Progress on the Long-term Objectives of the International Ocean Discovery Program Science Plan (and associated issues)

Prepared for the interim IODP Forum meeting,
Vienna, Austria, April 2023

Henk Brinkhuis, Forum Chair

with substantial input from the IODP Science Support Office:
Michiko Yamamoto & Charna Meth

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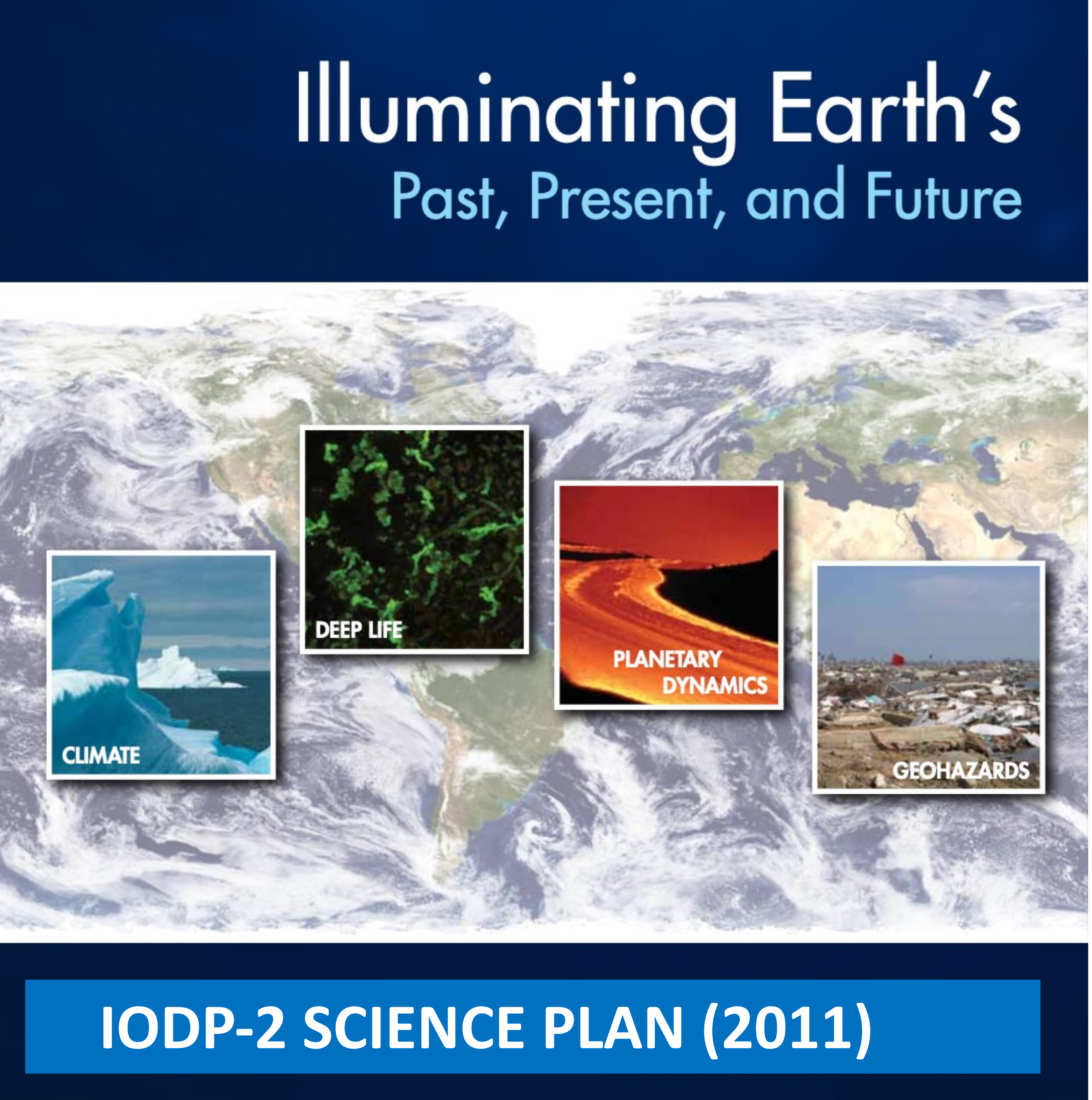

Climate & Ocean

Biosphere Frontiers

Earth connections

Earth in Motion

Progress on the Long-term Objectives of the International Ocean Discovery Program Science Plan – Evaluation of IODP2

State of the Art & Remaining Challenges

Lessons Learned – to be learned

Approaches – Topics – Issues – FORUM committee's?

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

CHALLENGES

1 | How does Earth's climate system respond to elevated levels of atmospheric CO_2?

2 | How do ice sheets and sea level respond to a warming climate?

3 | What controls regional patterns of precipitation, such as those associated with monsoons or El Niño?

4 | How resilient is the ocean to chemical perturbations?

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

CHALLENGES

8 | What are the composition, structure, and dynamics of Earth's upper mantle?

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

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

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

Biosphere Frontiers: Deep Life and Environmental Forcing of Evolution

CHALLENGES

5 | What are the origin, composition, and global significance of deep subseafloor communities?

6 | What are the limits of life in the subseafloor realm?

7 | How sensitive are ecosystems and biodiversity to environmental change?

Earth in Motion: Processes and Hazards on Human Time Scales

CHALLENGES

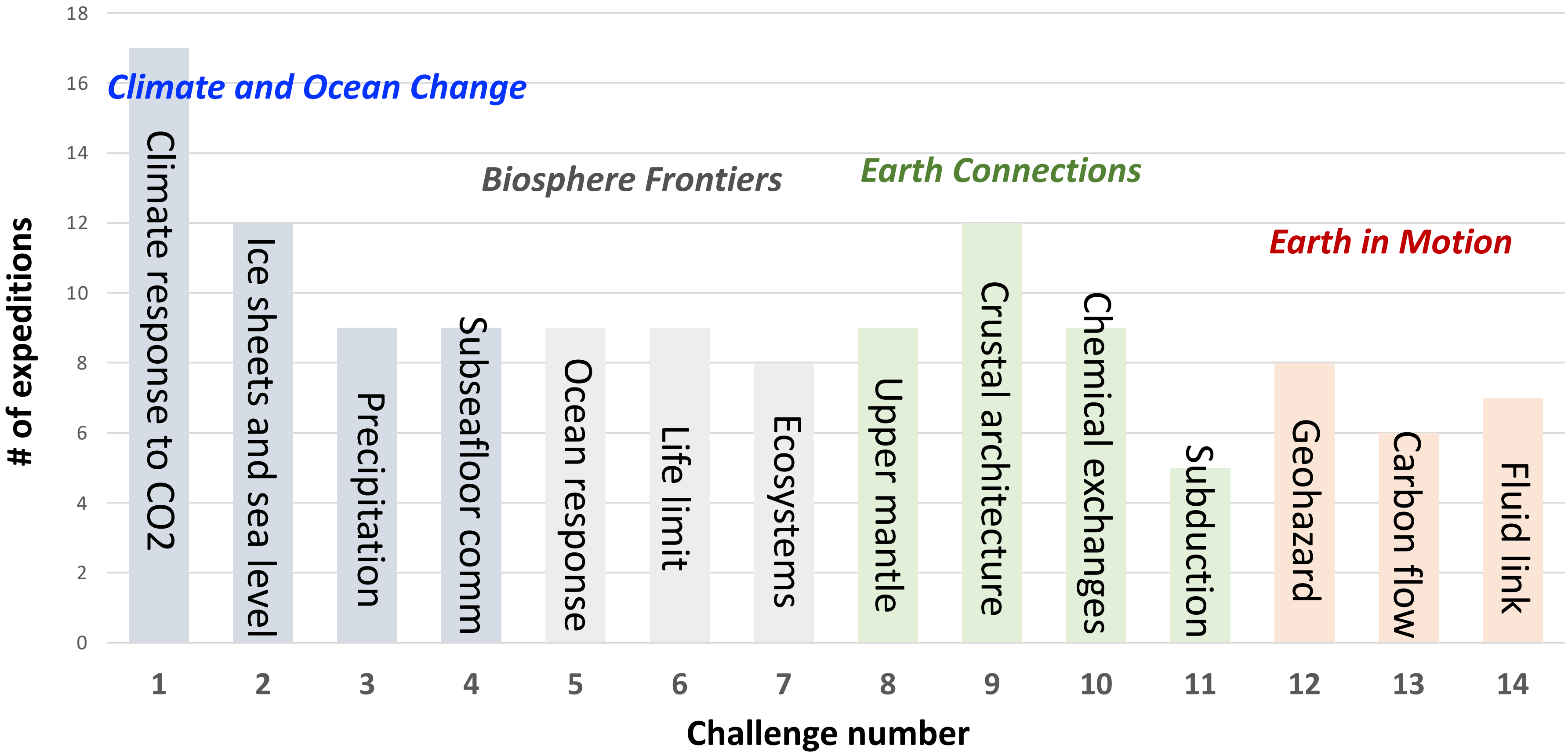
12 | What mechanisms control the occurrence of destructive earthquakes, landslides, and tsunami?

13 | What properties and processes govern the flow and storage of carbon in the subseafloor?

14 | How do fluids link subseafloor tectonic, thermal, and biogeochemical processes?

Lets' start:

