J-DESC Workshop

"Scientific Ocean Drilling beyond 2023"

「科学掘削の未来：2023年からその先へ」

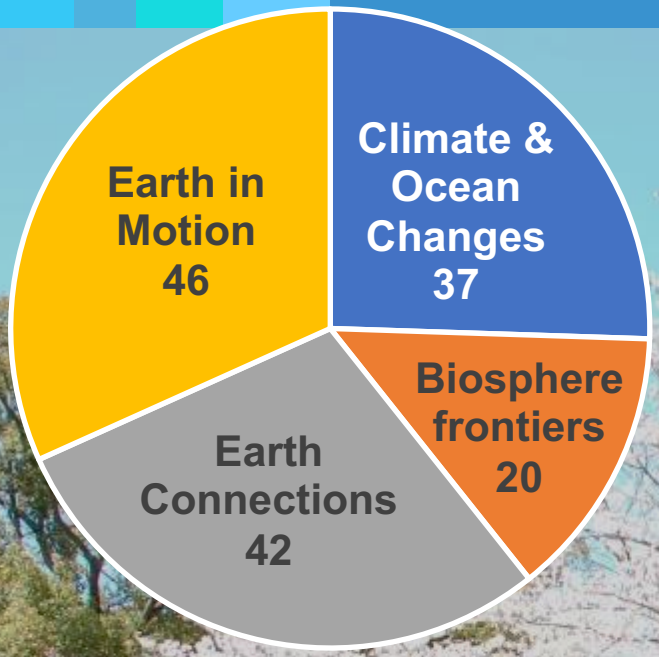
地球科学における巨大プロジェクト“科学掘削”。
若手・中堅研究者が、その未来を描くためのワークショップを開催する。
日本発の科学プランを創っていこう！

2019年
4月2日(火)～3日(水)

場所：海洋研究開発機構 横浜研究所 三好記念講堂（JAMSTEC Yokohama Institute）
使用言語：英語／日本語

Junichiro **KURODA** (Univ. Tokyo) & **Yuki MORONO** (KCC, JAMSTEC)

Participants



- Total ~150 participants
- 1/4 was graduated students
- Rep: JRFB, ESSAC, ANZIC, SEP

Steering Committee

steering committee		
Theme	Name	Institution
Climate and Ocean Change	Junichiro Kuroda	AORI / Univ. Tokyo
	Azumi Kuroyanagi	Tohoku Univ.
	Yusuke Okazaki	Kyushu Univ.
	Tsuyoshi Nakagawa	Ritsumeikan Univ.
	Megumi Saito	Nat. Museum Nature Sci.
Biosphere Frontiers	Yuki Morono	KCC / JAMSTEC
	Natsuko Hamamura	Kyushu Univ.
	Yohei Suzuki	Univ. Tokyo
	Masanori Kaneko	AIST / GSJ
	Fumito Shiraishi	Hiroshima Univ.
	Yoshinori Takano	JAMSTEC
Earth in Motion	Kotaro Ujiie	Tsukuba Univ.
	Asuka Yamaguchi	AORI / Univ. Tokyo
	Saeko Kita	BRI Building Research Institute
	Osamu Fujiwara	AIST / GSJ
Earth Connections	Tomoaki Morishita	Kanazawa Univ.
	Shigeaki Ono	JAMSTEC
	Katsuyoshi Michibayashi	Nagoya Univ,
	Norikatsu Akizawa	AORI / Univ. Tokyo
	Satoko Ishimaru	Kumamoto Univ.
Administration		
Secretary	Nobu Eguchi	JAMSTEC / CDEX
	Kae Takahashi	
	Yumi Ebashi	

