IRSO Meeting in Yokosuka
Oct.17, 2017

Chikyu Project Challenges
Science, Technology and Operation

International Research Ship Operators

Dr. Shin'ichi KURAMOTO
Center for Deep Earth Exploration (CDEX)
JAMSTEC
http://http://www.jamstec.go.jp/chikyu/e/

Deep-sea Drilling Vessel “Chikyu”

(Built in 2005)

Drill Floor

Laboratory Area

Helicopter Deck

Living Area

Bridge

Derrick

Drilling Mud Control Area

Riser Pipe

Pipe rack

Engine Room

D/V *Chikyu* Missions

D/V *Chikyu* IODP scientific drilling records

(as of March 2017)

Expeditions: 16　Drilling: 41 km

Deepest water depth record: 6,928.5 m (Exp. 343)

Exp holes: 101

Cumulative collected core lengths: 5.6 km

Exp days: 911 days

Number of cores: 1057 cores

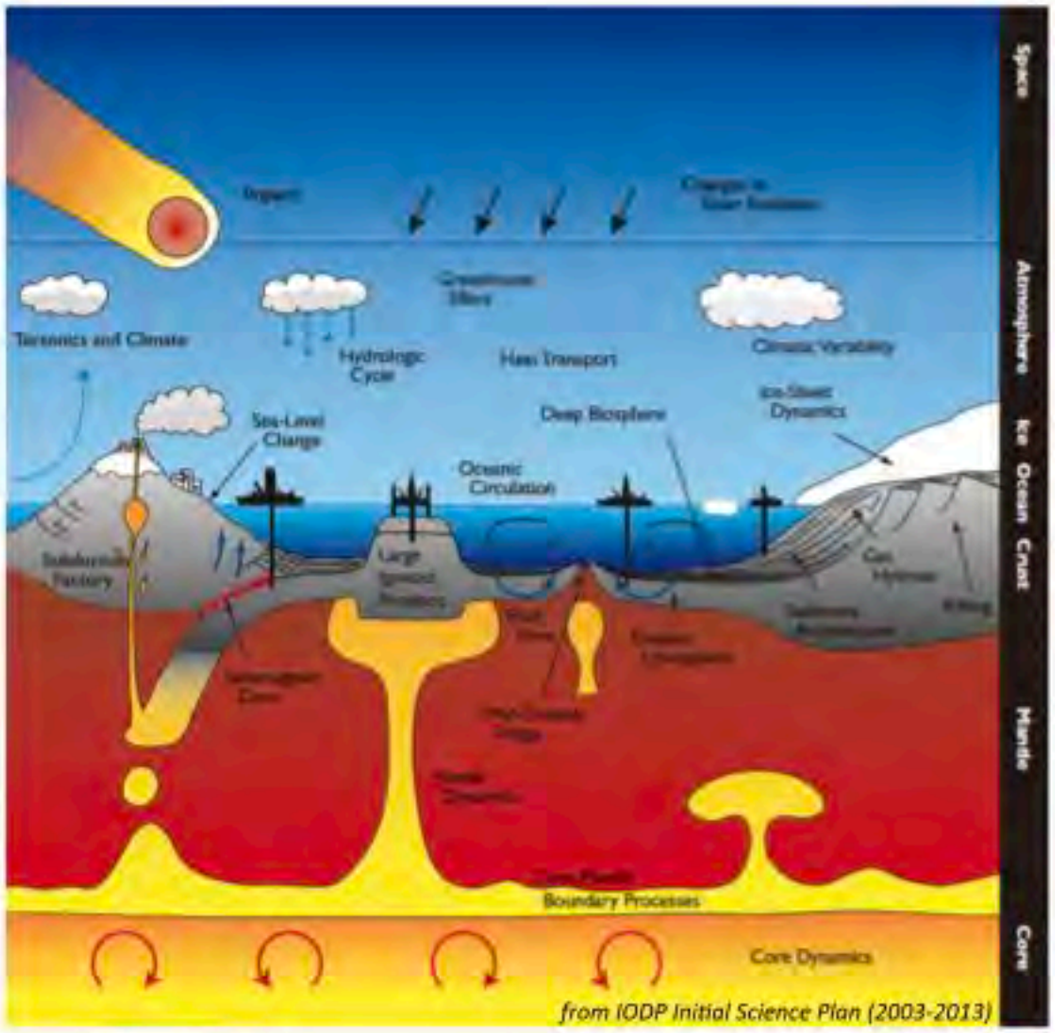
Deepest hole record: 3,058.5 m (Exp. 348)

IODP

International Ocean Discovery Program

Exploring the Earth under the Sea

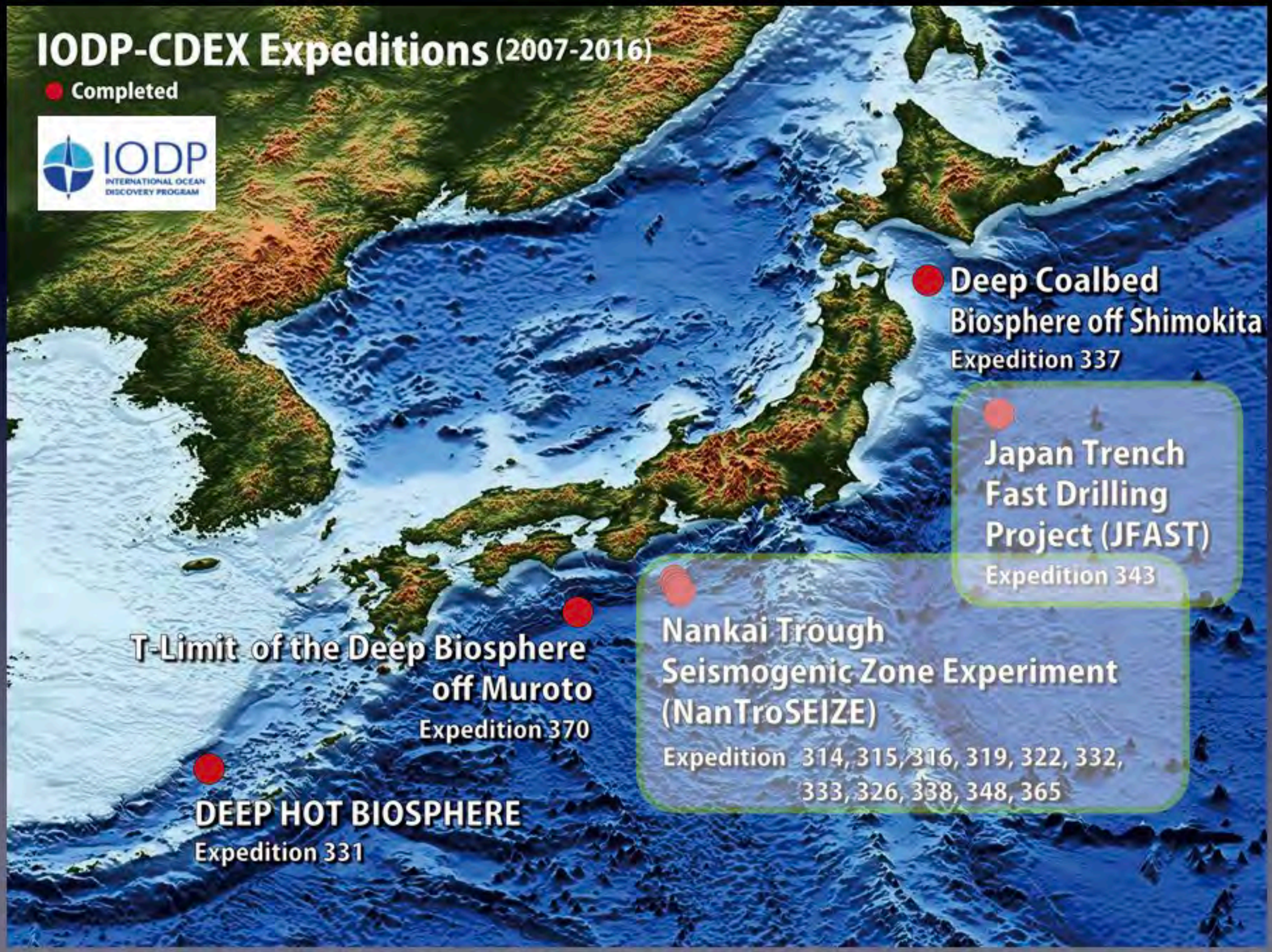
2013-2023



from IODP Initial Science Plan (2003-2013)

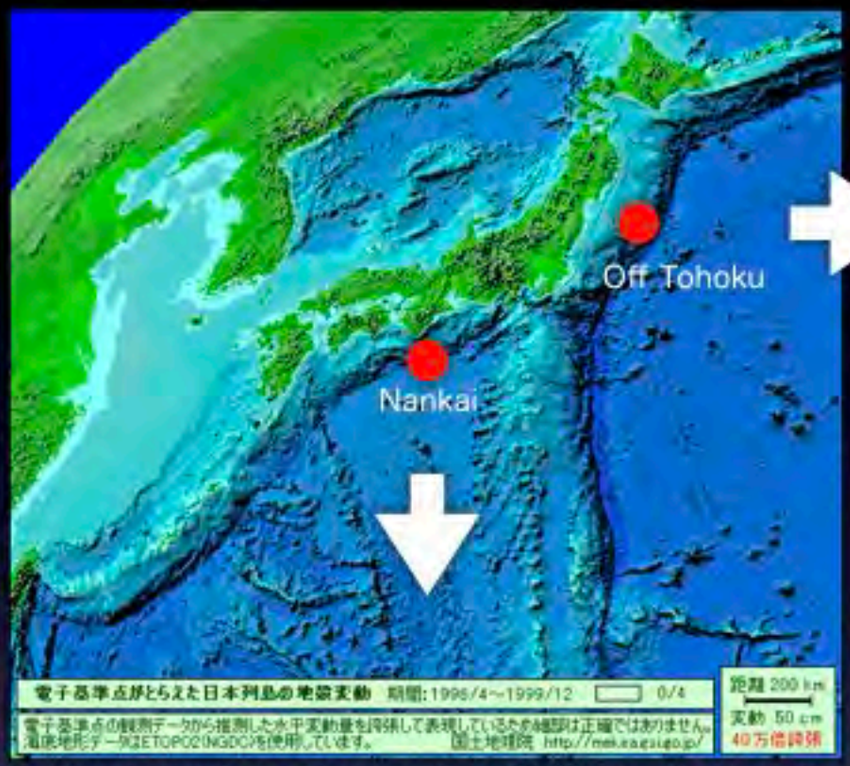
- The Deep Biosphere and the Subseafloor Ocean
  - Deep Biosphere
  - Gas Hydrates
- Environmental Change, Process and Effect
  - Extreme Climates
  - Rapid Climate Change
- Solid Earth Cycle and Geodynamics
  - Continental Breakup and Sedimentary Basin Formation
  - Large Igneous Provinces
  - 21st Century Mohole
  - Seismogenic Zone