Science Plan Challenges covered in IODP 2013-2024



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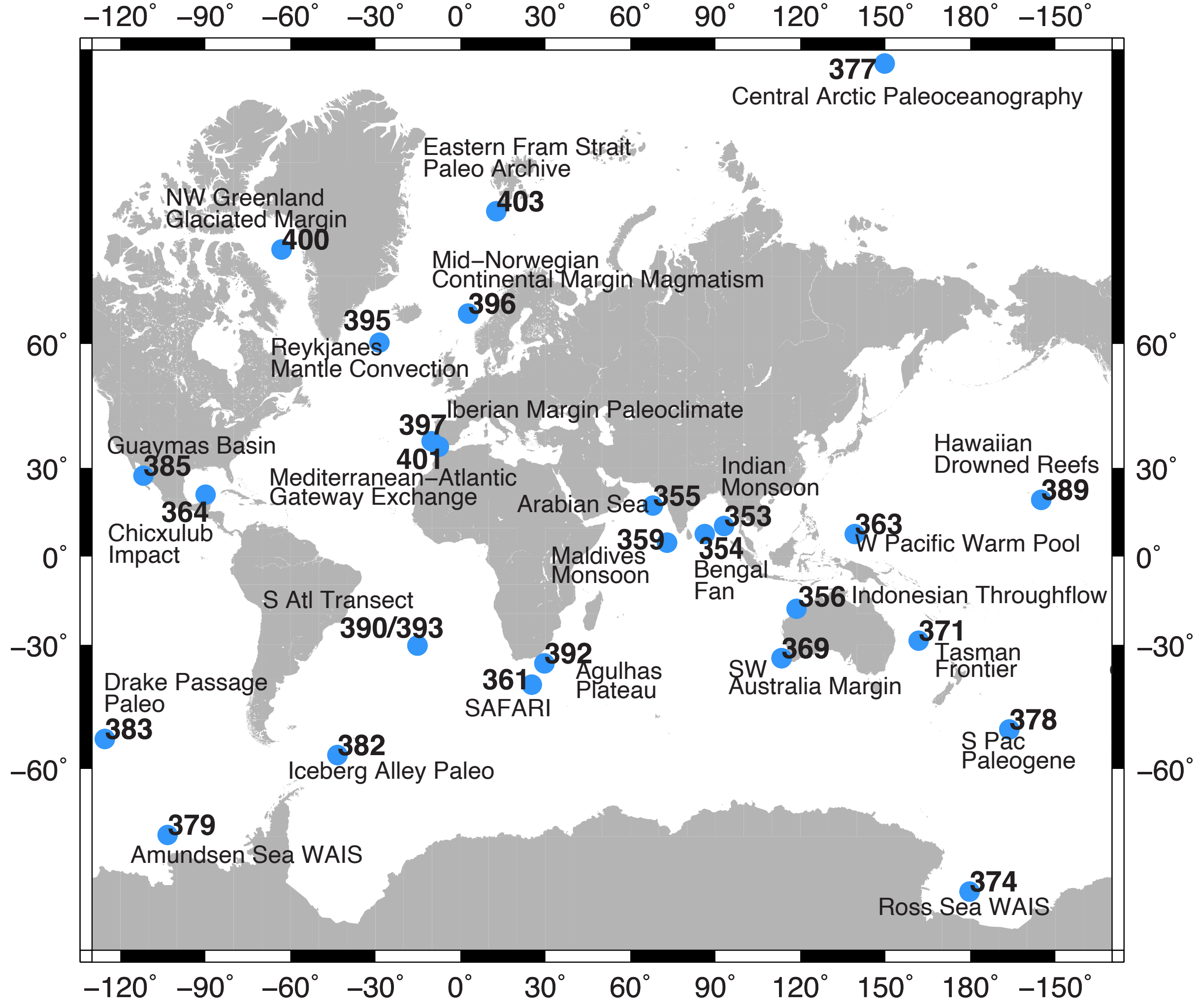
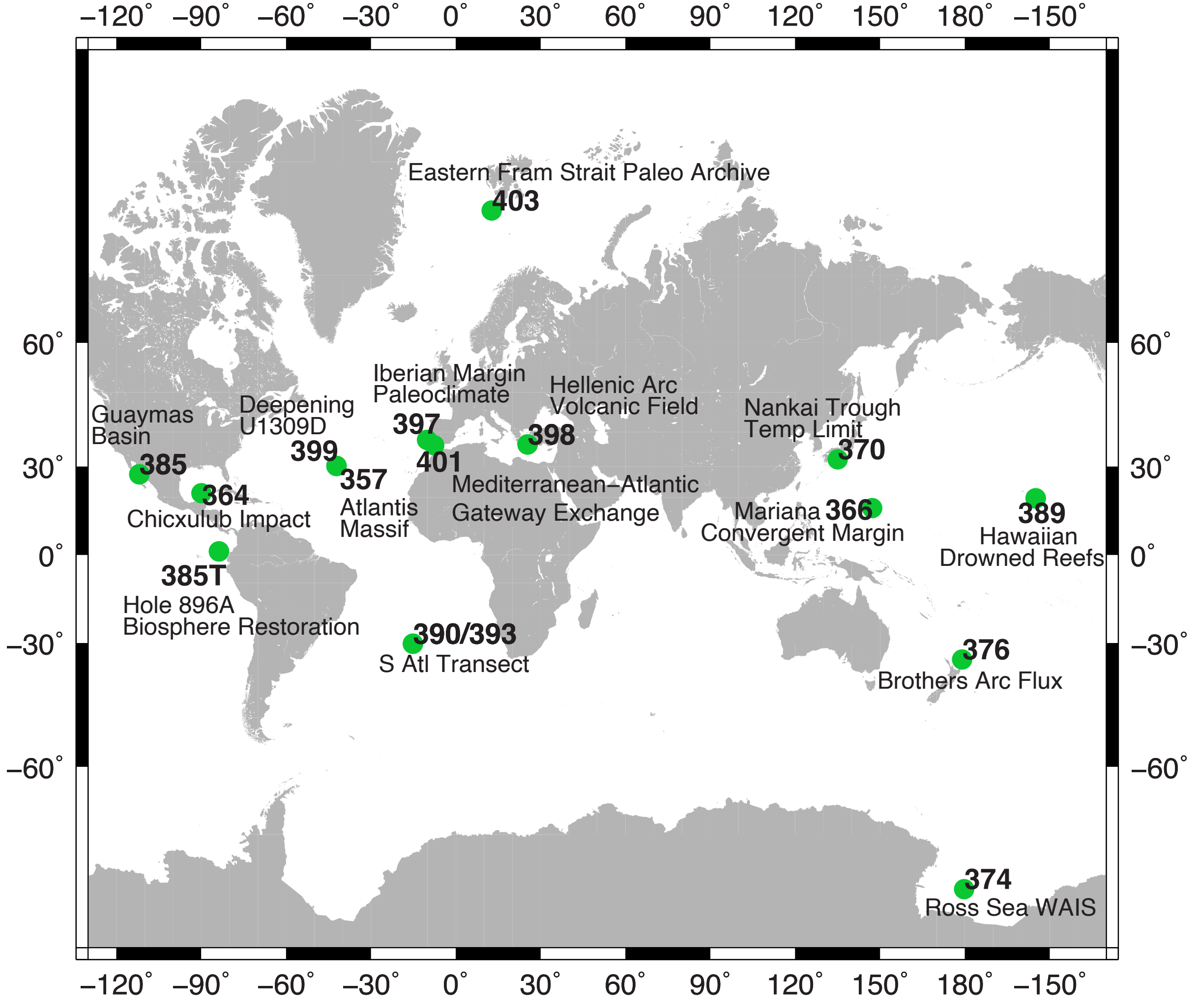
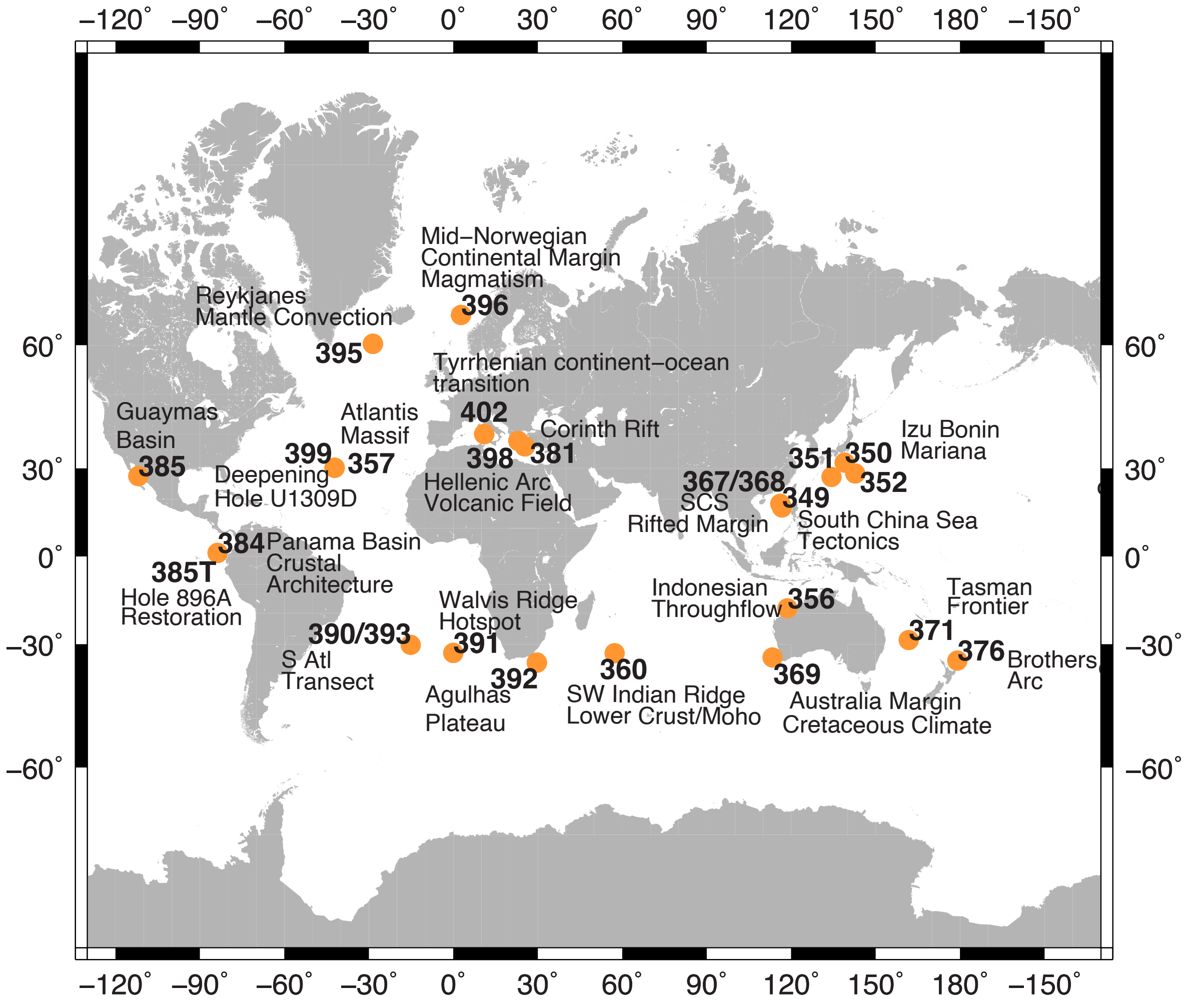
Climate and Ocean Change