Schedule

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

Day 1: Tue. 2 April

Introduction and review of the current program		
9:00	Registration	
9:30-9:40	Introduction	Gaku Kimura (J-DESC)
9:40-9:45	Guest speech	Tatsuya Watanabe (MEXT)
9:45-9:55	Review of the current program	Nobu Eguchi (CDEX)
9:55-10:05	Reporting from the domestic workshop in 2018	Harue Masuda (J-DESC)
10:05-10:30	Process of making IODP science plan and prospects for the next program	Naohiko Ohkouchi (JAMSTEC)
10:30-10:40	Break	
Current situations and discussions in other countries		
10:40-11:20	Current situations and discussions in other countries toward making the new science plan	
Keynote speech 1		
11:20-11:40	Exploring New Scientific Frontiers with Chikyu	Fumio Inagaki (JAMSTEC)
Breakout session 1 – Breakout session on four current IODP science plan themes		
11:40-12:10 13:00-17:00	Breakout session on four current IODP science plan themes: ▪ Climate and Ocean Change ▪ Biosphere Frontiers ▪ Earth Connections ▪ Earth in Motion *Note: Lunch break is from 12:10 to 13:00*	
Keynote speech 2		
17:00-17:30	Japanese Mars Exploration Program: Exploring Habitable Subsurface World	Tomohiro Usui (JAXA)
17:30-18:10	Reporting and sharing among the breakout session groups	
18:30-20:30	**Social gathering (Optional) Fee: 1,000 yen for students / 3,000 yen for others**	

Day 2: Wed. 3 April

Plenary session on new methods and technologies		
9:00-10:40	Plenary session on new methods and technologies for earth sciences	
	Scientific Drilling and Data-driven Science	Tatsu Kuwatani (JAMSTEC)
	Towards "Neutrino Geoscience" with Geo-neutrino Measurements	Hiroko Watanabe (Tohoku Univ.)
	STXM-based sub-micron scale microscopic analysis protocol and its application	Hiroki Suga (Univ. Tokyo)
	A new tool for micropaleontology using AI (artificial intelligence): automation of identification and collection for microfossil species	Takuya Itaki (AIST)
10:40-10:45	Break	
Breakout session 2 – Breakout session on interdisciplinary fusion		
10:45-12:00	Breakout session on interdisciplinary fusion 1st period combinations: ▪ Biosphere Frontiers – Climate and Ocean Change ▪ Earth Connections – Earth in Motion	
12:00-13:00	Lunch break	
13:00-14:15	2nd period combinations: ▪ Biosphere Frontiers – Solid Earth* ▪ Climate and Ocean Change – Solid Earth* * Solid Earth = Earth Connections & Earth in Motion	
14:15-14:30	Break	
Keynote speech 3		
14:30-15:00	Earthquake faults, oceanic crust and arc volcanoes: What geophysicists have learned	Shuichi Kodaira (JAMSTEC)
Plenary session on future science plan		
15:00-17:00	Reporting, sharing and discussion	
17:00-17:30	Summary	

Key Questions discussed

1. Do you think the framework of IODP necessary beyond 2023? and why?

   What is your motivation to participate in IODP/ICDP?
   What are the benefits of participating in IODP/ICDP?
   What is the reason why IODP/ICDP should continue?

2. What's your idea on achievements in **challenges** of ISP? Is it necessary to be supplemented/modified beyond 2023? How?

   What new scientific themes/challenges should be formulated in the next program, in addition or replace to the current themes/challenges?

3. What is the science(s) only be achieved by IODP beyond 2023? What is necessary to accomplish the goal (ship, International collaboration, Onboard opportunity, etc.)

