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Scientific Drilling
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The International Ocean Drilling Programme (IODP[3])

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1 Importance and history of subseafloor scientific investigation

Science-based knowledge of Planet Earth is of fundamental importance for supporting a modern resilient society facing the global challenges posed by climate change, natural hazards, energetic transition, and the needs of a safe and sustainable blue economy.

The equilibrium between Earth, human society, and ecosystems can only be achieved by considering Earth to be a system in which the understanding of Earth's history, Earth's dynamics, and the deep Earth biosphere concur with the shaping of a better future for the planet.

Scientific drilling has supported science-based knowledge of Earth's interior since the 1960s through a continued and coordinated series of international programs that together represent the largest and longest-living initiative of international scientific collaboration in the field of Earth science.

In the ocean realm, which represents about 70 % of Earth's surface, scientific drilling facilities with engineers, technicians, scientists, and managers have allowed the scientific community to access some of Earth's most challenging environments, collecting data and samples of sediments, rocks, geo-fluids, living organisms, and monitoring data from below the seafloor.

Scientific ocean drilling programs have operated for more than 5 decades: the Deep-Sea Drilling Project (DSDP) 1968–1983, the Ocean Drilling Program (ODP) 1985–2003, the Integrated Ocean Drilling Program (IODP) 2003–2013, and the International Ocean Discovery Program (IODP) 2013–2024. Scientific ocean drilling expeditions have transformed the understanding of our planet by addressing some of the most fundamental questions about Earth's evolution, narrowing knowledge gaps and generating new questions and challenges. Technological innovation by scientists and engineers has improved sampling and in situ measurement and/or monitoring tools that are now widely employed in the geosciences in both the academic and industrial sectors. Long-term borehole observatories have provided data and samples from below the seafloor. Those instruments were built by the generation of knowledge accumulated by researchers and engineers. Some of the observatories are connected to the seafloor cable network and provide in situ data in real time. Equally importantly, scientific ocean drilling has fostered enduring international collaboration, trained new generations of students and scientists across scientific disciplines, and engaged the public worldwide in scientific discoveries.

Each of the scientific ocean drilling programs has been scientifically inspired by science steering documents conceived by the international scientific community. The most recent one was published in 2020, is entitled *Exploring Earth by Scientific Drilling – 2050 Science Framework* (https://www.iodp.org/iodp-future/2050-science-framework, last access: 19 March 2024), and is envisioned through long-term, multidisciplinary research efforts that require multiple expeditions over 10- to 20-year time intervals, each combining research goals from multiple strategic objectives – the Flagship Initiatives. The 2050 Science Framework was built on the legacy of previous programs and defined seven Strategic Objectives. It also introduced "Enabling Elements" for the first time in the history of scientific ocean drilling programs. These elements aim to increase the impact of scientific and outreach initiatives, promoting partnerships and collaborations with organizations that have complementary scientific goals, e.g., land-to-sea scientific drilling in partnership with the International Continental Scientific Drilling

Program (ICDP) and stimulating continued technology development and innovative applications of advanced big data analytics.

2 Principles of the International Ocean Drilling Programme – IODP^3

The end of the International Ocean Discovery Programme on 30 September 2024 will mark major changes in the organization of international activities related to scientific ocean drilling. After decades of unified international programs, from the DSDP to the current IODP, post 2024, scientific ocean drilling initiatives will see a transition from a single international program operated by independent platform providers to independent ocean drilling programs.

The European Consortium for Ocean Research Drilling (ECORD) and Japan, who have advocated for the continuation of a single international program, intend to continue providing scientific ocean drilling opportunities post 2024 to the international scientific community, based on their well-established infrastructures, competitiveness in the international research landscape, and maximum scientific return from investment.

Through a 2-year long process of exchange of views and ambitions, ECORD and Japan agreed to build a joint scientific ocean drilling program: the IODP^3 (IODP-cubed).

The IODP^3 will consist of an international scientific collaboration addressing important questions in the Earth, ocean, environmental, and life sciences described in the 2050 Science Framework, based on the study of rock and/or sediment cores, borehole imaging, in situ observatory data, and related geophysical imaging obtained from the subseafloor.