IODP Expeditions Implemented by Chikyu

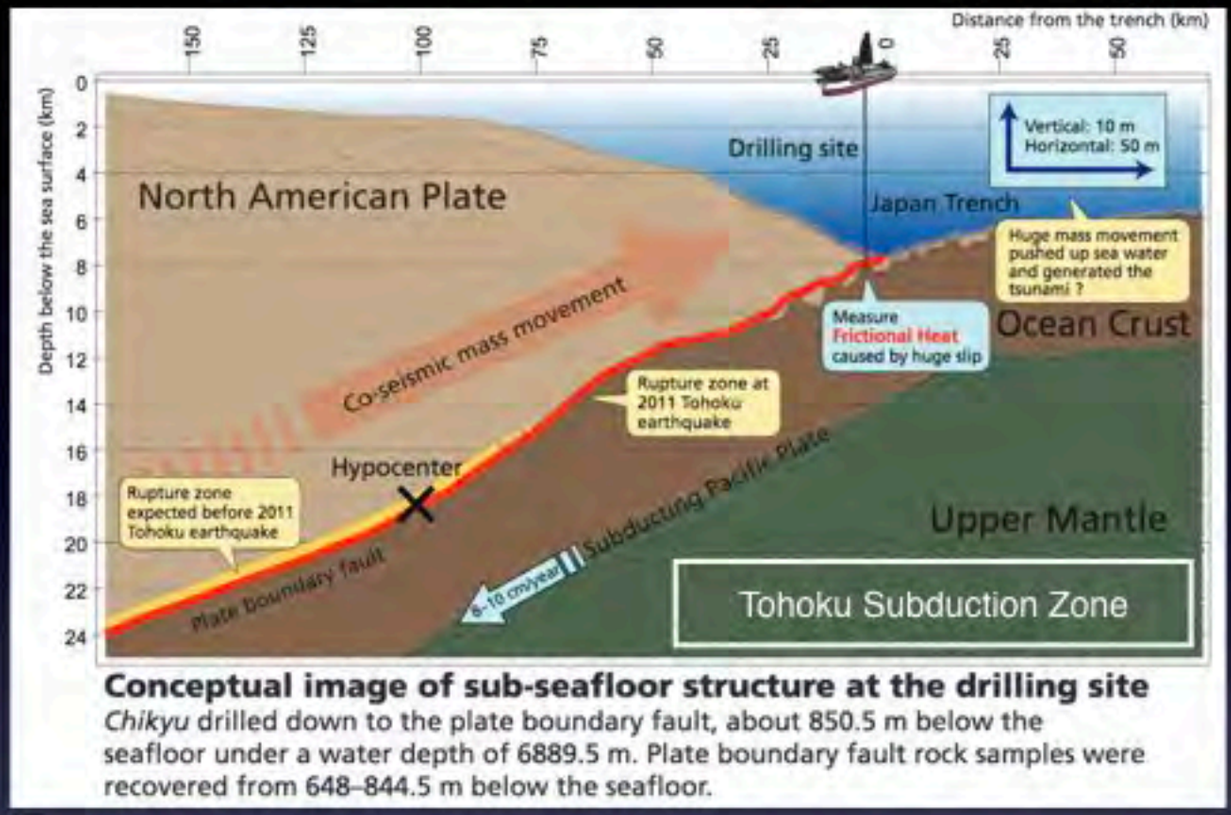


Seismogenic Zone

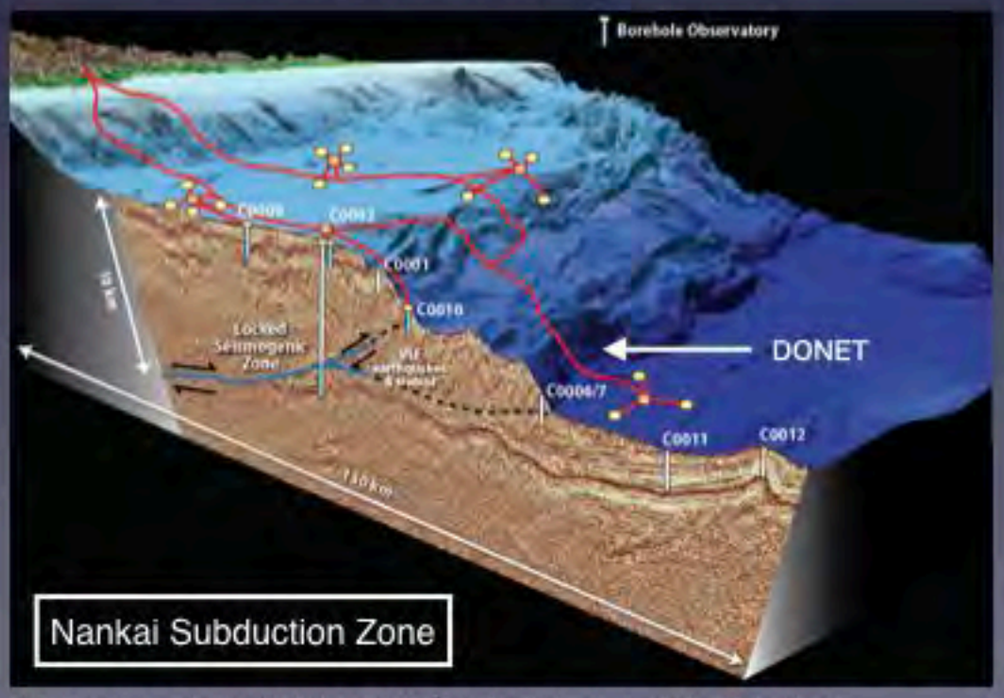
Nankai Trough and Off Tohoku



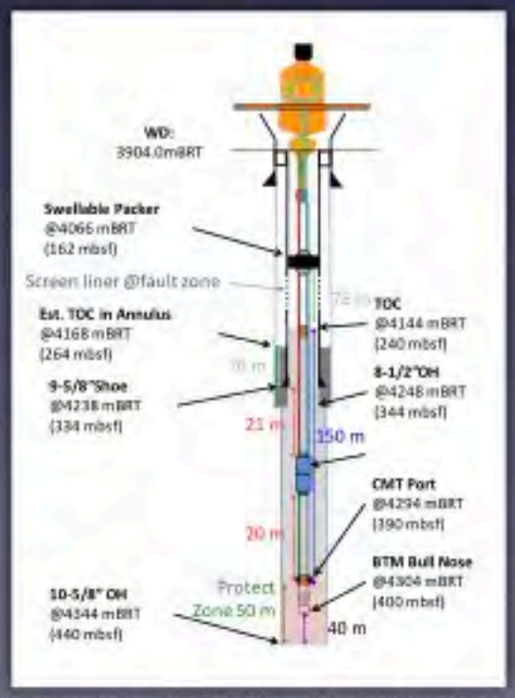
Crustal movement around Japan using a GNSS network observation.
Horizontal exaggeration is 400K. (GSI)



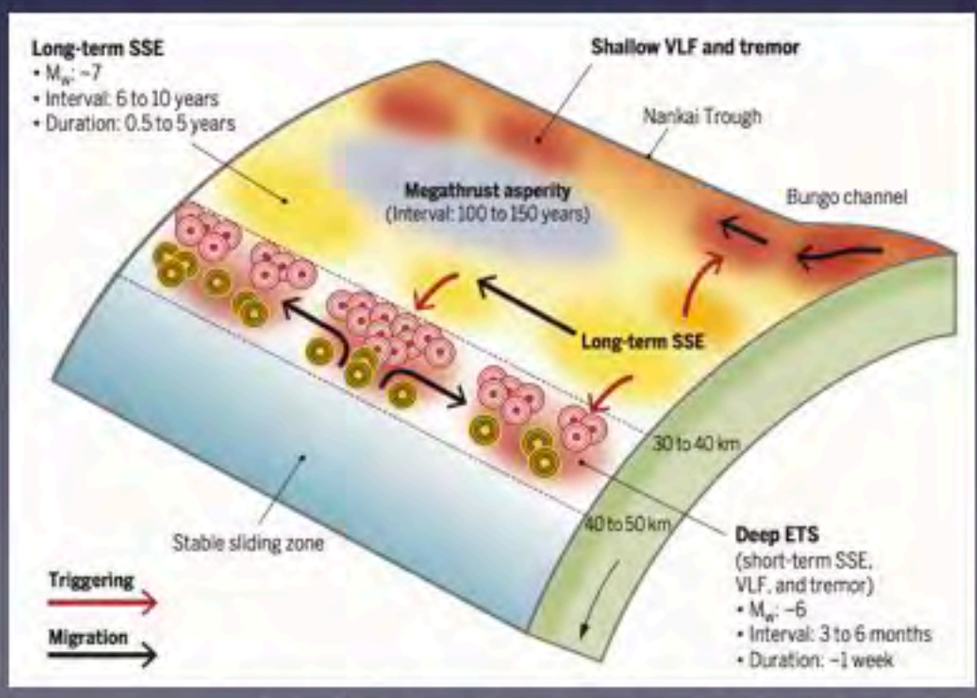
Conceptual image of sub-seafloor structure at the drilling site
Chikyu drilled down to the plate boundary fault, about 850.5 m below the seafloor under a water depth of 6889.5 m. Plate boundary fault rock samples were recovered from 648–844.5 m below the seafloor.