4. Do you think linkage between IODP and ICDP is necessary? If yes, please describe why necessary and how to link?

Climate & Ocean Changes

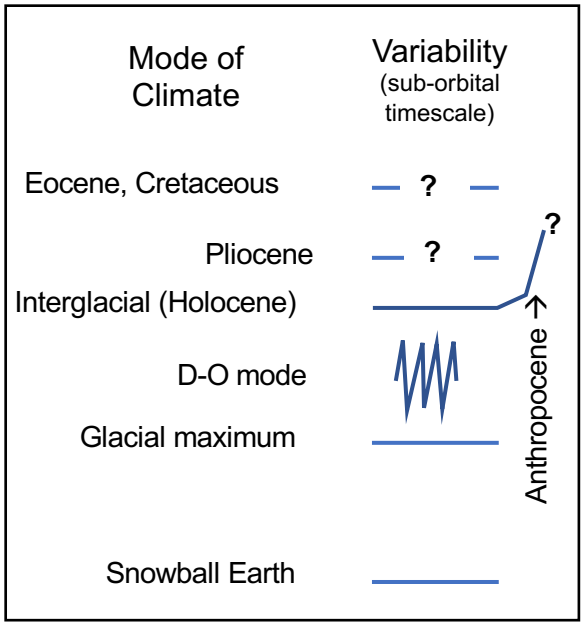
J. Kuroda, Y. Okazaki, A. Kuroyanagi, M. Saito & T. Nakagawa

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

The discussion was stimulated by four flash talks;

1) Leads and lags of the deglacial climatic oscillations among key records (T. Nakagawa),
2) Insight of sea-level and ice-sheet changes through scientific drilling (T. Ishiwa),
3) Paleoclimate modelling of ice age cycle, millennial scale change and deep past (A. Abe), and
4) Denudation, deposition, and paleoclimate (H. Naruse) +deconvolving bioturbation,

- The Earth's climate has some "modes"; Extreme Greenhouse (Cretaceous, Eocene), Greenhouse (mid-Pliocene), Interglacial (Holocene, MIS-5e), Stadial-Interstadial, Glacial Maximum (MIS-2), and the Snowball Earth. Variability, stability, amplitude and rate of climate change at each climatic modes (in sub-orbital timescale) should be highlighted.
- A wider spatial coverage of paleoclimatic data "from Sites to Network" is necessary for better collaboration with paleoclimate modelling.
- Not only the mean average, but also its amplitude, deviation, heterogeneity and diversity of climate change are important to understand the variability.



Potential new challenge;

How the Earth's climate is variable and unstable at each climatic modes in the suborbital timescale? What is the amplitude of those variations?

Additional key words; Anthropocene, eutrophication, hydrological cycles, coastal processes,

Biosphere Frontiers

Y. Morono, Y. Takano, N. Hamamura, F. Shiraishi & M. Kaneko

We discussed
- IODP itself as international framework
- The degree of accomplishment of challenges in ISP and open question for future
- The advantages of IODP for moving forward the biosphere frontier research

- The IODP framework has been promoting the international scientific collaboration and knowledge exchange among various ages
- To be a sustainable research field, interdisciplinary collaboration and **attracting non-IODP folks** and **new generations** will be VERY important
- Basic scientific questions will remain to be challenged. Potentially interesting targets are; **Microbe-mineral interactions, gradient of abiotic/biotic reactions, geosphere and biosphere interaction, water availability**
- **Subseafloor virosphere** (virus) is the underexplored field
- Integrative sciences in IODP have brought great findings. How to **sustain this big science framework** will be a subject of discussion (including outreach, public relations)

Earth Connections

K. Michibayashi, T. Morishita, S. Ono & N. Akizawa

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

We evaluated 4 challenges in the ISP, and discussed on necessity for their modification

Challenge 8: What are the composition structure and dynamics of Earth's upper mantle?

No expeditions have retrieved mantle rocks in this IODP phase

Challenge 9: How are seafloor spreading and mantle melting linked to ocean crustal architecture?

Only one expedition (Exp. 360) addressing seafloor spreading processes in this phase of IODP.

Challenge 10: What are the mechanisms, magnitude, and history of chemical exchanges between the oceanic crust and seawater?

Expedition 357 began to address this challenge, but core recovery was limited. ***Other proposals are needed*** to address the wider question of fluid-rock interactions.

Challenge 11: How do subduction zones initiate, cycle volatiles, and generate continental crust?

We don't know if the results from IBM applied to all subduction zones. We realize the importance of subduction termination and exhumation of mantle rocks.