The IODP^3 will adopt a transparent, open, flexible, and international modus operandi, program-wide standard policies and guidelines, sustainable management, and publicly accessible knowledge-based resources. The IODP^3 will adopt the 2050 Science Framework Enduring Principles.

3 Objectives and organization of the IODP^3

IODP^3 investigations will be based on research proposals that address the objectives of the 2050 Science Framework or other outstanding new research ideas.

The IODP^3 will implement and fund

- offshore expeditions following an expanded Mission Specific Platform (MSP) concept and
- Scientific Projects using Ocean Drilling ARChives (SPARCs) that are international and multidisciplinary projects with objectives originating from or based on ocean drilling archives.

Drilling and SPARC proposals will be submitted with a bottom-up process to the IODP^3 Science Office by teams of proponents belonging to the international research community.

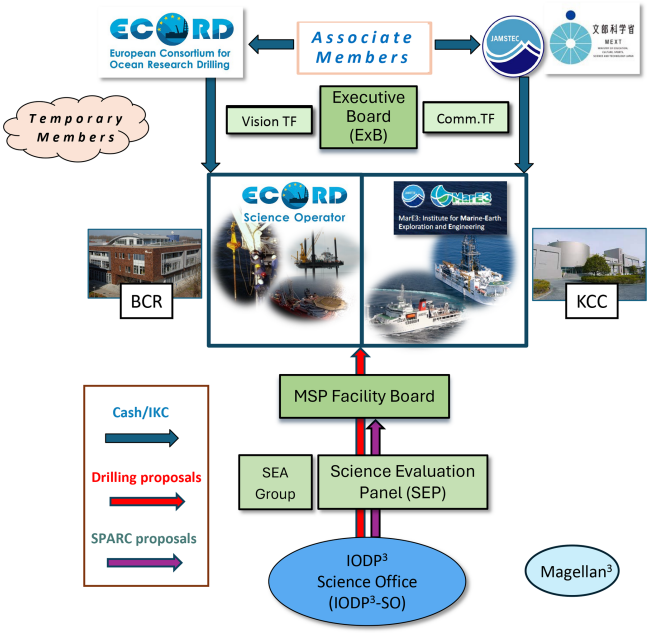

Figure 1. Organization of the International Ocean Drilling Programme. Photos and logos: © ECORD/IODP, © JAMSTEC, and © JAMSTEC/KCC.

The primary responsibility of the Science Evaluation Panel (SEP; Fig. 1) is to evaluate all proposals submitted to the IODP^3 in a fair, open, and transparent manner in terms of both scientific excellence and the completeness and quality of the site characterization data packages. The SEP will be composed of top international experts selected through competitive calls.

The Safety and Environment Advisory (SEA; Fig. 1) Group will be an advisory body to the MSP-FB, SEP, and IODP^3 Operators and will provide independent advice regarding potential safety and environmental issues associated with the general and specific geological settings of proposed IODP^3 drill sites.

The SEP and the SEA Group will be logistically supported by the IODP^3 Science Office and will serve all the platforms employed by the program. IODP^3 drilling expeditions and SPARCs will be scheduled by the MSP Facility Board based on their scientific merit and operational constraints within the limits of the available resources.

The IODP^3 Executive Board (ExB; Fig. 1) will be the IODP^3 entity responsible for ensuring effective decision-making and overseeing the program.

The Magellan^3 Workshops will be designed to support scientists from IODP^3 and ICDP members in developing new and innovative scientific drilling proposals that meet the ambitions of the 2050 Science Framework and/or the ICDP Sci-

ence Plan 2020–2030 by funding or co-funding workshop proposals and travel grants.

The IODP^3 will include two task forces (Fig. 1): the Vision Task Force will be in charge of developing a long-term scientific and funding strategy, and the Communication Task Force will be in charge of program-wide communication activities.

3.1 MSP expeditions

IODP^3 drilling expeditions will be implemented by the MSP Operators, ESO and/or JAMSTEC-MarE3, following the MSP concept. This concept will be an expanded MSP concept by diversifying drilling and coring technologies – riserless and riser drilling, giant piston coring – and applying them to all drilling environments, as determined by scientific priorities, operational efficiency, and better value for money. D/V *Chikyu* and R/V *Kaimei* are identified as MSP facilities that are crucial facilities for the successful implementation of the 2050 Science Framework.