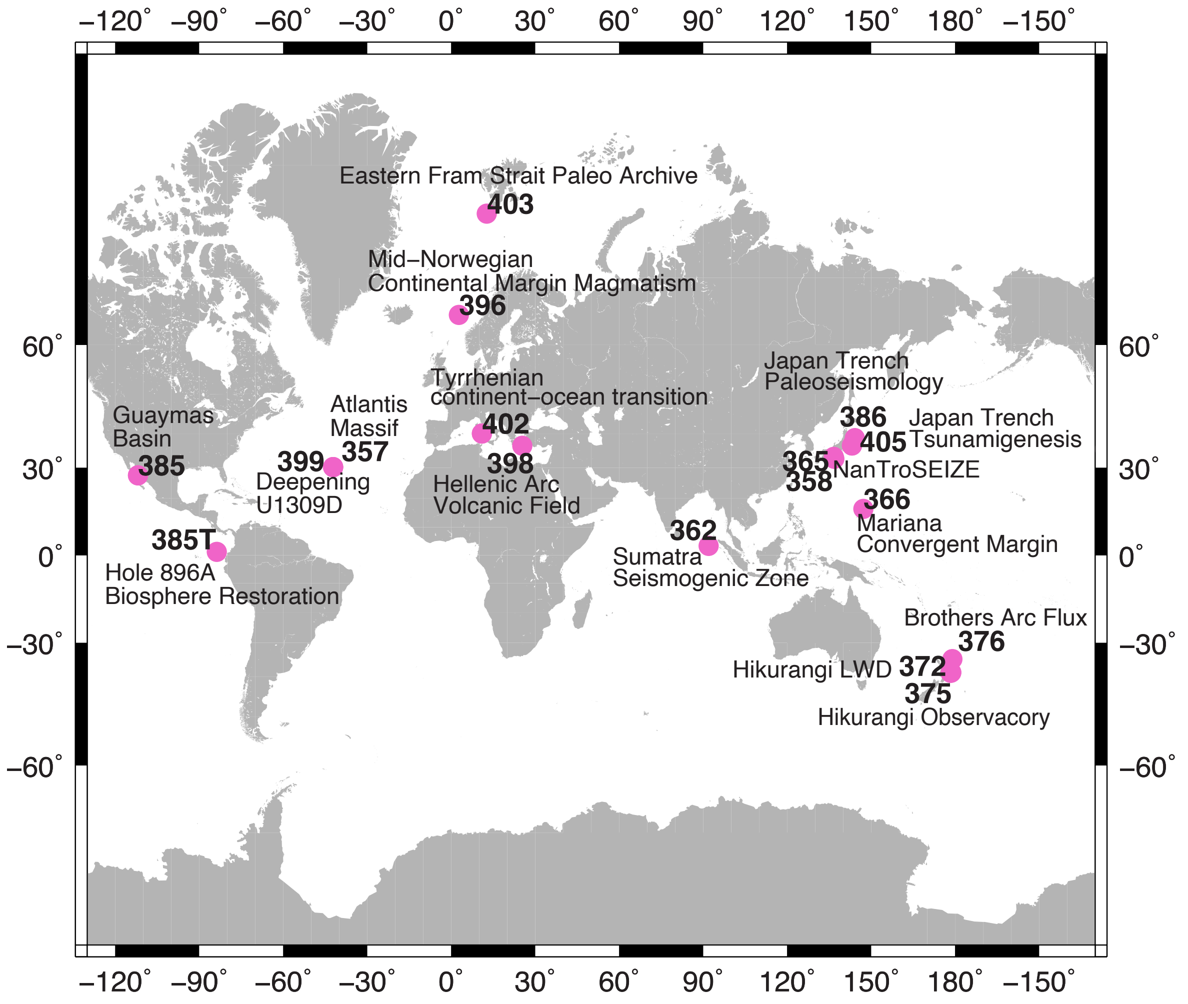
Biosphere Frontiers



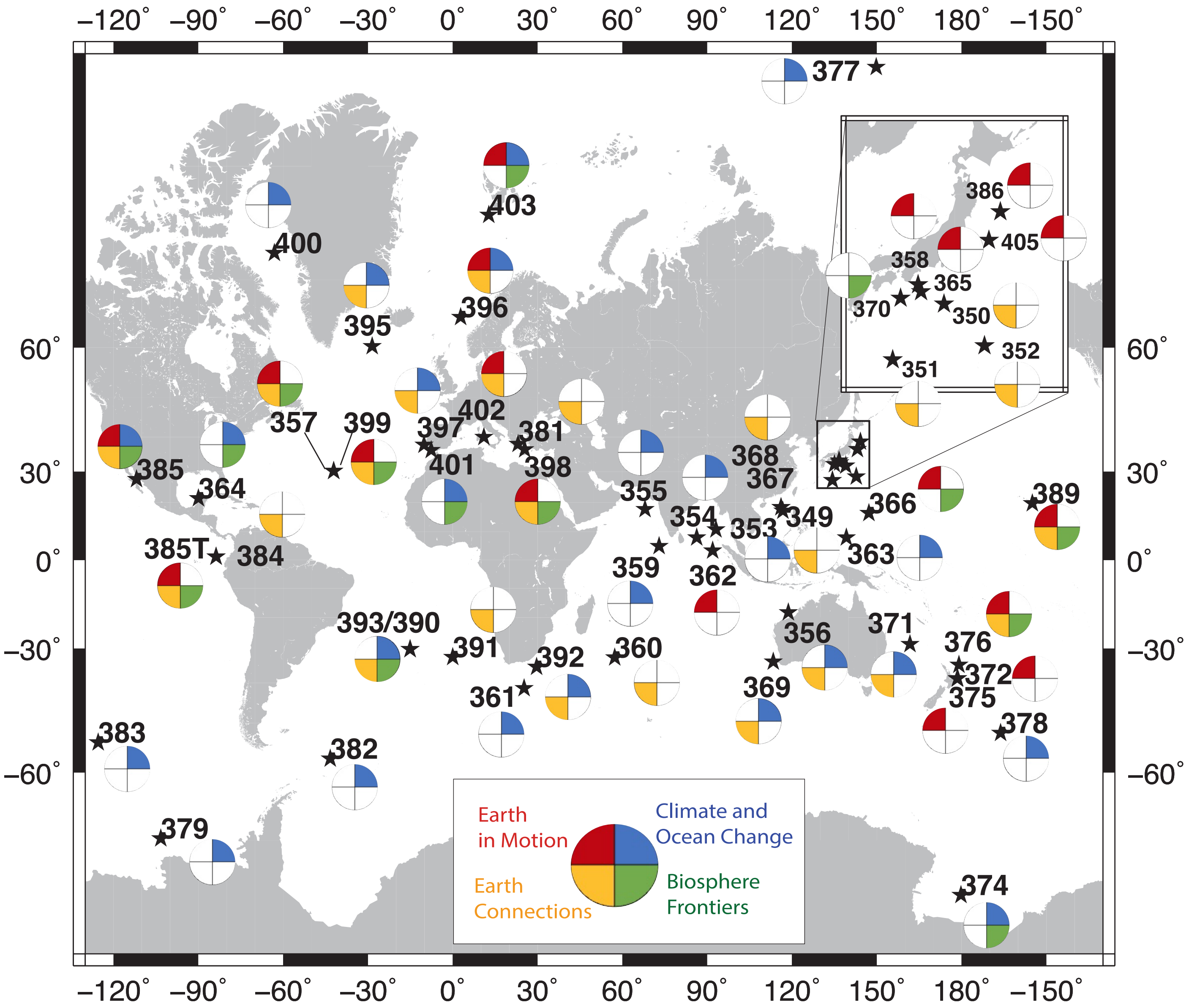
Earth Connections



Earth in Motion



Science Plan Theme Distribution



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Jamie Austin: "..The assessment of how proposals and expeditions are answering the call of the Science Plan themes/challenges does not include any post-expedition assessment, by SEP/FBs/Co-Chiefs/IODP Forum,... The international scientific ocean drilling community could and should take this on as an important ongoing priority, as we begin to envision a post-2023 program…."

Issue's: Evaluation of the elative and absolute success of Expeditions, Peer Review of Proceedings, others?

Recent example of IODP2-proceedings

Proceedings of the International Ocean Discovery Program

Volume 396

Mid-Norwegian Margin Magmatism and Paleoc Implications

Expedition 396 of the R/V *JOIDES Resolution*
from and to Reykjavík, Iceland
Sites U1565–U1574
6 August–5 October 2021

Volume authorship

Planke, S., Berndt, C., Alvarez Zarikian, C.A., and the Expedition 396 Scientists

IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM

Planke, S., Berndt, C., Alvarez Zarikian, C.A., and the Expedition 396 Scientists
Proceedings of the International Ocean Discovery Program Volume 396
publications.iodp.org

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1 Introduction
3 Background
6 Scientific objectives
8 Operations and coring strategy
17 Site summaries
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Keywords
International Ocean Discovery Program, IODP, *JOIDES Resolution*, Expedition 396, Mid-Norwegian Margin Magmatism and Paleoclimate Implications, Earth Connections, Climate and Ocean Change, Site U1565, Site U1566, Site U1567, Site U1568, Site U1569, Site U1570, Site U1571, Site U1572, Site U1573, Site U1574, North Atlantic Igneous Province, NAIP, volcanic rifted margin, large igneous province, LIP, Paleogene hothouse, Paleocene–Eocene Thermal

Expedition 396 summary[1]

S. Planke, C. Berndt, C.A. Alvarez Zarikian, A. Agarwal, G.D.M. Andrews, P. Betlem, J. Bhattacharya, H. Brinkhuis, S. Chatterjee, M. Christopoulou, V.J. Clementi, E.C. Ferré, I.Y. Filina, J. Frieling, P. Guo, D.T. Harper, M.T. Jones, S. Lambart, J. Longman, J.M. Millett, G. Mohn, R. Nakaoka, R.P. Scherer, C. Tegner, N. Varela, M. Wang, W. Xu, and S.L. Yager[2]

[1] Planke, S., Berndt, C., Alvarez Zarikian, C.A., Agarwal, A., Andrews, G.D.M., Betlem, P., Bhattacharya, J., Brinkhuis, H., Chatterjee, S., Christopoulou, M., Clementi, V.J., Ferré, E.C., Filina, I.Y., Frieling, J., Guo, P., Harper, D.T., Jones, M.T., Lambart, S., Longman, J., Millett, J.M., Mohn, G., Nakaoka, R., Scherer, R.P., Tegner, C., Varela, N., Wang, M., Xu, W., and Yager, S.L., 2023. Expedition 396 summary. In Planke, S., Berndt, C., Alvarez Zarikian, C.A., and the Expedition 396 Scientists, Mid-Norwegian Margin Magmatism and Paleoclimate Implications. Proceedings of the International Ocean Discovery Program, 396: College Station, TX (International Ocean Discovery Program). https://doi.org/10.14379/iodp.proc.396.101.2023
[2] **Expedition 396 Scientists' affiliations.**

Abstract

The opening of the northeast Atlantic, starting around 56 My ago, was associated with the emplacement of the North Atlantic Igneous Province, including the deposition of voluminous extrusive basaltic successions and intrusion of magma into the surrounding sedimentary basins. The mid-Norwegian Margin is a global type example of such a volcanic rifted margin and is well suited for scientific drilling with its thin sediment cover and good data coverage. During International Ocean Discovery Program Expedition 396, 21 boreholes were drilled at 10 sites in five different geological settings on the mid-Norwegian Margin. The boreholes sampled a wide variety of igneous and sedimentary settings ranging from lava flow fields to hydrothermal vent complexes,

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Proceedings of the International Ocean Discovery Program

Volume 396

Mid-Norwegian I… Implications

Expedition 396 of the R/V *JOIDES*
from and to Reykjavík, Iceland
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6 August–5 October 2021

Volume authorship

Planke, S., Berndt, C., Alvarez Zari…

6. Preliminary scientific assessment

During Expedition 396, we collected data from 21 boreholes in five different geological settings along the volcanic rifted margin off mid-Norway. The boreholes probe almost all elements of a typical volcanic rifted margin and the associated sedimentary archive. Recovery ranges from the subbasalt stratigraphy through hydrothermal vent complex deposits, thick flood basalts deposits in SDR sequences to postbreakup phreatomagmatic volcanoes, and basalts representing thickened oceanic crust formed during early seafloor spreading. The cored sediments include a comprehensive record of the Upper I… PETM. Thick Lower Eoce… the environment and subs… tic Ocean formation. Alor… and legacy boreholes from… and reevaluate the develo… climate and mass extincti…

In spite of the ambitious v… nificantly surpass our ope…

6.1. Primary objectives

The first main objective of the expedition was to constrain the tectonomagmatic processes that lead to excess volcanism during the formation of a new ocean. Magmatism is controlled by the composition and rheological properties of the upper mantle, the initial pressure and temperature conditions, and the tectonically controlled unloading of the mantle through space and time. These boundary conditions will ultimately control the response of the system, including induced convection, passive, and active upwelling—processes that move mantle material into the melt window. We drilled 587 m of breakup-related basalts in eight different holes that cover a wide range of compositions. Cores from these holes will allow us to constrain the pressure and temperature conditions and the composition of the upper mantle during various phases of breakup volcanism through geochemical analyses, whereas the age of the magmatism will be constrained by geochronology. The igneous rocks comprise the main Inner SDR units, the Outer High, and the Outer

p.proc.396.101.2023

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Volume 39

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Planke, S., Berndt, C.