Key words beyond 2023

Ocean crustal architecture is not simple; Large igneous provinces; Initiation and termination of subduction; serpentinization; ***drilling into the Moho***

Earth in Motion

K. Ujiie, A. Yamaguchi, S. Kita & O. Fujiwara

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

1. Is IODP framework necessary beyond 2023?

Science must be brushed up by international collaboration.
Good for education, especially for students and early-career scientists
Important for understanding realistic and fine-scale phenomena, especially for geo physicists

2. Achievements on challenges in ISP & need for supplement/modification

Understanding of co-seismic slip to the trench (NanTroSEIZE & JFAST)
Detection of shallow slow earthquakes by Long-Term Borehole Monitoring System (LTBMS)

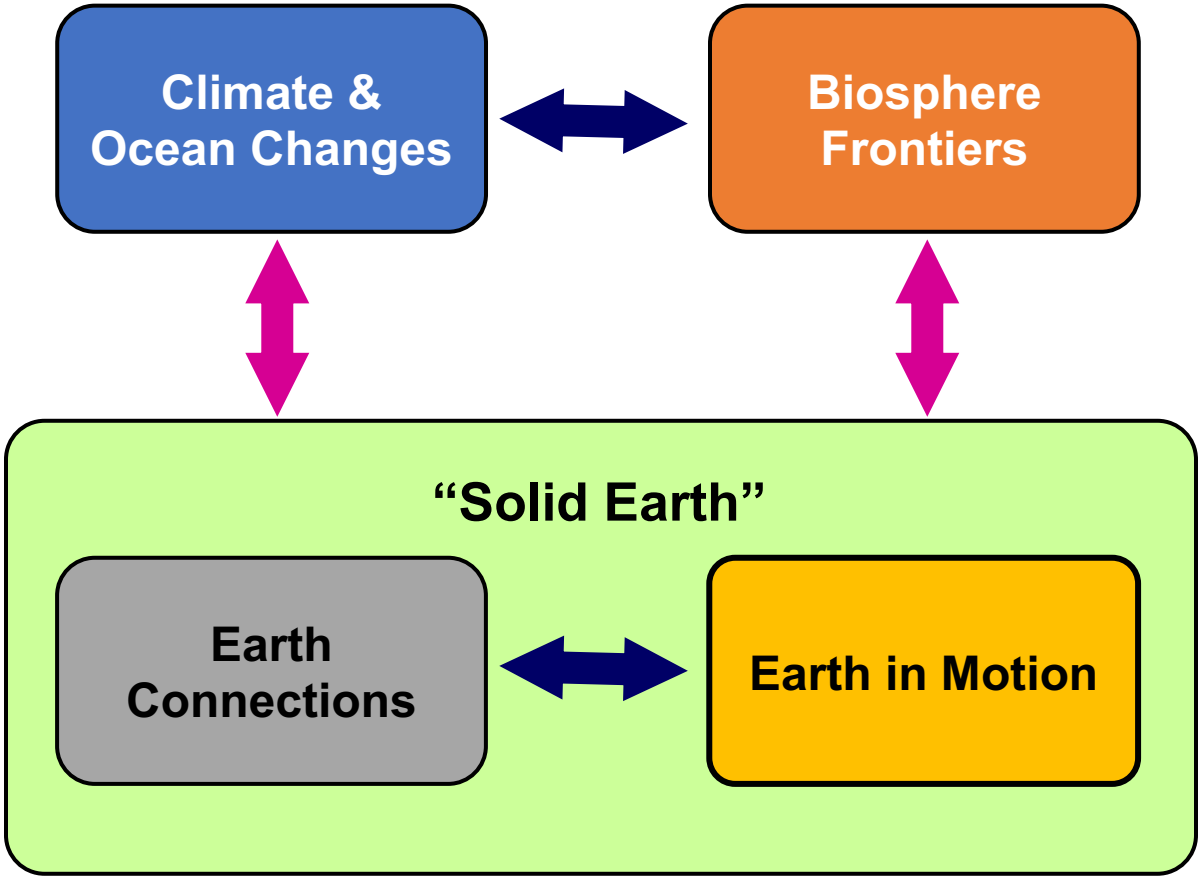
**Challenge 12: What mechanisms control the occurrence of destructive earthquakes, landslides, and tsunami?*

