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 & Rosalind Coggon
Co-lead Editors
and the Science Framework Authors and Reviewers

representing the international scientific ocean drilling community
PROCEED: Expanding Frontiers of Scientific Ocean Drilling

A two-day workshop to define new goals for a future international scientific ocean drilling program to be developed beyond 2023.

6-7 April 2019
Austrian Academy of Sciences, Vienna
PROCEED: The content of the current science plan is appropriate to guide ocean drilling beyond 2023 but a new architecture is required.

Is the scientific content of the current science plan still relevant?

- Yes 94%
- No 6%

...but...

Do we need a new architecture for a new Science Plan?

- Yes 93%
- No 7%
PROCEED: In developing a new Science Plan we need to consider audience, purpose, content and architecture

- **NEW Science Plan** needs to highlight that this is a **NEW Program** advancing NEW Frontiers

- **BALANCE** between:
  - **ACHIEVABLE TOPICS** ➔ demonstrate success to public/funding agencies
  - **ASPIRATIONAL GOALS** ➔ may not complete within 15-year program

- **TIMEFRAME** of the new Science Plan:
  - include science **ACHIEVABLE in 5, 10, 15 & 15+ YEARS**

- **CONTENT & ARCHITECTURE** depend on **TARGET AUDIENCE & PURPOSE**

- **MULTIPLE AUDIENCES** ➔ **DIFFERENT SP VERSIONS/FORMATS** needed
PROCEED: In developing a new Science Plan we need to consider audience, purpose, content and architecture

- Include a **MISSION STATEMENT** – what we will do/how we will do it
- **UP-FRONT SECTIONS** to highlight:
  - *Exceptional past successes and Serendipitous nature*
  - *Outstanding legacy (including training/diversity)*
  - *Technology – including new capabilities*
  - *Links with other programs (e.g. ICDP, Planetary Science)*
- Use **NEW TERMINOLOGY** - e.g. ‘Grand Challenges’
- **REDUCE** the number of science questions – from 14 to 5-10
- Science questions should be: **CLEAR, BROAD**, important for **SOCIETY**
- Focus on **INTERDISCIPLINARY LINKS** between research fields
- The final ‘documents’ should include:
  - **non-linear digital** Science Plan with **hyperlinks**
  - **printed (linear)** executive summary with clear **infographics**
Developing a community-driven framework for future Scientific Ocean Drilling

Science Framework Working Group

- Interconnected
- Aspirational
- Societal Impact
- Inclusive
- Collaborative
- Technology
- New structure
- Audience-specific
- Digital/hyperlinked
The outcome of an extensive peer review process and a high level of community input is an exciting 30 year outlook

Aug 2019
SFWG Roadmap
COMMUNITY REVIEW

Sept 2019
ENDORSED
BY IODP FORUM

Oct 2019
Writing/Review Team –
First meeting

8 Dec 2019
Draft 1
ONLY in person
meeting (AGU)

15 Jan 2020
Draft 2
Internal Review
Rebalance Science Content

21 Feb 2020
Version 1
COMMUNITY REVIEW

April – July 2020
Lead Editors & professional team
Focus on Design / Graphics / Frontiers
Rewrite followed by Internal Review

20 July 2020
Version 2
COMMUNITY REVIEW

Sept 2020
ENDORSED
BY IODP FORUM

1,717 comments:
Wording (758), Graphics (127)
Missing Science (76)
The Framework structure combines broad interconnected science topics and aspirational goals

**ENDURING PRINCIPLES**
- Open Access to Samples and Data
- Standard Measurements
- Bottom-Up Proposal Submissions and Peer-Review
- Transparent Regional Planning
- Promoting Safety and Success Through Site Characterization
- Regular Framework Assessments
- Collaborative and Inclusive International Program
- Enhancing Diversity

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

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

**ENABLING ELEMENTS**
Key facets of scientific ocean drilling that facilitate our research activities, enhance our scientific outputs, and maximize their impact.
The **NEW** 2050 Science Framework is significantly different from its predecessor science plans...

**IT IS A FRAMEWORK, NOT A SCIENCE PLAN**

- in place **before** new program(s) are developed
- the **foundation** on top of which new programs/facilities are built
- eight **enduring principles** will underpin its implementation
- written by the community **for the community**
This is a page from a scientific article discussing future research directions in ocean drilling and the importance of understanding the Earth's past climate through drilling samples from ancient sediments. The text highlights the potential for new insights into Earth's climate history and the development of new tools and techniques for analyzing these samples.

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**Samples from Extreme Environments**

Sample return from extraterrestrial bodies significantly advances our knowledge of the formation and evolution of these planets. A major initiative is to collect samples from the surface of Mars, which serves as a proto-planet and a potential target for future human missions. The Solar System Exploration Strategy (SSES) addresses the need for samples from the surface of Mars, which could provide critical insights into the early conditions of our solar system and the potential for past or present life.