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tion 396 data will be complemented b

Table T6. Assessment, Expedition 396. **Download table in CSV format.**

Location	Proposed drilling	Target	Max depth (mbsf)	Drilled holes	Main result	Logs	Total (m)	Recovery (m)	Target (m)	Comments
Kolga High basalts	20A 1 hole	Subbasalt	200 (30)	U1565 2 holes	Monzogranite basement		60	20	11	Target reached. Initial basalt and interbasalt sediments cored and logged in Hole U1566A. Subbasalt granitic rocks cored at both sites.
	23A 1 hole	Initial basalt and subbasalt	200 (25)	U1566 1 hole	Basalt flows with sediments, alkali granite below	4 runs	182	100	158	
N Modgunn vent complex	31A 1 hole	Sediments across PE transition	200 (55)	U1567 3 holes	Paleocene, Paleocene–Eocene transition, PETM, vent infill	2 runs	384	303	282	Target reached. Hole U1567A is a reference hole across the Paleocene/Eocene boundary. The other four holes provide a detailed sampling of the vent complex in-fill, including the PETM. Abundant ash layers recovered, and two holes were logged.
	40B 2 holes	Vent complex, Paleogene	200 (55)	U1568 2 holes	Vent infill, PETM, Late Paleocene	2 runs	325	239	252	
Mimir High Paleogene	55B 2 holes	Early Eocene to Late Paleocene	800 (255)	U1569 1 hole	Expanded Early Eocene, PETM, Late Paleocene	Bridge	405	145	268	Target reached. Site U1569 sampled the Early Eocene, the PETM, and the Late Paleocene before total depth at 405 mbsf. Ribbon sites provided complimentary sampling of the Early Eocene, the PETM, and Middle and Late Paleocene, with very pristine microfossils. Abundant ash layers. A thin igneous unit was cored in two holes.
	56A (alt) ribbon	Paleocene to earliest Eocene	200	U1570 4 holes	Expanded Early Eocene, PETM, Paleocene; dacite unit	2 runs	764	270	603	
Skoll High basalts	61A 1 hole	Lava field—Landward Flows	240 (125)	U1571 2 holes	Subaerial basalt flows with sediments	3 runs	391	229	164	Target reached. Hole U1571A cored and logged a sequence of subaerial tabular lava flows and interbasalt red sediments. A very different basalt sequence was sampled in the upper 50 m of the basalt basement in U1572A, likely deposited in an aquatic environment; interlava black sediments.
	7A 1 hole	Pitted basalt flows/SDR	320 (220)	U1572 2 holes	Mixed basalts with various sediments	1 run collapse	555	359	142	
Lofoten Basin Eldhø basalts	9A 2 holes	Basalts of Outer SDR	550 (450)	U1573 1 hole	Sheet flows with interbasalt sediments		441	141	59	Target reached. Hole U1573A cored a sequence of basalt flows with interbedded marine sediments, one of which could be data. A very different basalt

Reviewers for this volume

Pending.

International Ocean Discovery Program

JOIDES Resolution Science Operator

Website: http://iodp.tamu.edu

IODP JRSO

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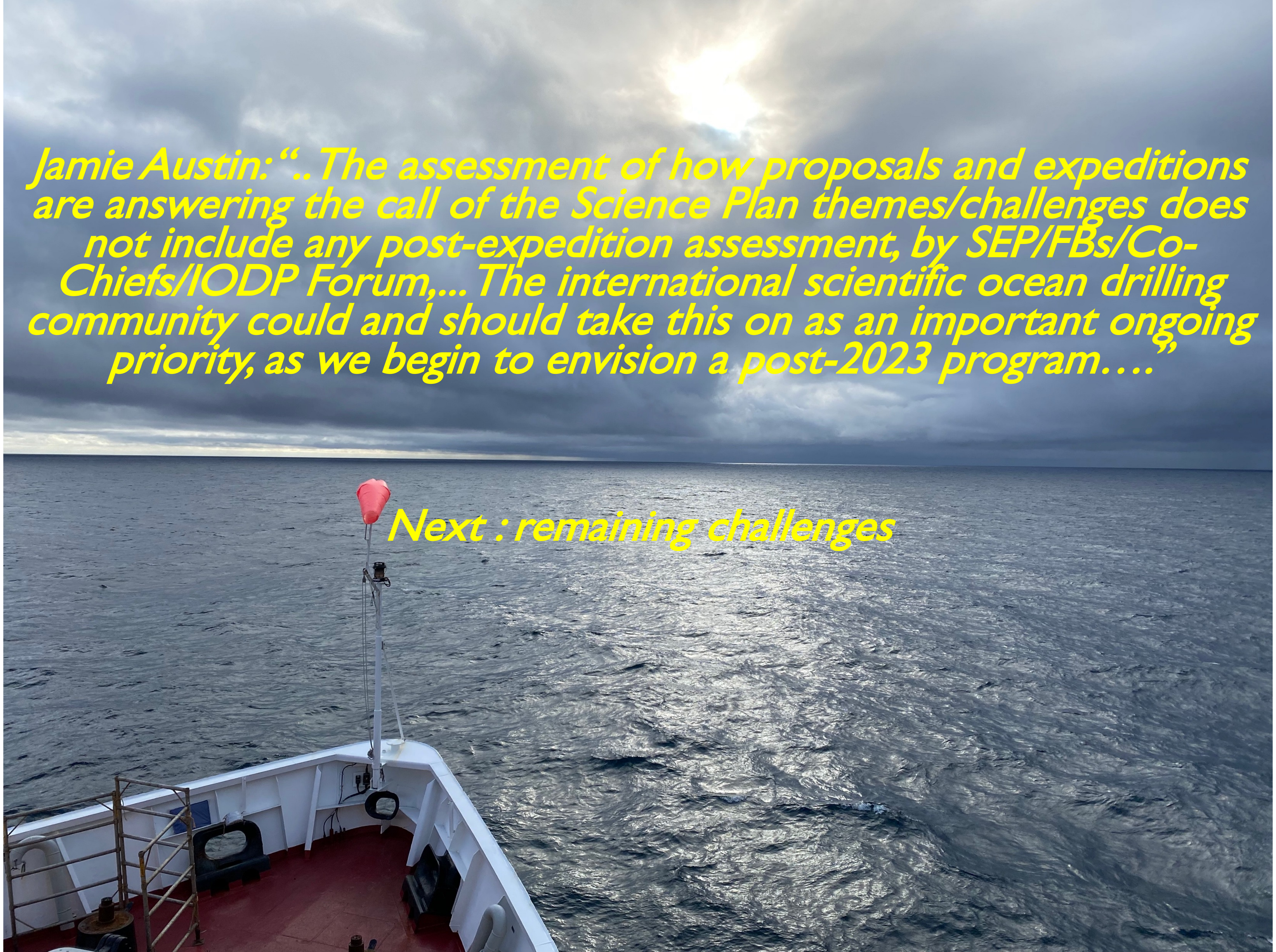
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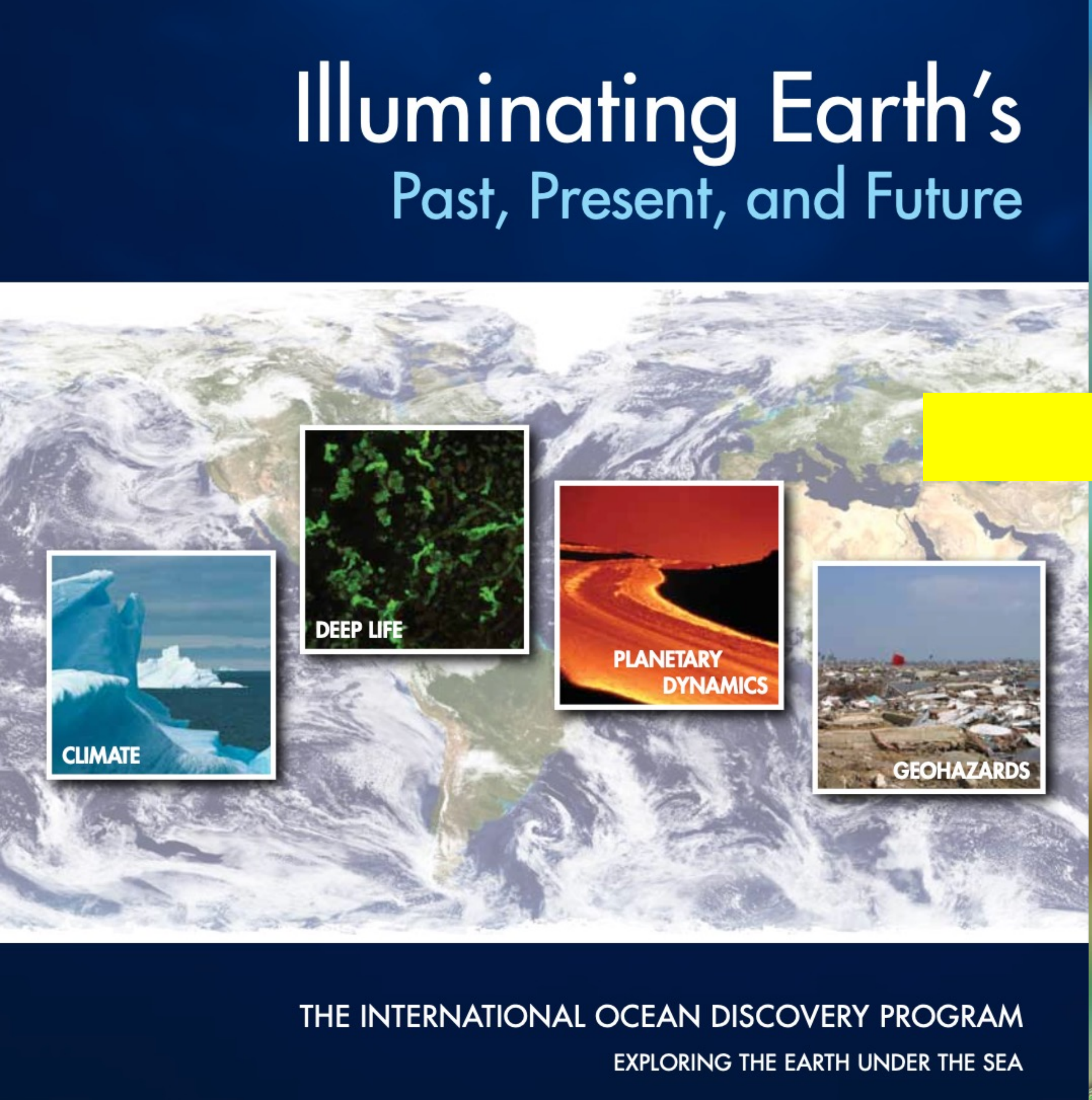
Next : remaining challenges