Need for "rapid response drilling" after megathrust earthquake and slow earthquakes
What are mechanisms of a diversity of slip behavior and their interactions?
Submarine landslide and related tsunami: not well known, but the roles of weak horizon or pore pressure can be understood by drilling

3. Science only achieved by IODP & what is necessary to accomplish the goal

Active experiments (e.g. slow earthquakes, induced earthquakes)
Monitoring before/during/after megathrust earthquakes and slow earthquakes
Collaboration with other fields of science (e.g. AI, oil engineering, drilling parameter, etc.)
Technological development for active experiments, deep drilling, good core recovery
Flexible use of budget is necessary

Fused discussions across disciplines



Biosphere Frontier x Climate/Ocean

M. Kaneko, A. Kuroyanagi, M. Saito, J. Kuroda & Y. Morono

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

- Our discussion was focused on how we can collaborate and what are the contact points between BF and COC.
- We recognized that a **common axis** (e.g. "**energy flow**") is required to connect and make collaborations between two disciplines.

  For example, **sedimentary organic** matter is one of the important factors for sustainable **deep life**, which is results of **paleo-primary production**. This can be seen with an axis of solar energy.
- It is difficult to reconstruct **diversity of paleo-primary producers** with current techniques.

  Recent **new techniques** and knowledges including ancient DNA, isotopic composition (e.g. ^{14}C vs ^{13}C) of organic compounds, etc., could help addressing this issue.
- Investigations of **diversity of modern primary producer** (quality and quantity) and its effects on microbial communities in the ***surface*** sediment is required, before the cross-cutting studies with ***deep*** sediment samples.

Earth connections x Earth in Motion

K. Ujiie, O. Fujiwara, S. Kita & N. Akizawa

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

Importance of:

- New scientific themes throughout interconnecting collaborations between **ICDP & IODP (or [MSP + JR] x Chikyu as a lab)**

- Comprehensive elucidation of **life of oceanic lithosphere** (down to Moho level) from mid-ocean ridge to subduction zone
  Kew words: hydrothermal alteration, serpentinization, hotspot, petit-spot, hydration at outer, mechanism causing earthquakes

- Firm interconnection and collaboration between geophysics and geology
  → Imaging oceanic lithosphere from geophysical and geological data

- **In situ monitoring** of physical property through max. usage of drill holes

Solid Earth x Climate/Ocean

Y. Okazaki, A. Yamaguchi, T. Morishita & J. Kuroda

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

Keynote talk; Y. Yokoyama

- Estimation of **viscosity of the Lower Mantle** based on the geodynamic rebound after deglaciation.
- Continental arc volcanism as the potential **source of CO_2**, degassed by skarn formation.
- Exposure of ophiolite body under ITCZ may accelerate silicate weathering (sink of CO_2).

Mini Talk; Y. Okazaki & A. Yamaguchi

- Sediments rich in **diatom** (porous and hydrated) characterize the physical property of sediments and subducting slab, possibly **causing submarine landslide and/or faulting**.
- Gateway opening (**Drake Passage**) associated with the rifting of South Sandwich Plate

General Discussion

- **LIPs eruption** may have contributed to **short-term climate change**, but the history of LIPs eruption (early-middle phase of formation) have not been recovered yet. Drilling at a deep canyon in oceanic plateaus may enable to recover the early phases of LIPs, and understand the history and the duration of LIPs eruption.
- **Mantle drilling** may have a great potential for the **deep carbon sequestration**.