15 sites have been drilled and 2 sites have been installed borehole observatories. DONET (Dense Oceanfloor Network System for Earthquakes and Tsunamis) is under realtime operation now.



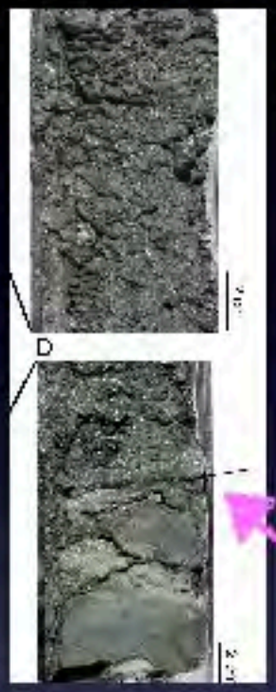
An example of LTBMS in Nankai boreholes. Slow slips are monitored with high resolution data.

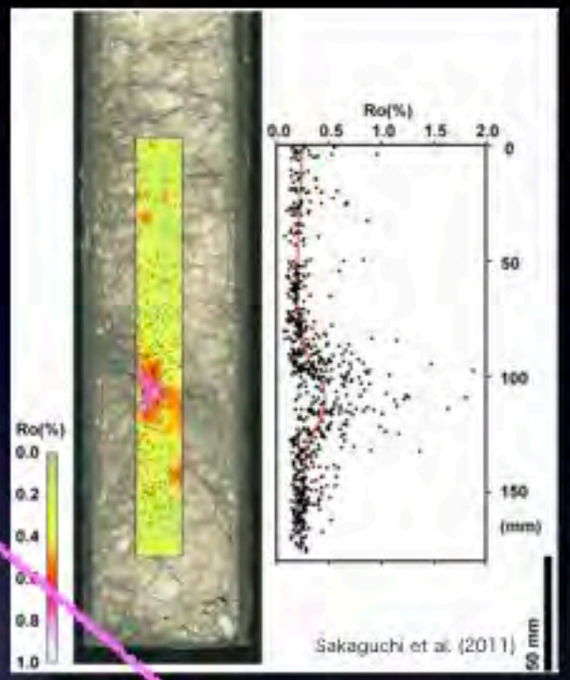


A model of slow slip and large earthquake relationship.
Obara & Kato (2016)

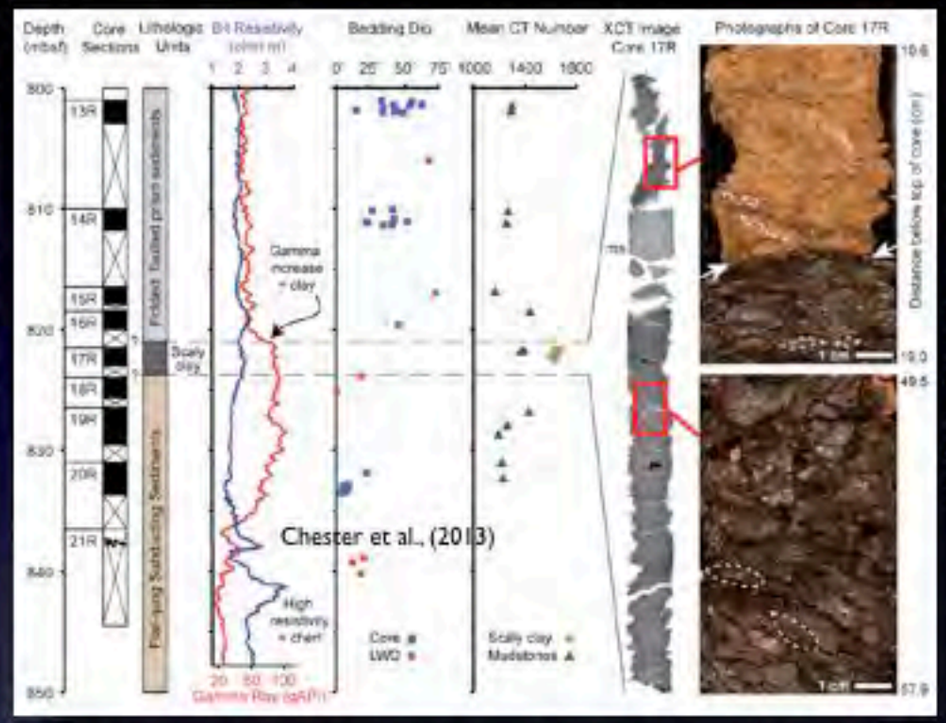
Common LargeTsunami Generation Mechanism?

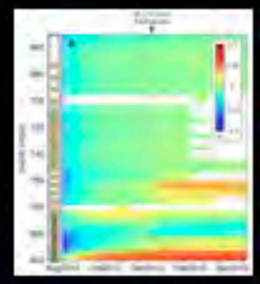
A New Finding at the Toe of Accretionary Prisms both Nankai and Tohoku





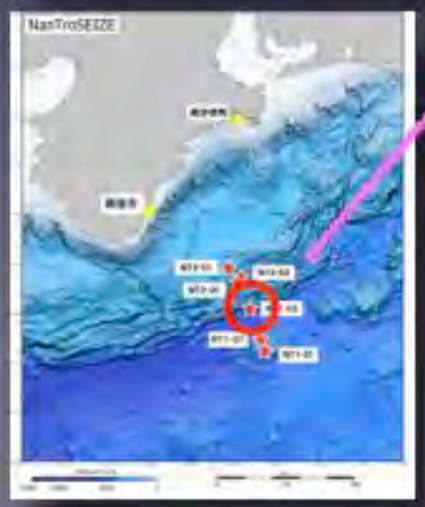
When estimating the frictional heat generated during an earthquake by using drilling samples, it was greater than 400 °C. It is believed that high-speed slip occurs even near the trench axis. This finding requests to re-writing our text book.

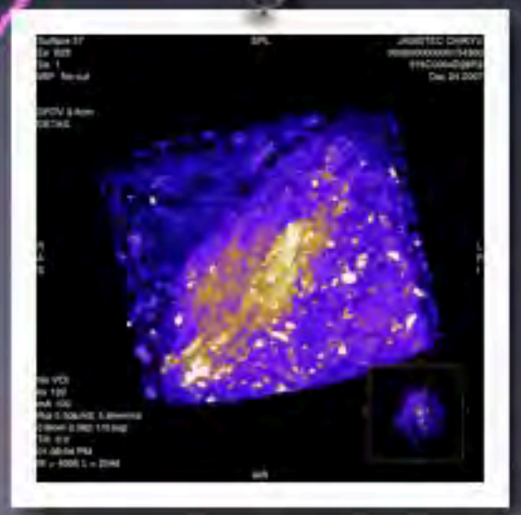




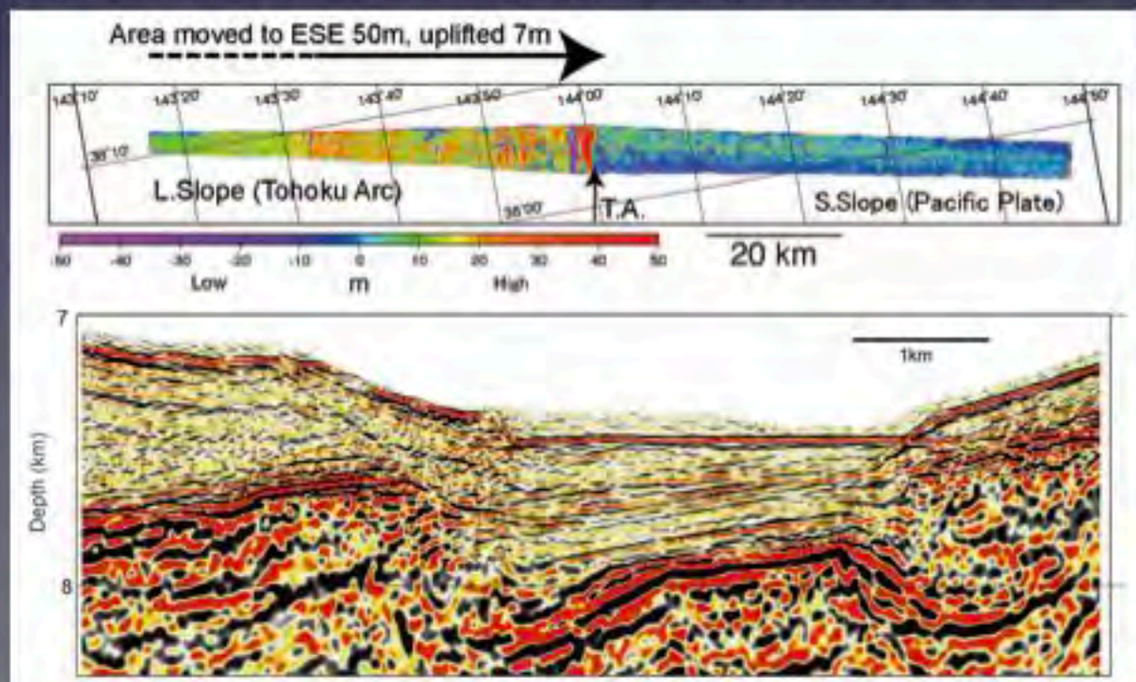
Frictional heating at the fault boundary detected using a chain of precise thermistors.