Illuminating Earth's
Past, Present, and Future
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PLANETARY DYNAMICS
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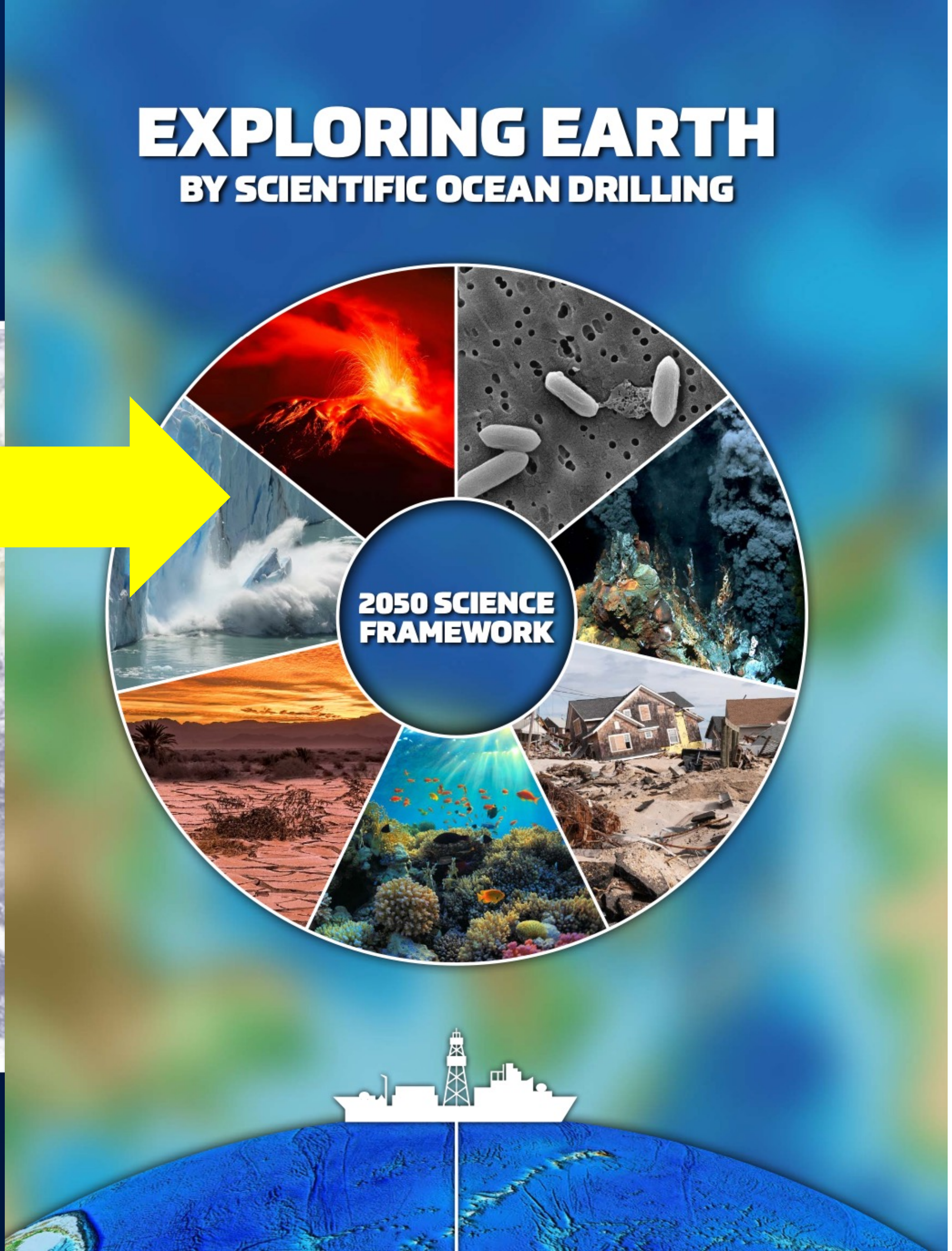
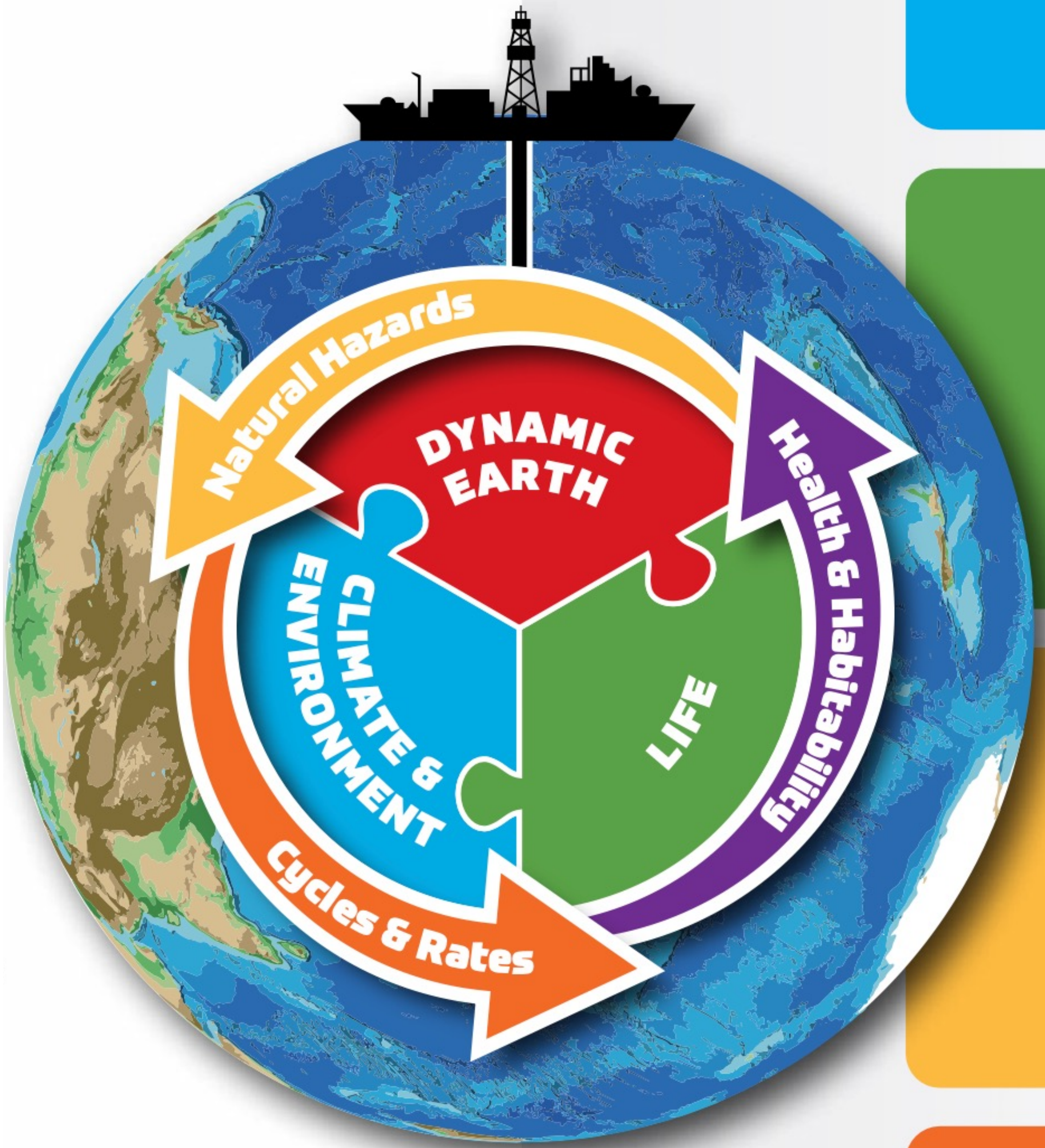
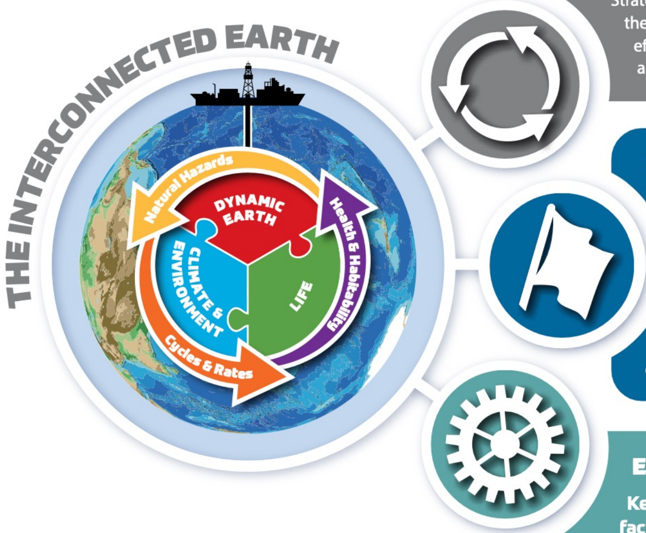
EXPLORING THE EARTH UNDER THE SEA


EXPLORING EARTH
BY SCIENTIFIC OCEAN DRILLING
2050 SCIENCE FRAMEWORK



The 2050 Science Framework Structure



STRATEGIC OBJECTIVES

Broad areas of scientific inquiry that focus on understanding the interconnected Earth system.

Strategic Objectives are multidisciplinary, cutting across the traditional themes of previous scientific ocean drilling efforts and are open-ended to encourage innovation and evolution of scientific ideas.

FLAGSHIP INITIATIVES

Long-term drilling endeavors that aim to inform issues of particular interest to society, typically combining goals from multiple Strategic Objectives.