Solid Earth x Biosphere Frontiers

K. Michibayashi, S. Ishimaru, Y. Suzuki, Y. Morono & Y. Takano

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

Hard-rock biosphere

Lavas/Upper crust – Explored.
Dikes and lower crust – Next mission
Mantle – Next mission

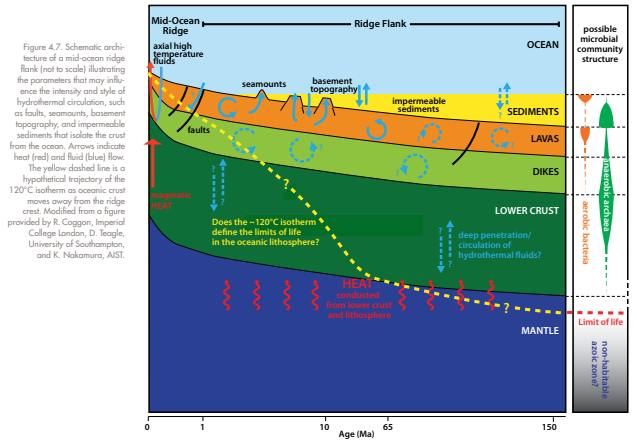
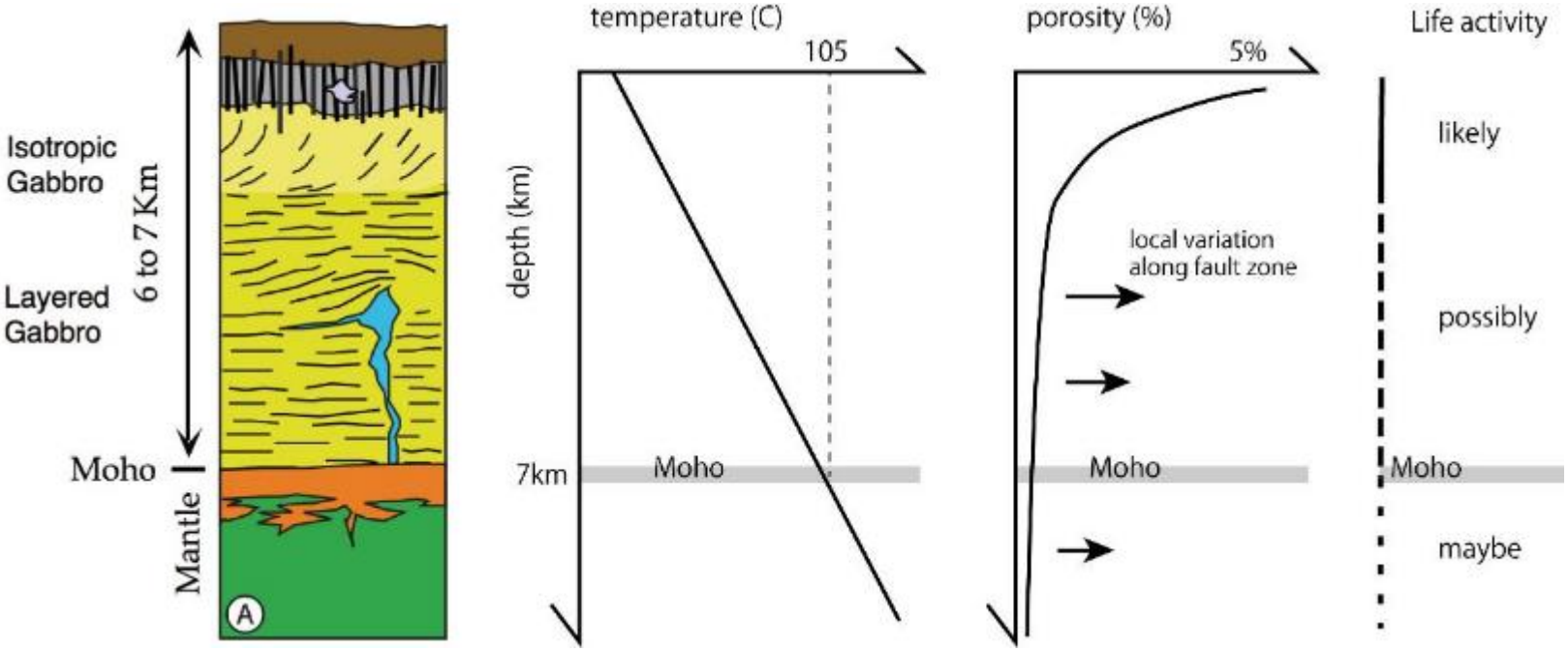