3.11 seismic fault was thin (less than 5 m thick) and contains smectite more than 70%. It is a fundamental condition to cause “Thermal Pressurization”. The mechanism significantly weaken the faults.



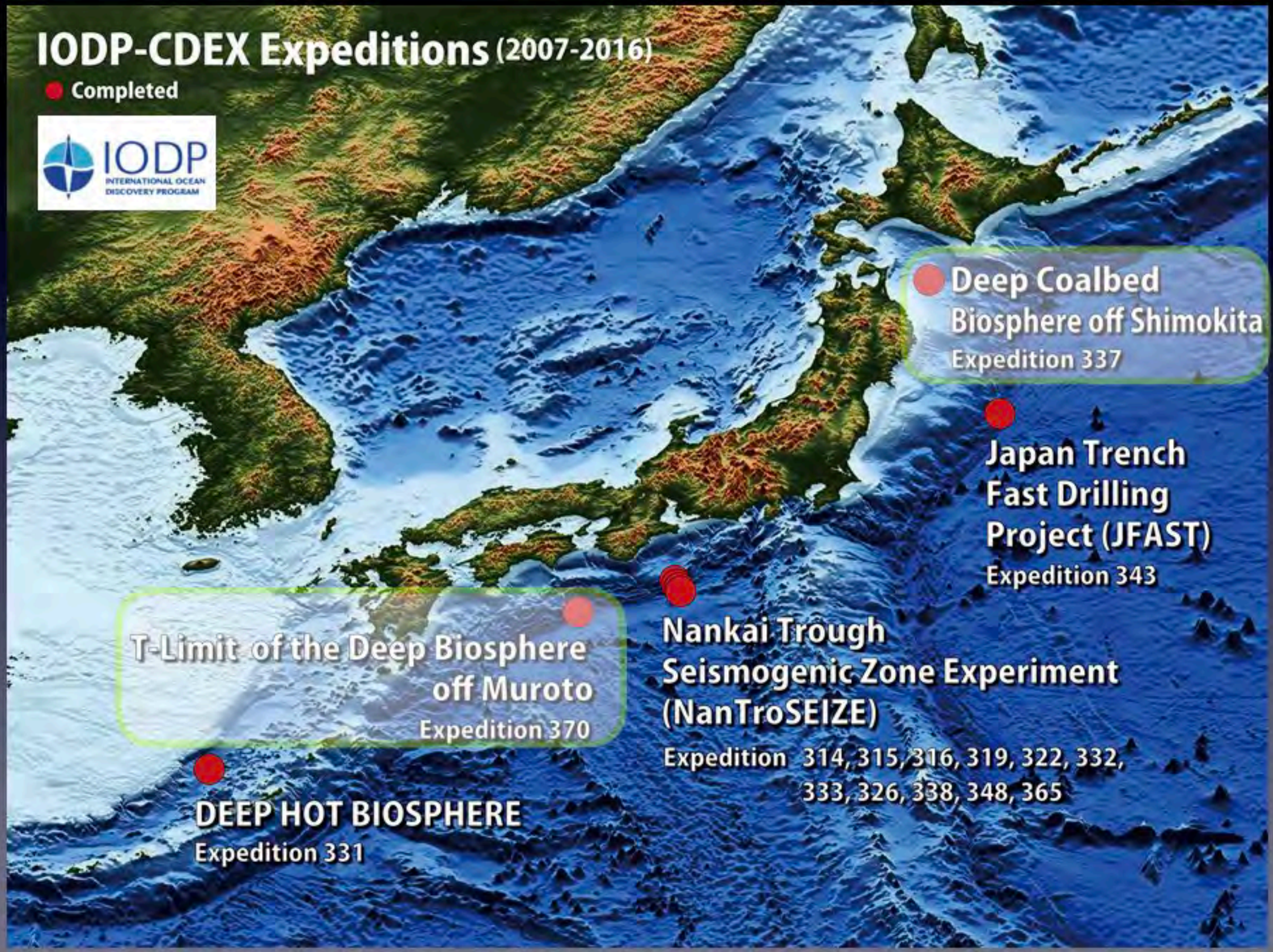


3D X-rays Image



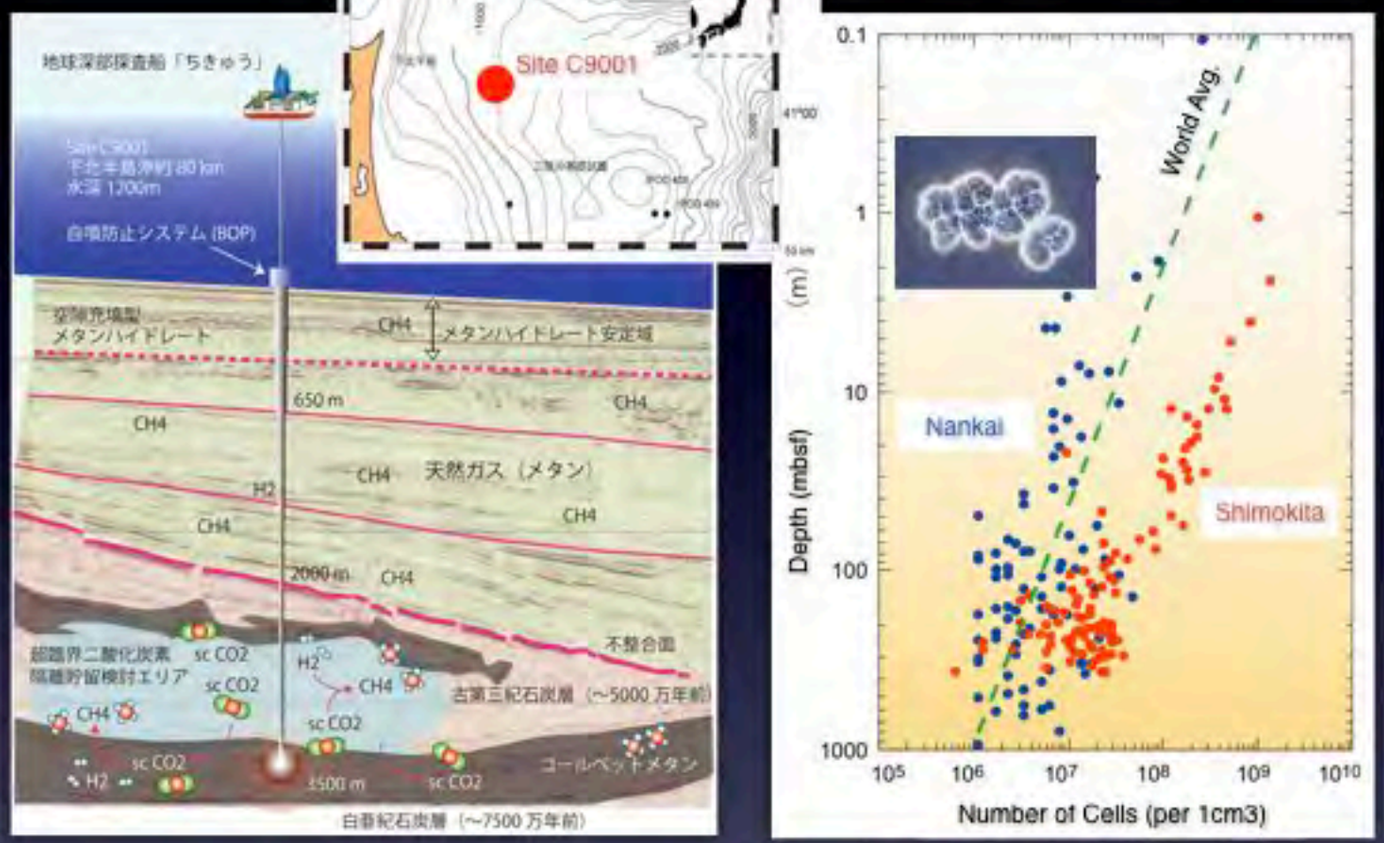
Before

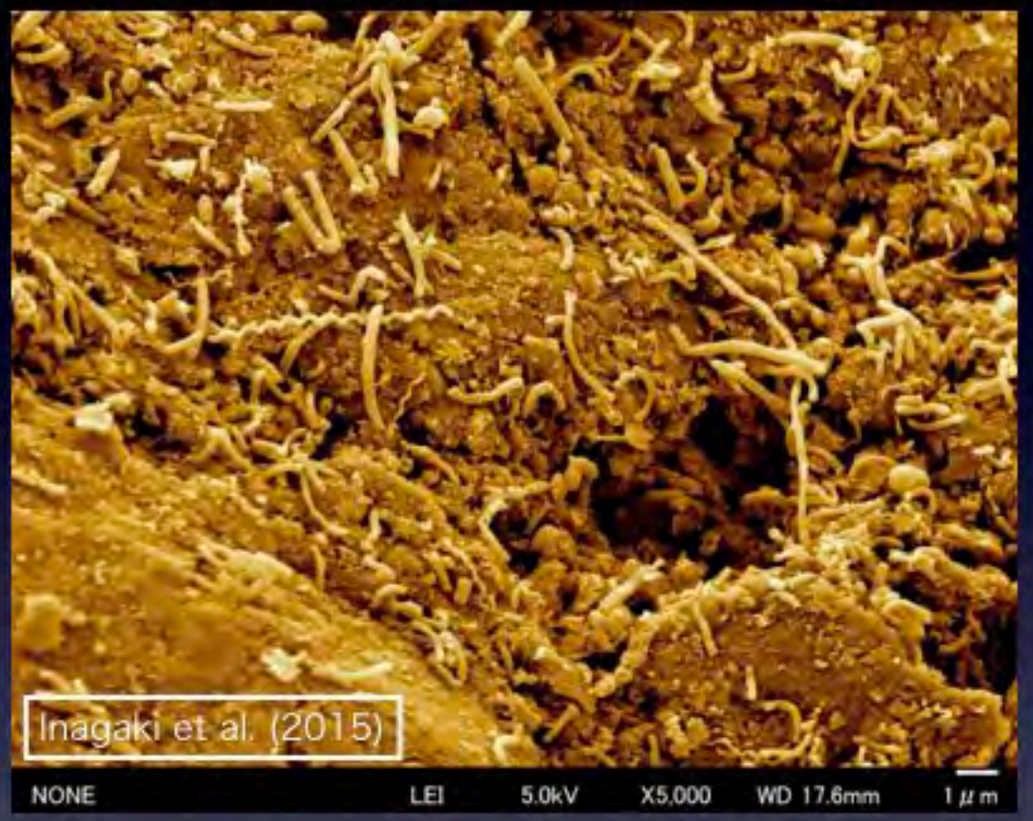
IODP Expeditions Implemented by Chikyu