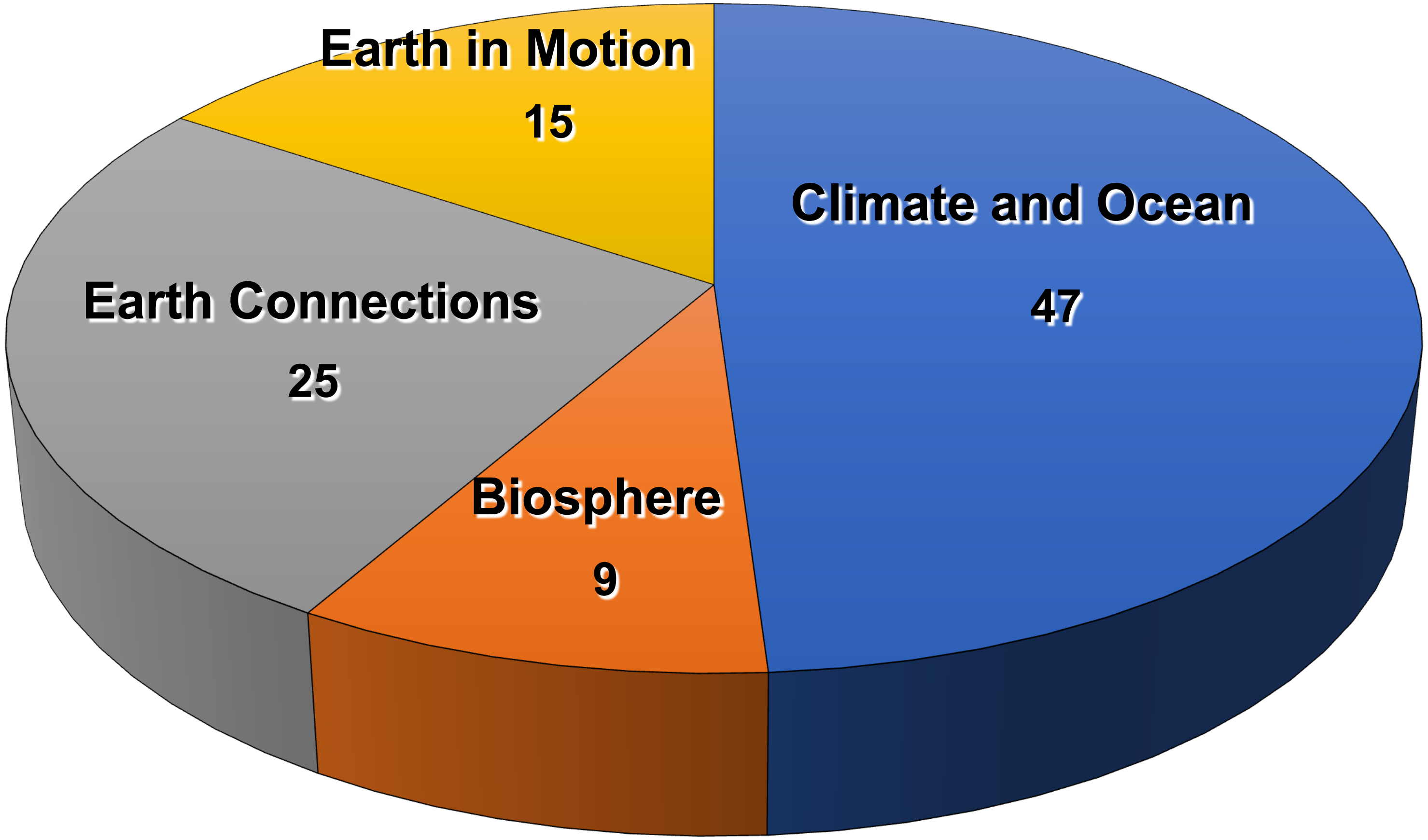
Flagship Initiatives will require the community to develop strategies and technologies to implement multiple coordinated expeditions, taking advantage of the 25-year timeframe of the *Science Framework*.

ENABLING ELEMENTS

Key facets of scientific ocean drilling that facilitate our research activities, enhance our scientific outputs, and maximize their impact.

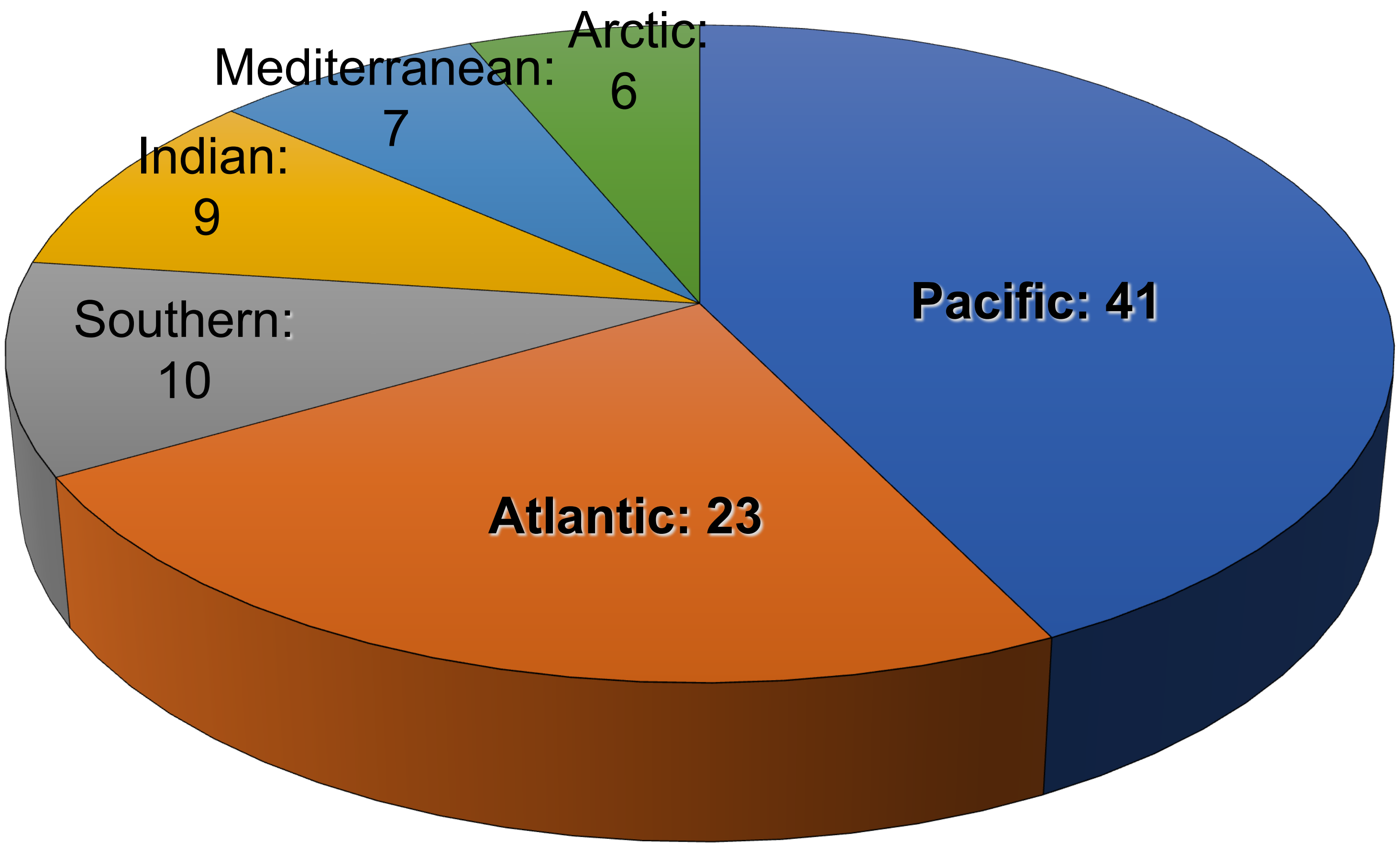
Enabling Elements include links with major allied programs, effective strategies to communicate results to the public, and the generation of new opportunities through novel technology and data approaches.