Figure 4.7. Schematic architecture of a mid-ocean ridge flank (not to scale) illustrating the parameters that may influence the intensity and style of hydrothermal circulation, such as faults, seamounts, basement topography, and impermeable sediments that isolate the crust from the ocean. Arrows indicate heat (red) and fluid (blue) flow. The yellow dashed line is a hypothetical trajectory of the 120°C isotherm as oceanic crust moves away from the ridge crest. Modified from a figure provided by R. Coggon, Imperial College London, D. Teagle, University of Southampton, and K. Nakamura, AIST.

Pressure is not a big deal for life, but energy, fluid, and temperature constraints. Biosphere can possibly exist in isolated space...but water, energy, flux is important.



Out of Box: New collaboration opportunities & new methods and technologies for Earth Sciences

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

Mars Sample Return

Martian Moon eXploration (MMX) 2024-

Talk by T. Usui (JAXA)

Geo-neutrino measurement

Ocean Bottom Detector (OBD)

Talk by H. Watanabe (Tohoku U.)

Identification & separation of microfossil tests by AI

Talk by T. Itaki (GSJ)

Data-driven ("Big Data") Geosciences

Talk by T. Kuwatani (JAMSTEC)

Synchrotron (STXM)-based geomicrobiology & chemistry

Talk by H. Suga (U. Tokyo)

Discussion in the Joint Session

- ✓ We recognized that the new ISP should emphasize what the science community wants to do in the next program.
- ✓ **Re-packaging** of the theme chapters should be considered.
- ✓ A stem chapter (Theme) that highlights **mantle drilling** is proposed for the next ISP.
- ✓ We continue to open the **community survey to ask New Challenges**, by 12th of April.
- ✓ New discovery and exploration could be backed by development of **new analytical methods**, **proxies** and **technologies**.

Key words;
Connect everything; Earth under Flux, Interaction, Energy Flow...

Potential themes

J-DESC Workshop
"Scientific Ocean Drilling beyond 2023"

Theme: **Resilient Society on Dynamic Earth**
Aim: *Learning from Earth's past and present to support sustainable future*
Main topics:
Geohazards (earthquakes, landslides, tsunamis, volcanic eruptions (+extreme climate events, hurricanes…?))
Ocean, climate & life (past & present climate change, ocean acidification, biosphere response)
Natural resources (gas hydrates, ore deposits, fisheries, potential for carbon capture & storage (geoengineering))

Theme: **Terrestrial to Extraterrestrial**
Aim: *Understanding Earth as an example of a planetary body capable of sustaining life*
Main topics:
Plate tectonics (seafloor spreading, subduction zones, global geochemical cycles, origin of continental crust)
Planetary structure (deep drilling: mantle drilling, LIPs (also info for Mars/Moon/etc), New Caledonian ophiolite)
Origins & limits to life (physical & chemical limits to life, quantifying the deep biosphere)

Theme: **Frontier Technologies**
(Explorations and Discoveries backed up by New Technologies) + Education Outreach
Aim: *Advancing science and society by pursuing technological innovations*
Main topics:
Subseafloor observatories (in situ measurements, real time onshore monitoring)
Drilling technology (improved recovery of hard rock & sandy sediments, extreme conditions (mantle drilling))
Data analysis & distribution ('big data' science, AI, commitment to open access data & samples, science outreach)

J-DESC White paper DRAFT in preparation