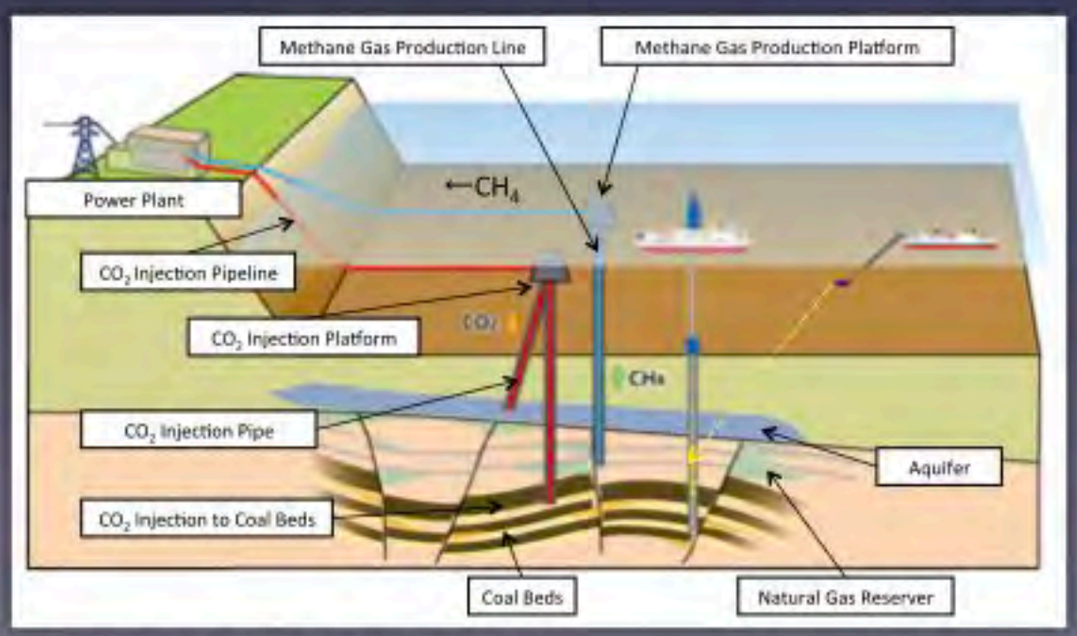


Life Sciences under Extreme Condition

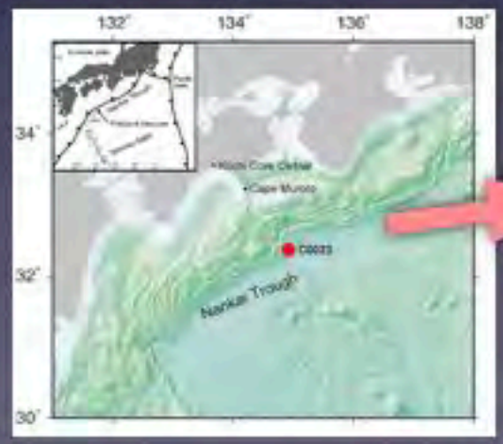
Shimokita-Hachinohe and Off Cape Muroto



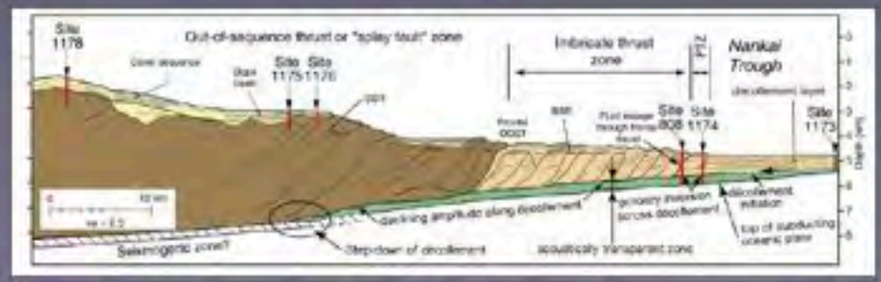




CCS-U Concept for the Future Research

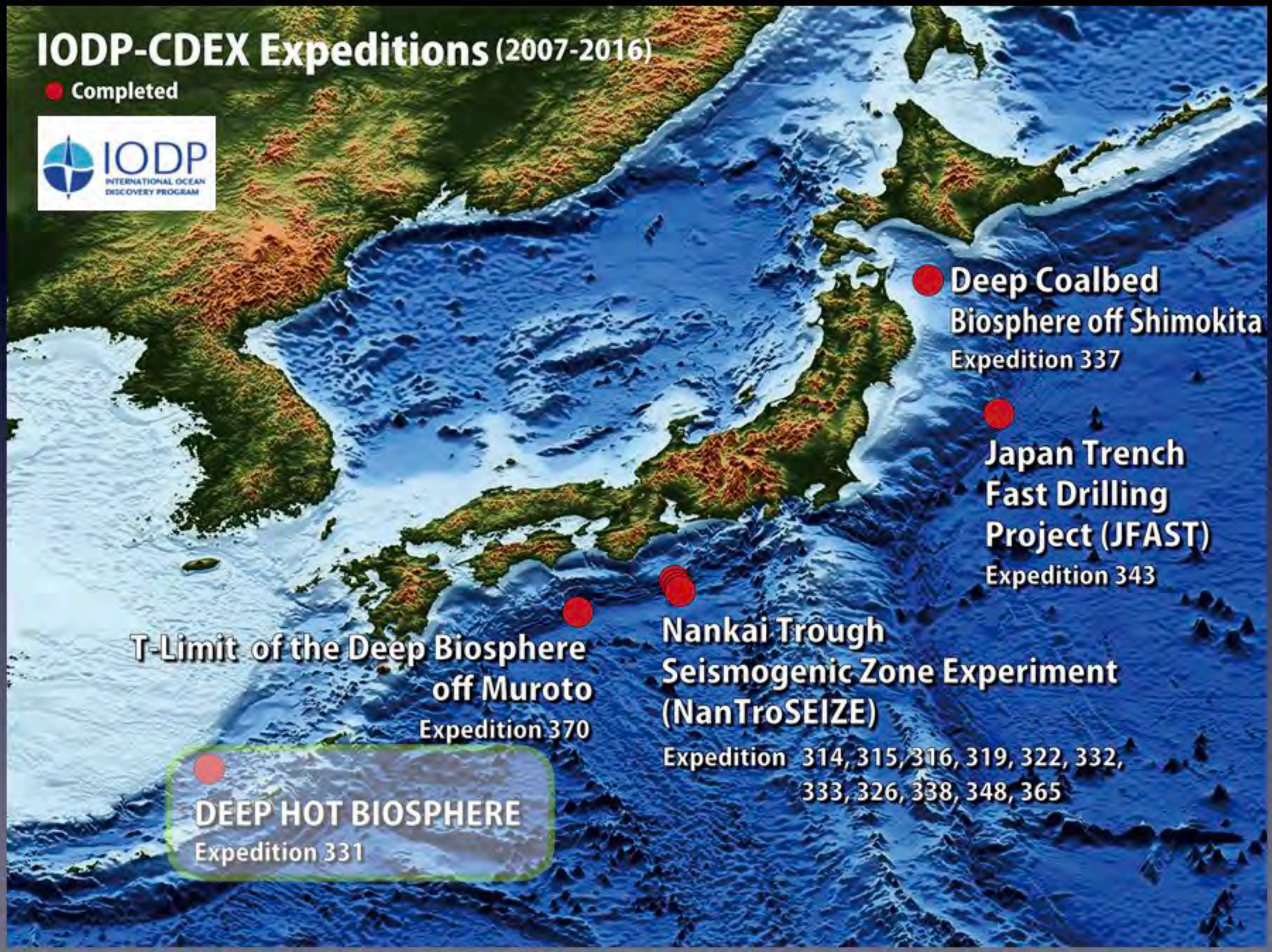


Transmission electron microscope picture of a microbe from 300 mbsf.



