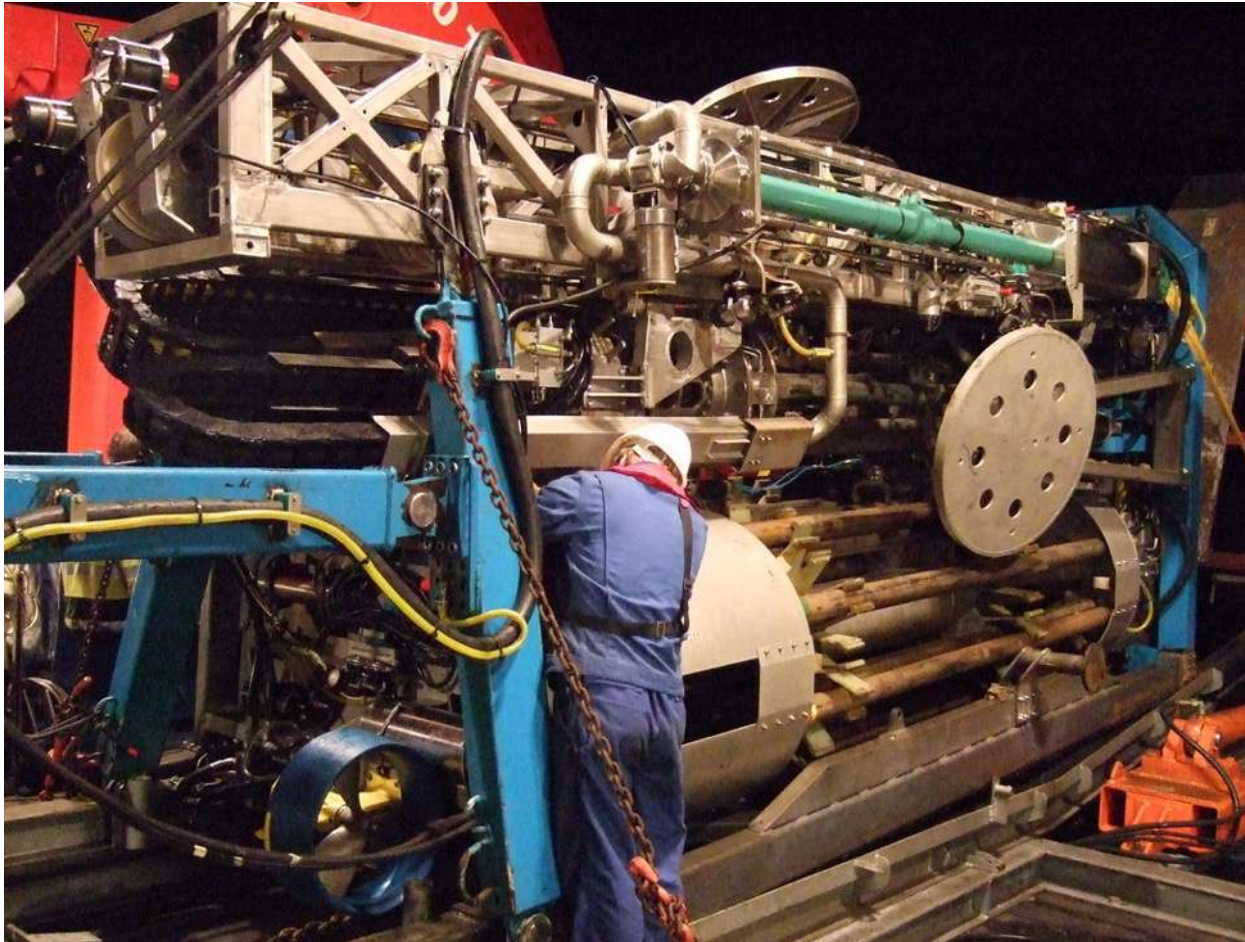
- Transport of the System within 20' shipping containers, that are mounted on the working deck of the research vessel

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)**