Active proposals: 96
by IODP-2 science plan themes



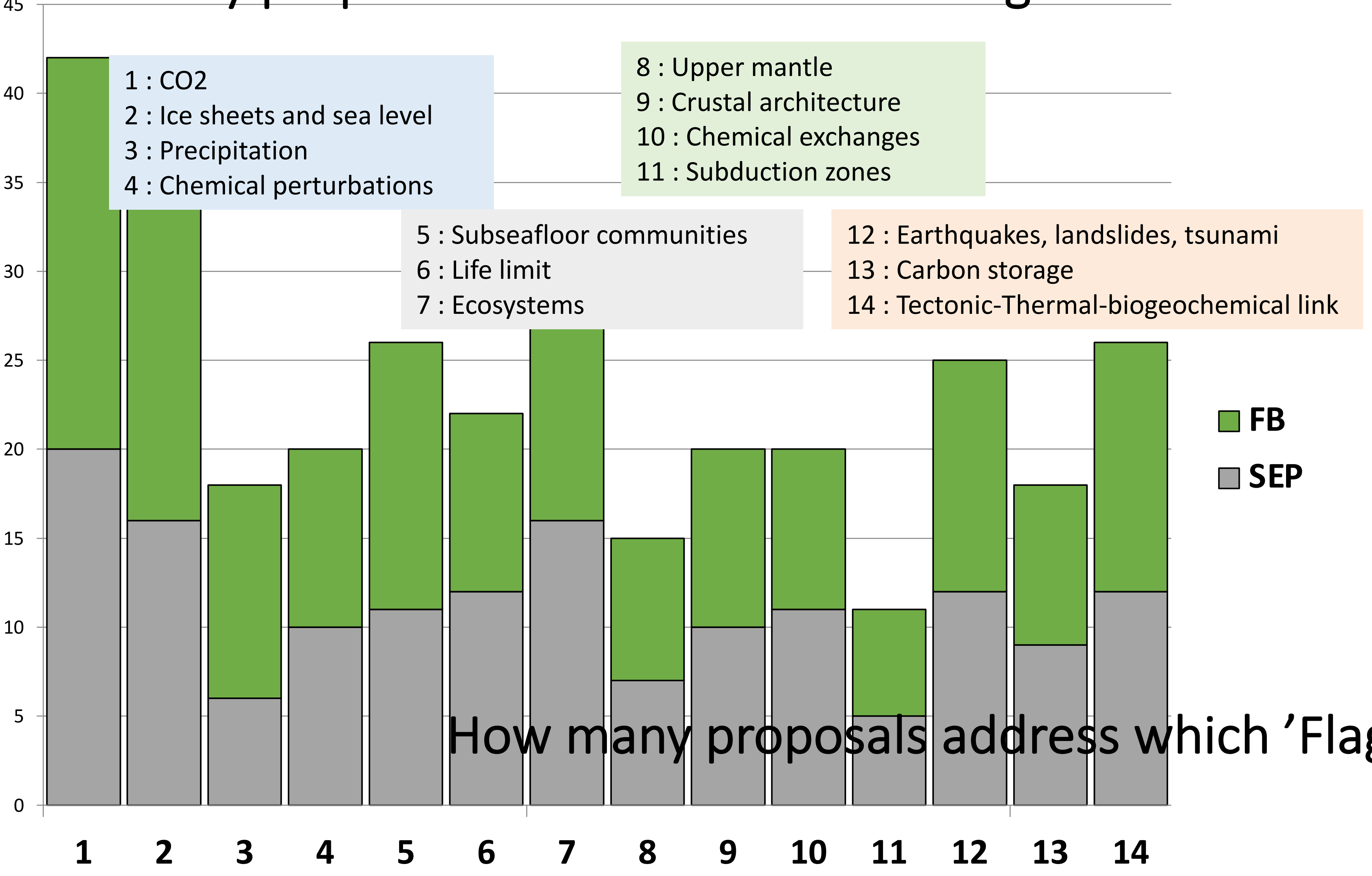
As of April 13, 2023

‘Active proposal’ status: 96
by target ocean



As of April 13, 2023

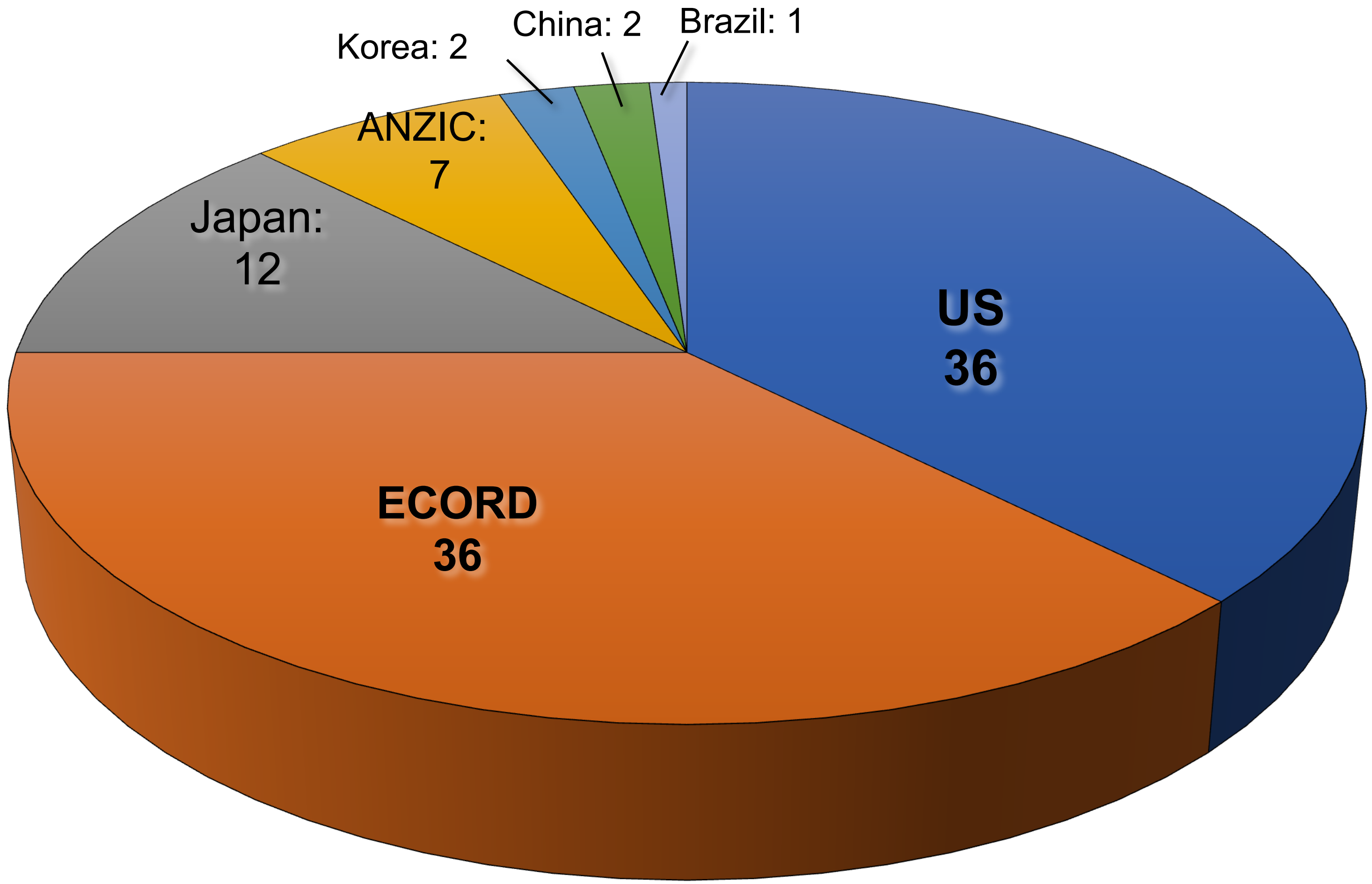
How many proposals address which challenges?



How many proposals address which ’Flagship’?

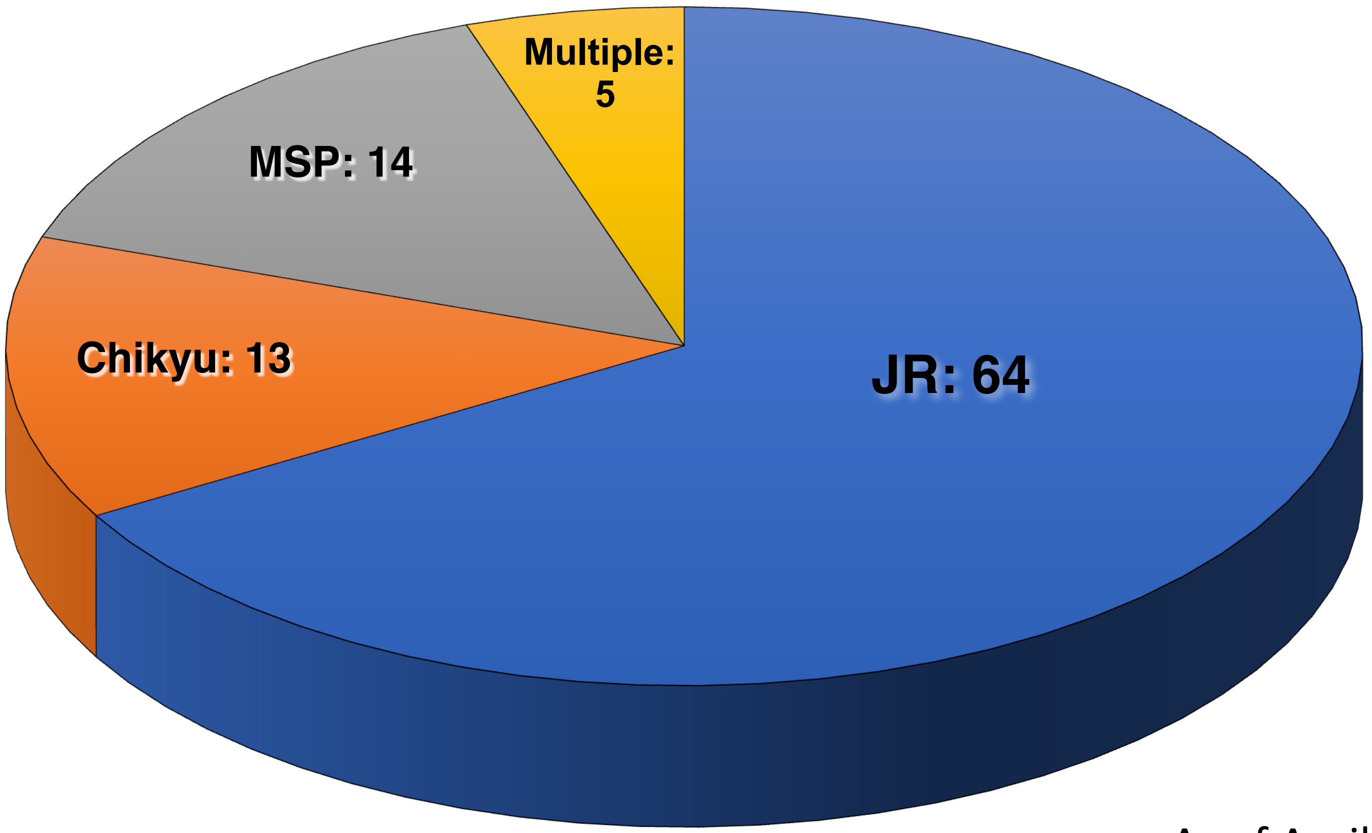
As of April 13, 2023

Active proposals: 96
by lead proponent's member affiliation



As of April 13, 2023

Drilling Platforms for 96 Active Proposals



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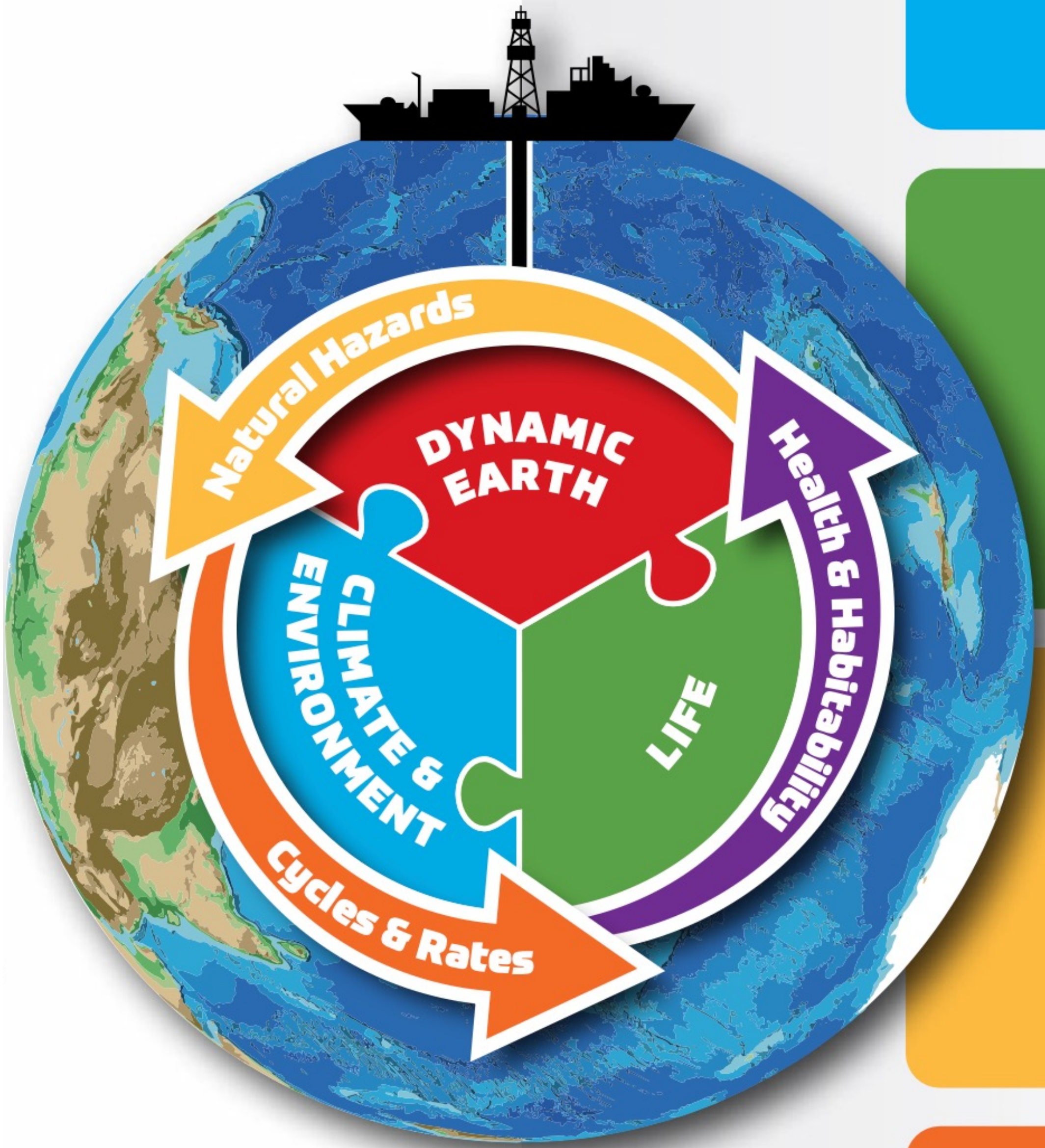

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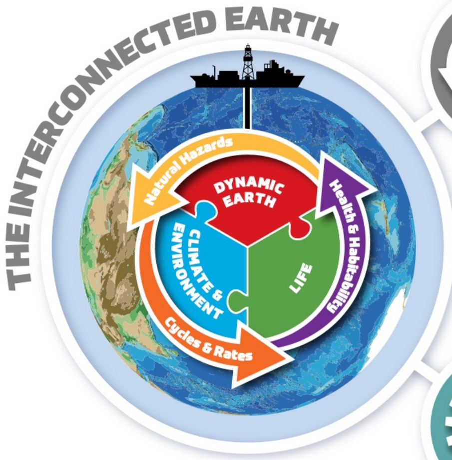

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- *Evaluation of absolute and relative success, technically and scientifically*
- *Identification of remaining challenges*
- *Lessons learned – organization, operations, and other*
- *Improvements, generally*

Evaluation procedures? Committee's?