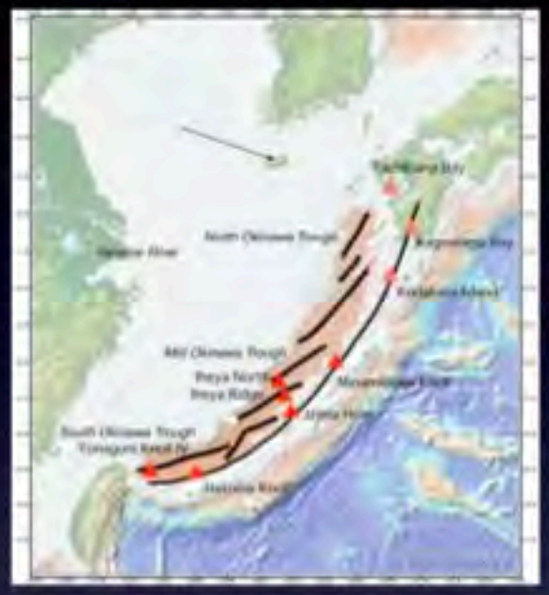
Temperature at the bottom of hole is **>120°C**

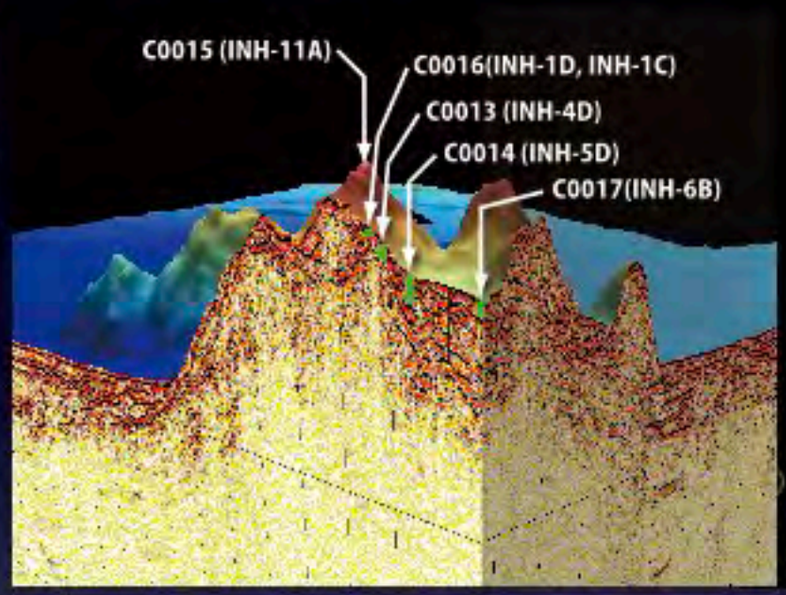
IODP Expeditions Implemented by Chikyu

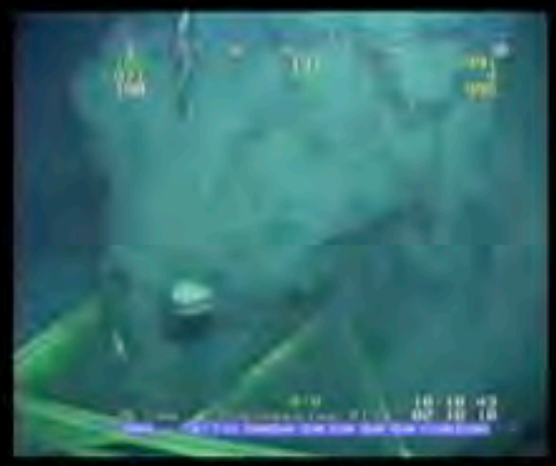


Hydrothermal System

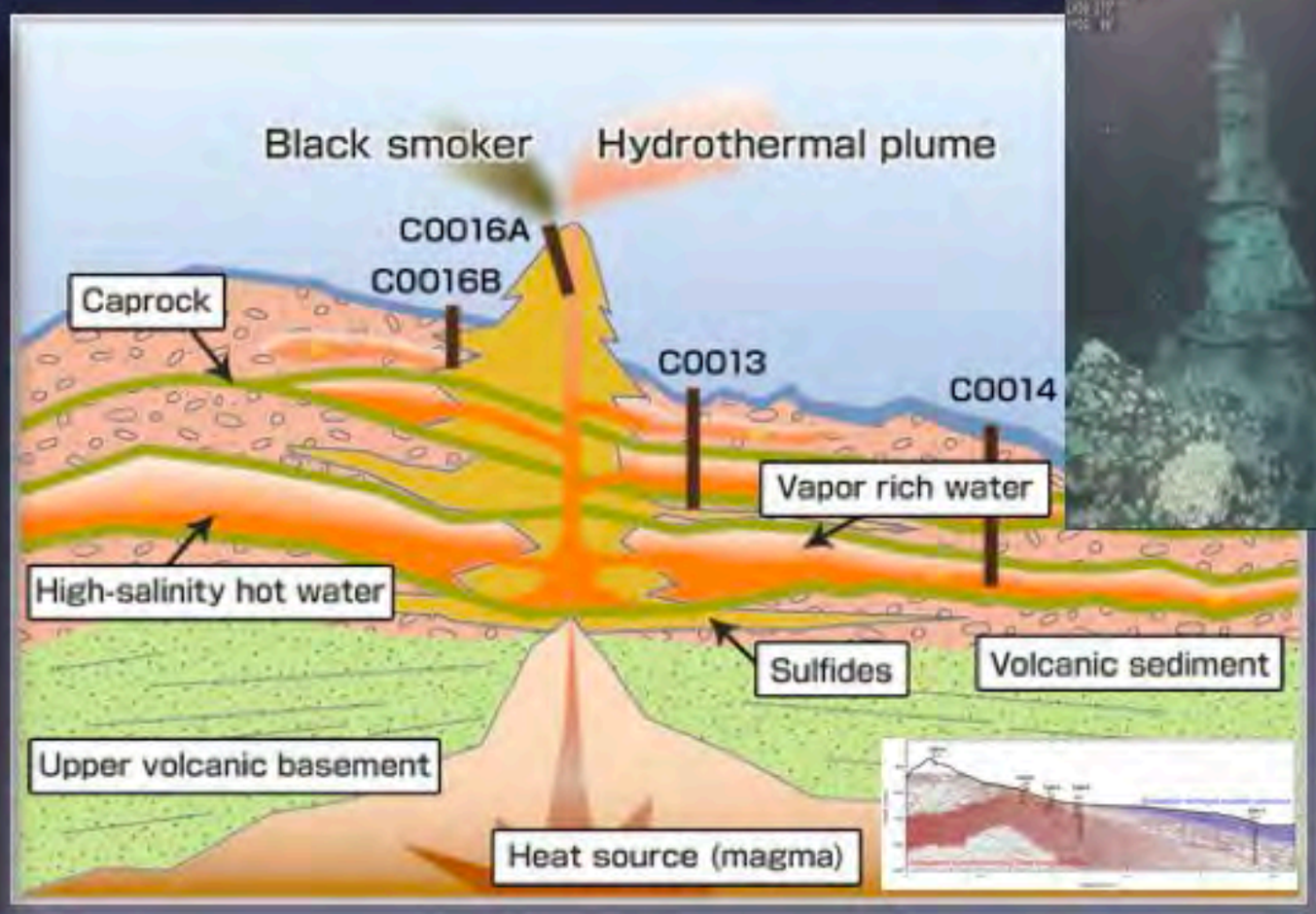
Okinawa Trough







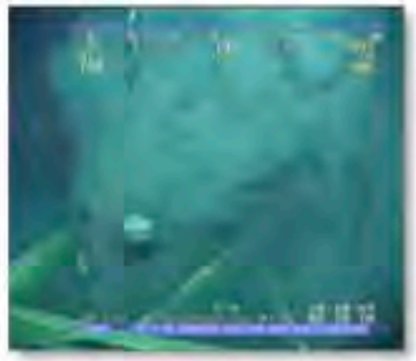
Accurate Drilling Technology at Extremely High Temp. Area



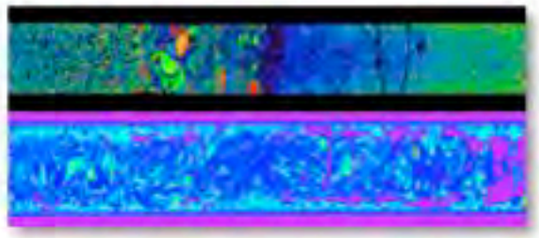
CHIKYU Technological Challenges Open A New Scientific Horizon

- Deep Water Drilling Technology
  - Exp. 343 JFAST, Japan Trench (WD: 6883.5m + 856.5 mbsf)
    - M9 earthquake fault coring, LWD and monitoring
- Deep Drilling Technology
  - Exp. 348, Nankai Trough (3000 mbsf)
    - Accretionary Prism (complex geology) drilling

- Riser Drilling under High Speed Current Technology
  - NanTroSEIZE, Nankai Trough (~6kts)
    - To be reach the splay fault/plate boundary



- Borehole Monitoring System Development
  - Real-time Monitoring through a submarine cable network
    - Frictional heat measurement at M9 fault and Nankai-DONET
- Coring Technology
  - Hybrid Pressure Core Sampler, Gel-Coring System & Turbine Driven Coring System
    - Methane gas hydrate coring, micro-bio sampling & deep penetration
- State-of-the-art Laboratory
  - X-CT, P-Mag, ICP-MS, Micro-Bio, etc
    - High-resolution measurements