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**Future Collaboration**

The future of scientific ocean drilling and space exploration is promising. With the development of new technologies and techniques, we can expect to make significant progress in understanding our planet and the universe around us. Collaboration among scientists, engineers, and policymakers is crucial to ensure the success of these endeavors.

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**Scientific Ocean Drilling**

Scientific ocean drilling provides a unique opportunity to explore the Earth's past climate and understand the evolution of the planet. By drilling into ancient sediments, we can gain insights into past climates, ocean conditions, and the behavior of Earth's systems. This knowledge is essential for predicting future climate change and developing strategies to mitigate its impacts.
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WHAT FACTORS LEAD TO MASSIVE SUBDUCTION EARTHQUAKES?

The massive earthquakes in 2011 in Japan and in 2004 in the eastern Indian Ocean highlight our lack of understanding of the factors that promote and amplify seismic slip at subduction zones. In both cases, slip was large and for extended periods further seaward toward the trench than expected. Scientific ocean drilling has already played an important role in revealing some of the physical properties of the subduction faults that lead to the earthquake and tsunami in these two regions. To make significant headway in understanding the slip potential of major subduction zone faults globally requires collecting a broad range of observations from diverse environments at different stages in the earthquake cycle.

To understand how and why earthquakes occur requires knowledge about how fault zone lithology, chemical environment, and stress affect the slip behavior of faults. Core and in situ physical and chemical measurements from scientific ocean drilling programs with their diverse geophysical networks, surface geology, and ancient sediments. Collecting data that will contribute important information about how some of the world’s tallest and most active faulted valleys work and how they produce devastating earthquakes and tsunamis, or its fault slip, across the continents. There are numerous opportunities to integrate observations from scientific ocean drilling programs with those from other geophysical networks, surface geology, and ancient sediments. Collecting data that will contribute important information about how some of the world’s tallest and most active faulted valleys work and how they produce devastating earthquakes and tsunamis, or its fault slip, across the continents. There are numerous opportunities to integrate observations from scientific ocean drilling programs with those from other geophysical networks, surface geology, and ancient sediments.
ENABLING ELEMENTS

1. Broader Impacts and Outreach
2. Land to Sea
3. Terrestrial to Extraterrestrial
4. Technology Development and Big Data Analytics
Scientific Ocean Drilling Through 2050

Two hundred million years of Earth history are locked to the seafloor and rocks beneath the world's oceans. Scientific ocean drilling provides access to this archive, allowing scientists to examine the intricately connected processes that characterize the complex Earth system. It furnishes critical details about geologic processes as well as natural hazards that pose risks to society. Analyses of samples recovered by scientific ocean drilling establish the geologic context for interpreting human impact on climate and the environment, providing the data needed to improve the accuracy of computer models that predict the seas of today, the rates of polar ice sheet melt, and the rising of sea level and the melting of polar and glacial ice. Sampling and analyses also offer glimpses into the past microbial life that might exist elsewhere in our solar system and beyond.

The 2050 Science Framework guides scientific ocean drilling research to address the goals of scientific ocean drilling through education and outreach initiatives, partnerships, collaborations, and technology development, and innovative applications of advanced data analysis.

The 2050 Science Framework Structure

ENDURING PRINCIPLES
From Archean to Recent and Deep Subsurface Environments, Biocomplexity, Paleo Ecosystems, and New Worlds, Sustained Investments in a Broad Range of Science and New Sources Through the Characterized Drilling Framework, Ecosystems Collaborative, and the Innovative Program, Collecting Missions

STRATEGIC OBJECTIVES
Mandated areas of scientific inquiry that focus on understanding the Earth system

FLAGSHIP INITIATIVES
Constructing drilling environments that provide insights into the evolution of continental and marine systems and their surrounding oceans

ENABLING ELEMENTS
Key elements of scientific ocean drilling that facilitate research
The **NEW** 2050 Science Framework is significantly different from its predecessor science plans...

IT REQUIRES INVESTIGATION OF THE WHOLE EARTH SYSTEM

- focuses on *multidisciplinary science*
- emphasizes science with *societal impact* and/or *interest*
- drastically *different in structure* which will affect implementation

A PLAN FOR **UNTIL THE MID-21st CENTURY**

- much longer ranging across multiple program cycles
- need to maintain, revise, evaluate it
Strengthened collaborations between these programs will advance their closely allied objectives to investigate the interconnected global Earth system.

- Causes and consequences of sea level change
- An integrated global paleoclimate record
- Fluid flow across the coastline
- Earth Dynamics and natural hazards
LAND 2 SEA: Strengthened collaborations between scientific ocean and continental drilling will build on previous successes.

IODP Expedition 313
Mountain, Proust, et al.

IODP-ICDP Expedition 364
Morgan, Gulick, et al.

Kelemen, Matter, Teagle, et al.
The outcome of this extensive peer review process and the high level of community input and involvement has resulted in an exciting new outlook on more than 25 years of future scientific ocean drilling, with a focus on new scientific frontiers and research of societal impact and interest.

THANK YOU to everyone who has contributed to this process!!