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Remaining Data slides (Michiko)

Climate and Ocean Change

1. Climate response to high atmospheric CO2: 17 expeditions

Exp#	Title	Ship	P#
361	SAFARI	JR	702/845
369	Australia Cretaceous Climate and Tectonics	JR	760/897
371	Tasman Frontier subduction	JR	832
377	Central Arctic Paleoceanography	MSP	708
378	S Pac Paleogene	JR	567
382	Iceberg Alley Paleo	JR	902/846
383	Drake Passage Paleo	JR	912
389	Hawaiian Drowned Reefs	MSP	716
390/393	S Atl Transect	JR	853
392	Agulhas Plateau	JR	834
395	Reykjanes Mantle Convection	JR	892
396	Mid-Norwegian Continental Margin Magmatism	JR	944
397	Iberian Margin Paleoclimate	JR	771
400	NW Greenland Glaciated Margin	JR	909
401	Mediterranean-Atlantic Gateway Exchange	JR	895
403	Eastern Fram Strait Paleo Archive	JR	985

gray: orphan sites
green: scheduled

2. Ice sheet and sea level response to warming climate: 12 expeditions

Exp#	Title	Ship	P#
359	Maldives Monsoon	JR	820
369	Australia Cretaceous Climate and Tectonics	JR	760/897
374	Ross Sea WAIS	JR	751
377	Central Arctic Paleoceanography	MSP	708
379	Amundsen Sea WAIS	JR	839
382	Iceberg Alley Paleo	JR	902/846
383	Drake Passage Paleo	JR	912
390/393	S Atl Transect	JR	853
400	NW Greenland Glaciated Margin	JR	909
401	Mediterranean-Atlantic Gateway Exchange	JR	895
403	Eastern Fram Strait Paleo Archive	JR	985

gray: orphan sites
green: scheduled

3. Control of regional precipitation patterns: 9 expeditions

Exp#	Title	Ship	P#
353	Indian Monsoon	JR	795
354	Bengal Fan	JR	552
355	Arabian Sea	JR	793
356	Indonesian Throughflow	JR	807
359	Maldives Monsoon	JR	820
361	SAFARI	JR	702/845
363	W Pacific Warm Pool	JR	799
389	Hawaiian Drowned Reefs	MSP	716
401	Mediterranean-Atlantic Gateway Exchange	JR	895

4. Ocean response to chemical perturbation: 10 expeditions

Exp#	Title	Ship	P#
364	Chicxulub Impact	MSP	548
369	SW Aust K climate and tectonics	JR	760/897
374	Ross Sea WAIS	JR	751
378	S Pac Paleo	JR	567
385	Guaymas Basin	JR	833
390/393	S Atl Transect	JR	853
392	Agulhas Plateau	JR	834
396	Mid-Norwegian Continental Margin Magmatism	JR	944
401	Mediterranean-Atlantic Gateway Exchange	JR	895

Biosphere Frontiers

5. Origin, composition, and global significance of sub-seafloor biosphere: 9 expeditions

Exp#	Title	Ship	P#
357	Atlantis Massif	MSP	758
366	Mariana Convergent Margin	JR	505/693
385	Guaymas Basin	JR	833
389	Hawaiian Drowned Reefs	MSP	716
398	Hellenic Arc Volcanic Field	JR	932
390/393	S Atl Transect	JR	853
399	Deepening Hole U1309D	JR	937
385T	Hole 896A Biosphere Restoration	JR	921

gray: orphan sites
green: scheduled

6. Limits of sub-seafloor life: 10 expeditions

Exp#	Title	Ship	P#
370	Nankai Trough Temp Limit	Chikyu	865
374	Ross Sea WAIS	JR	751
376	Brothers Arc Flux	JR	818
385	Guaymas Basin	JR	833
385T	Hole 896A Biosphere Restoration	JR	921
389	Hawaiian Drowned Reefs	MSP	716
390/393	S Atl Transect	JR	853
398	Hellenic Arc Volcanic Field	JR	932
399	Deepening Hole U1309D	JR	937

7. Ecosystem sensitivity to environmental change : 9 expeditions

Exp#	Title	Ship	P#
364	Chicxulub Impact	MSP	548
385	Guaymas Basin	JR	833
389	Hawaiian Drowned Reefs	MSP	716
390/393	S Atl Transect	JR	853
397	Iberian Margin Paleoclimate	JR	771
398	Hellenic Arc Volcanic Field	JR	932
401	Mediterranean-Atlantic Gateway Exchange	JR	895
403	Eastern Fram Strait Paleo Archive	JR	985

Earth Connections

8. Upper mantle composition/structure/dynamics: 9 expeditions

Exp#	Title	Ship	P#
356	Indonesian Throughflow	JR	807
357	Atlantis Massif	MSP	758
360	SW Indian Ridge Lower Crust/Moho	JR	800
391	Walvis Ridge Hotspot	JR	890
392	Agulhas Plateau	JR	834
395	Reykjanes Mantle Convection	JR	892
396	Mid-Norwegian Continental Margin Magmatism	JR	944
398	Hellenic Arc Volcanic Field	JR	932
402	Tyrrhenian continent-ocean transition	JR	927

9. Seafloor spreading and ocean crustal architecture: 13 expeditions

Exp#	Title	Ship	P#
349	South China Sea Tectonics	JR	735
367/368	South China Sea Rifted Margin	JR	878
369	SW Australia K Climate & Tectonics	JR	760/897
381	Corinth Rift	MSP	879
384	Panama Basin Crustal Architecture	JR	769
385	Guaymas Basin	JR	833
391	Walvis Ridge Hotspot	JR	890
392	Agulhas Plateau	JR	834
395	Reykjanes Mantle Convection	JR	892
396	Mid-Norwegian Continental Margin Magmatism	JR	944
399	Deepening Hole U1309D	JR	937
402	Tyrrhenian continent-ocean transition	JR	927

10. Chemical exchange between oceanic crust and seawater: 10 Exp

Exp#	Title	Ship	P#
357	Atlantis Massif	MSP	758
376	Brothers Arc Flux	JR	818
385	Guaymas Basin	JR	833
385T	Hole 896A Biosphere Restoration	JR	921
390/393	S Atl Transect	JR	853
392	Agulhas Plateau	JR	834
395	Reykjanes Mantle Convection	JR	892
399	Deepening Hole U1309D	JR	937
402	Tyrrhenian continent-ocean transition	JR	927

11. Subduction, volatile cycling, and formation of continental crust: 5 Exp

Exp#	Title	Ship	P#
350	Izu Bonin Mariana: Rear Arc	JR	697
351	Izu Bonin Mariana: Arc Origins	JR	695
352	Izu Bonin Mariana: Forearc	JR	696
371	Tasman Subduction	JR	832
398	Hellenic Arc Volcanic Field	JR	932

green: scheduled

Earth in Motion

12. Control of earthquakes, landslides, tsunami: 8 expeditions

Exp#	Title	Ship	P#
358	NanTroSEIZE Riser Drilling	Chikyu	603C
362	Sumatra	JR	837
365	NanTroSEIZE Megasplay LTBMS	Chikyu	603D
372	Hikurangi LWD	JR	841
375	Hikurangi Observatory	JR	781A
386	Japan Trench Paleoseismology	MSP	866
398	Hellenic Arc Volcanic Field	JR	932
405	Japan Trench Tsunamigenesis	Chikyu	835

green: scheduled

13. Storage/flow of sub-seafloor carbon: 7 expeditions

Exp#	Title	Ship	P#
372	Hikurangi LWD	JR	841
375	Hikurangi Obervatory	JR	781A
385	Guaymas Basin	JR	833
396	Mid-Norwegian Continental Margin Magmatism	JR	944
399	Deepening Hole U1309D	JR	937
402	Tyrrhenian continent-ocean transition	JR	927
403	Eastern Fram Strait Paleo Archive	JR	985

14. Fluids linking sub-seafloor tectonic, thermal and biogeochemical processes: 8 expeditions

Exp#	Title	Ship	P#
357	Atlantis Massif	MSP	758
366	Mariana Convergent Margin	JR	505/693
376	Brothers Arc Flux	JR	818
385	Guaymas Basin	JR	833
385T	Hole 896A Biosphere Restoration	JR	921
399	Deepening Hole U1309D	JR	937
402	Tyrrhenian continent-ocean transition	JR	927
405	Japan Trench Tsunamigenesis	Chikyu	835

Summary: Exp - Challenge

Exp#	1	2	3	4	5	6	7	8	9	10	11	12	13	14
349									1					
350											1			
351											1			
352											1			
353			1											
354			1											
355			1											
356			1					1						
357					1			1		1				1
358												1		
359		1	1											
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361	1		1											
362												1		
363			1											
364				1			1							
365												1		
366					1									1
367									1					
368									1					
369	1	1		1					1					
370						1								
371	1										1			
372												1	1	
374		1		1		1								
375												1	1	
376						1				1				1
377	1	1												
378	1			1										
379		1												
381									1					
382	1	1												
383	1	1												
384									1					
385				1	1	1	1		1	1			1	1
385T					1	1				1				1
386												1		
389	1		1		1	1	1							
390	1	1		1	1	1	1			1				
391								1	1					
392	1			1				1	1	1				
393	1	1		1	1	1	1			1				
395	1							1	1	1				
396	1			1				1	1				1	
397	1						1							
398					1	1	1	1			1	1		
399					1	1			1	1			1	1
400	1	1												
401	1	1	1	1			1							
402								1	1	1			1	1
403	1	1					1						1	
405												1		1
Total	17	12	9	10	9	10	9	9	13	10	5	8	7	8