Drilling into the Mantle

Sample Return from Unexplored Interior of our Planet

Challenge of Deep Water and Deep Penetration

★New Riser Pipe for Deep-Water

▶CFRP Riser

★Tough Drilling Pipe

▶12,000m Class DP

★Long-Life Drill Bit

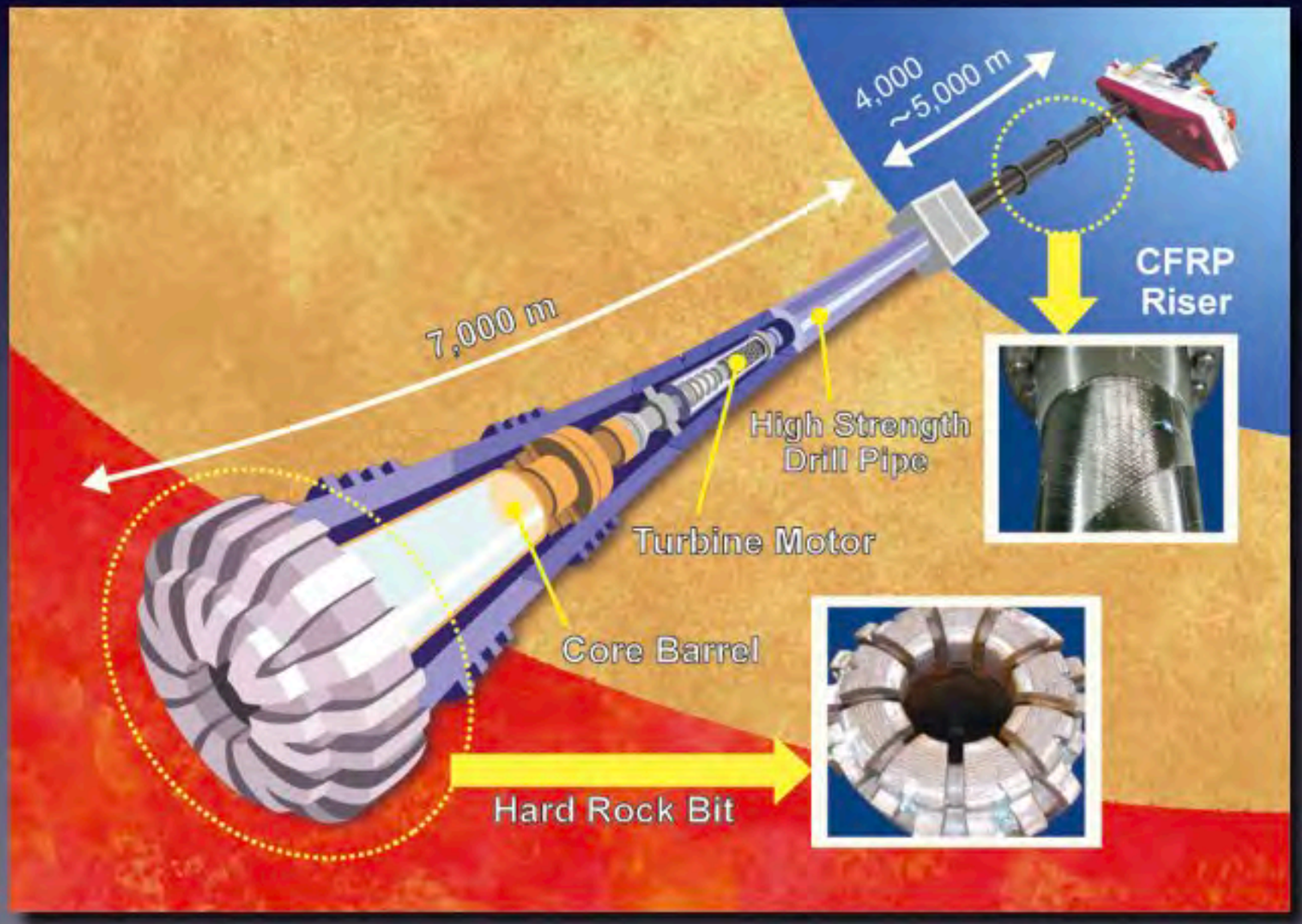
★High Temp. Drilling Fluid

▶>300°C

★High Temp. Logging Tools

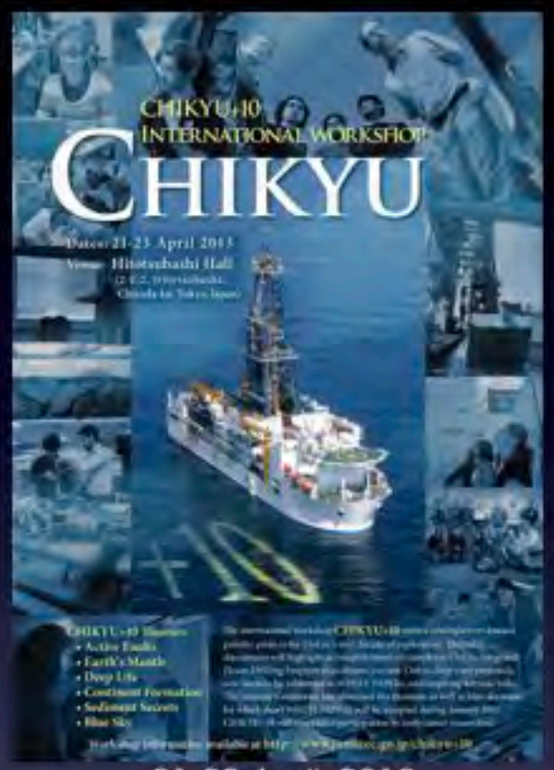
★Pilot Hole Drilling

▶Riser-less Drilling



Chikyu+10 International WS

April 2013



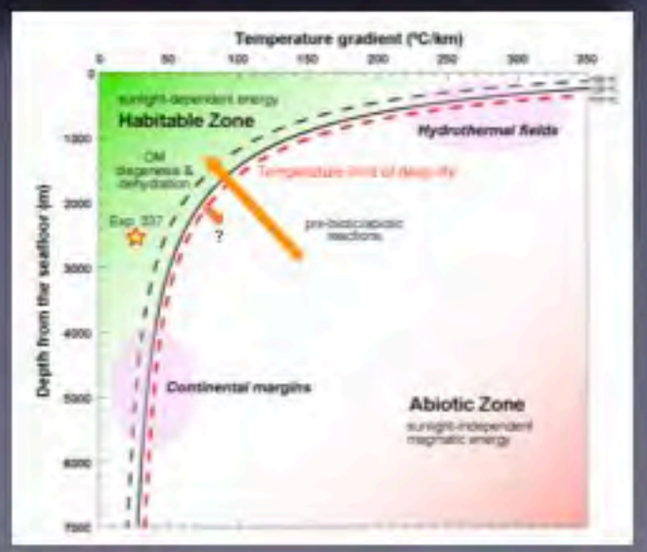
21-23 April, 2013

Science Theme	Flagship (Large) Project	Discovery (Small) Project	Other Opportunities
Dynamic Fault Behavior	NanTroSEIZE CRISP Hikurangi Margin	Japan Trench KAP	Faulting in Oceanic Crust Monitoring Nicoya Peninsula
Ocean Crust & Earth's Mantle	M2M Life Cycle of the Oceanic Lithosphere		Atlantis Bank Ontong Java Plateau IBM Godzilla Megamullion
Deep Life & Hydrothermal System	(Habitable Zone Drilling)		4500 m hole off Hachinohe Shikoku Basin (High Temp.) Décollement Hydrology (JFAST) Mud Volcano in the Kumano Basin Brothers Volcano (Kermadec Arc) Eastern Manus Basin Serpentinization System
Continent Formation	IBM		Aleutian
Sediment Secrets	Mediterranean Salinity Crisis (DREAM)	Lord Howe Rise Challenger Plateau Pegasus Basin South China Sea Santos Basin Bering Sea	Pacific Guyots Deep Pacific Somali Basin Eastern Mediterranean Santa Barbara Basin West Caroline Basin Bohai Basin Dronning Maud Land

working with Australian Government

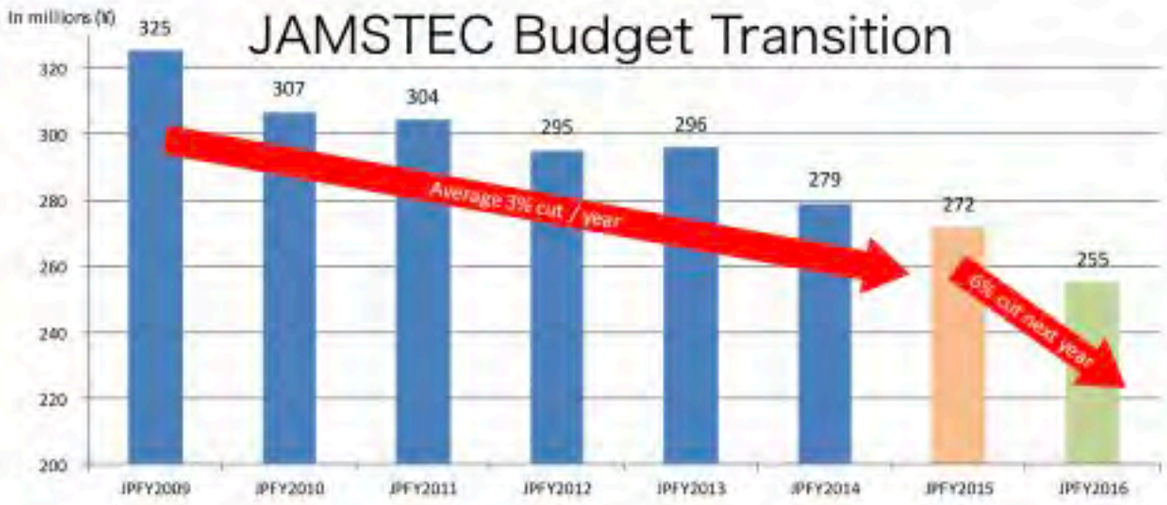
Country	Participants
JPN	261
USA	54
Europe	33
AUT	1
CAN	1
CRC	1
FRA	4
GER	10
ITA	2
NED	1
NOR	1
SPA	2
SUI	1
UK	9
AUS	11
NZL	4
CHN	22
TPE	1
TWN	2
INA	1
IND	1
KOR	7
Total	397

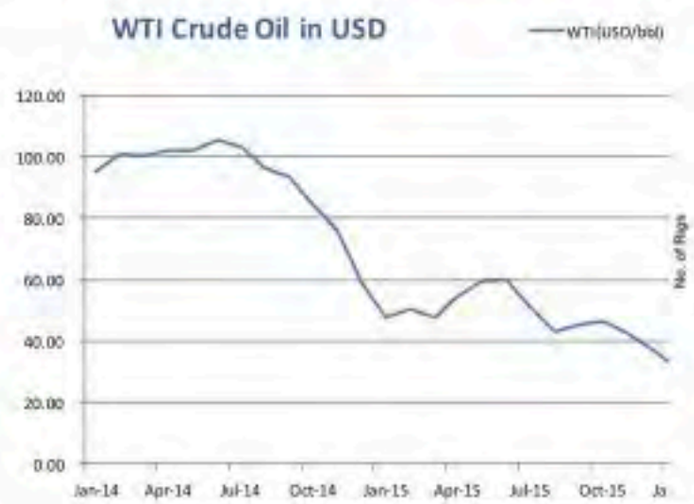
Over 400 people attended



Challenge of Operation - 1

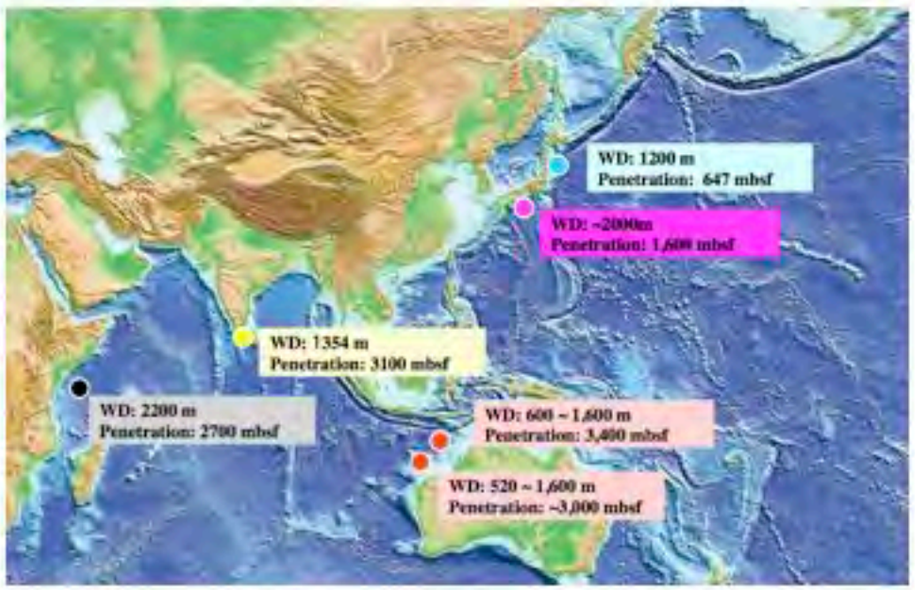
(secure sustainable operation Budget)



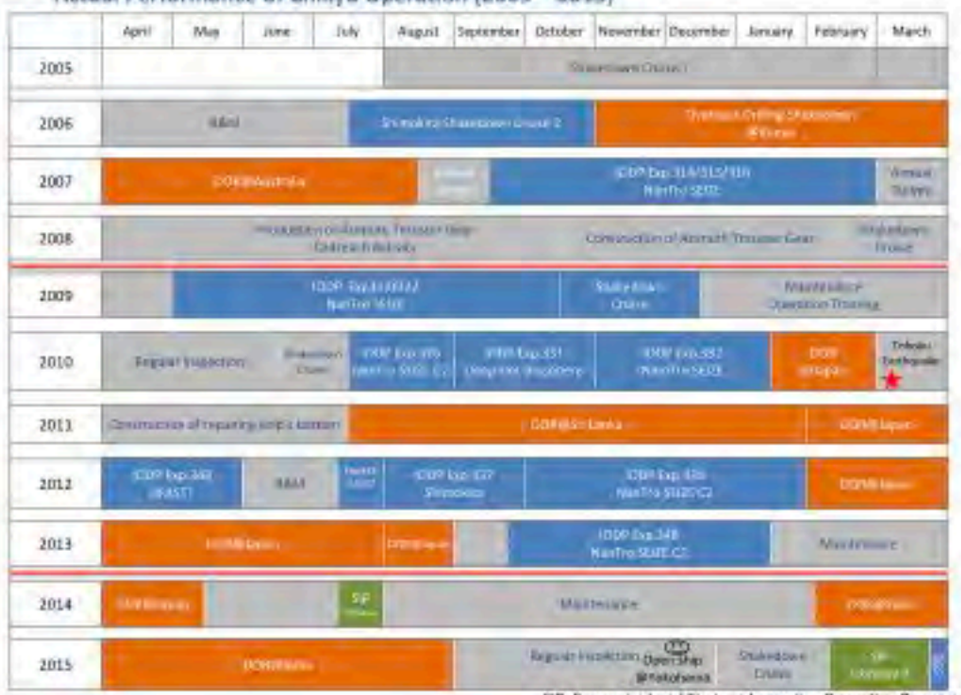


<Pros>
> Cost-cutting in operating expenses, i.e. personal cost, fuel, subcontractors and so on.

<Cons>
> Less opportunity for commercial drilling.
> Day rates will be much lower.



Actual Performance of Chikyu Operation (2005～2015)



SIP: Cross-ministerial Strategic Innovation Promotion Program

Challenge of Operation - 2

(secure pre-, during-, post-drilling Research Capability)

Pre-drilling Research

- shallow to deep crustal structure by 2D and 3D seismic survey
- hazard identification survey by high-res. seismic survey
- geo-tech core sampling
- topography and geophysical data
- met-ocean observation

During-drilling Research

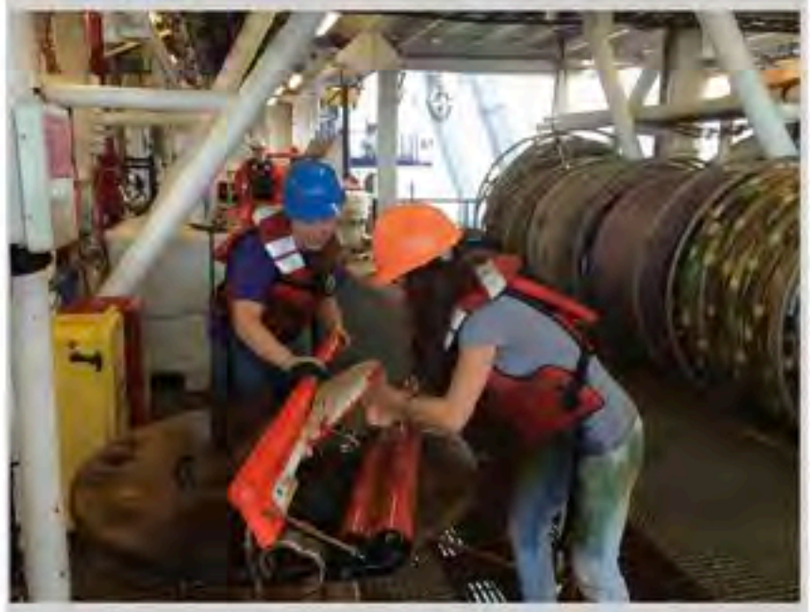
- walk-away VSP in 2D and 3D
- active monitoring
- bore-hole tomography

Post-drilling Research

- active/passive monitoring by LTBMS
- in-situ bore-hole experiments

Keeping Our Focus on the Subseafloor

Hard-pressed funding agencies wonder whether marine seismic facilities are worth the investment. A recent survey gives a resounding yes.



University of Texas at Austin Ph.D. students Kelly Olsen and Brooklyn Gose work on recovering, cleaning, and storing 1 of 50 streamer depth control birds on the back deck of the R/V *Langseth* during a marine seismic survey cruise. Although relatively few scientists go to sea to collect such data themselves, the data from these surveys provide valuable information on subseafloor structures to a much wider scientific community. Credit: Nathan Bangs

By Nathan Bangs and James A. Austin Jr. 3 October 2017

EOS. AGU

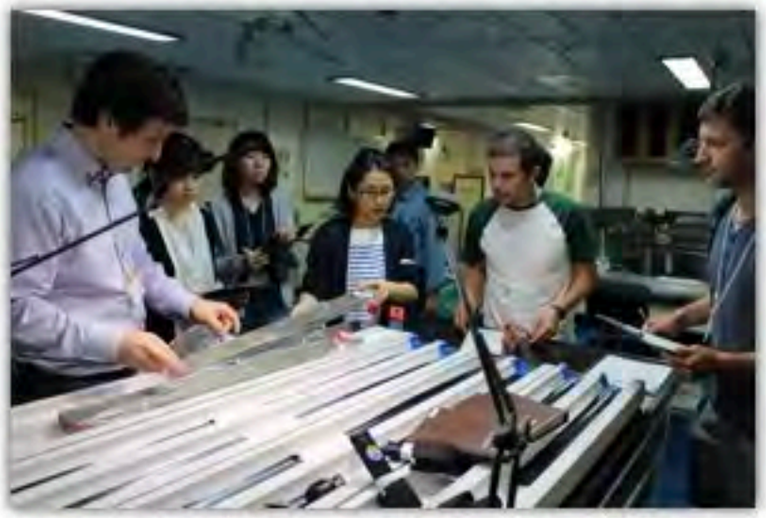
Challenge of Operation - 3

(promote next generation and capacity building)

Lecture Delivery to Science Museums

Invite students to the Chikyu

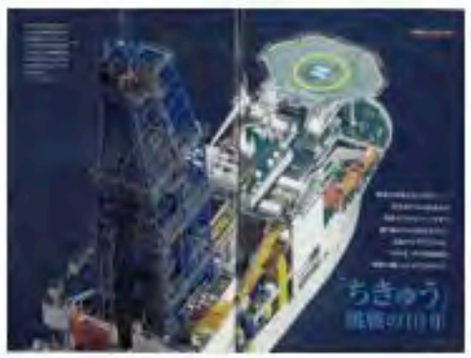
On-hand Lecture at the Chikyu Lab.



International Core School on the Chikyu

Symposiums

Open Ship Events



Collaborate w/ Mus.

Publications

TV Programs

Town Hall Mtg.

Lessons Learned from Chikyu Operation

- Seek multi sources of fund
  - more collaboration with industries, governments (and maybe science founders)
- Need to establish a PROJECT which supported by international colleagues and ship operators
  - gather ships, equipment, technology and operators
  - share data, samples, knowledges and opportunities of education/training
  - establish a Win-Win-Win- … relationship among contributors
- Educate next generation, early carrier people
  - otherwise no future for us

I'm happy to discuss this issue during the IRSO 2017 meeting in Yokosuka.
Thank you!

International Research Ship Operators