Land-to-Sea Transects (L2S), requiring scientific drilling at both onshore and offshore sites or at shallow marine sites to be implemented jointly with the ICDP, are one of the prime objectives of the IODP^3.

The duration of IODP^3 expeditions will be flexible and determined by scientific requirements and available funds.

IODP^3 drilling expeditions will be scheduled by the MSP Facility Board based on their scientific merit and operational constraints within the limits of the available resources.

IODP^3 expeditions are intended to have no significant environmental impact, and they are carried out in conformance with the highest accepted levels of environmental sensitivity.

IODP^3 expeditions will be undertaken by international teams of scientists – Science Parties – selected by the MSP Operator(s) and Co-chief Scientists and based on recommendations made by Program Member Offices (PMOs). Staffing decisions will consider, as far as possible, the goal of achieving the maximum diversity of gender, career stage, nationality, discipline, and culture in the Science Parties.

The sizes of the expedition Science Parties will be flexible and determined by scientific requirements.

The IODP^3 will include the services provided by the current IODP core repositories in Bremen (BCR) and Kochi (KCC).

The IODP^3 will provide open access to all expedition samples and data once the expedition Science Party members have had the opportunity to complete the initial studies within the established moratorium period, typically 1 year. After the expiration of the moratorium period, the program will make samples, cores, and data available to any scientist, in accordance with the IODP^3 Samples, Data and Obligations Policy following findability, accessibility, interoperability, and reusability (FAIR) data principles.

3.2 SPARCs

The IODP^3 SPARCs provide a mechanism for the international scientific ocean drilling community to propose new large-scale projects that may address any aspect of the 2050 Science Framework and involve interdisciplinary collaborations.

SPARCs will have objectives that maximize the return on the legacy assets (i.e., cores, samples, and data from current and past scientific ocean drilling programs) without new drilling or other operations at sea.

SPARCs will address globally significant processes and problems and use innovative, creative, and multidisciplinary approaches that could include, for example, the production of large new datasets from samples, integration of data across multiple expeditions and/or multiple boreholes, and/or the application of new methods or technologies (e.g., AI, "big data" approaches) that were not available when the legacy assets were collected. The scientific ambition of SPARC projects should far exceed that of standard requests for samples or data as they are intended to provide a new avenue to facilitate collaboration at scales larger than conventional single- or multi-proponent sample requests. In parallel, standard requests for samples and data may be submitted at any time.

Each SPARC will have a funded duration of 3 years and will receive EUR 300 000 for its implementation. SPARC proposals should have a maximum of five co-proponents. All the co-proponents of a funded SPARC will automatically become Science Party members (with two selected as Co-Chief Scientists), but the remaining Science Party members will be selected following an open call for applications. The overall size of the final Science Party for a SPARC is flexible and can be adapted to project needs but will normally consist of a minimum of 15 scientists, with no fixed upper limit.

4 IODP^3 partnership

As Platform Providers, ECORD and Japan will be the IODP^3 Core Members.

International governmental and non-governmental entities not regularly providing scientific ocean drilling platform(s) to the IODP^3 can become Associate Members by making annual cash contributions to the IODP^3 (on the order of EUR 1 million) or as Temporary Members by providing cash and/or project-based in-kind contributions (IKCs) (with a minimum of EUR 0.5 million) to access IODP^3 expedition(s). The Australian and New Zealand IODP Consortium (ANZIC) and India have already sent letters of interest to become IODP^3 Associate Members.

IKC and/or cash contributions from any IODP^3 member or non-member country or institution are potentially acceptable for funding offshore expeditions. IKCs may include essential scientific or operational services that the IODP^3 would normally pay for, fully or partly funded drilling platforms,

support vessels, hazard site surveys (if required), permission assistance, onshore facilities near drill sites (if required), ice management, and remote logistical assistance.

IODP^3 will set up an overarching Scientific Drilling Forum as a venue for exchanging ideas, views, and information between all international research programs that employ scientific drilling to explore Earth and planetary processes.

5 Forward look

Based on the well-established operation of the ECORD and JAMSTEC infrastructures, their successful implementation, their competitiveness in the international research landscape and a maximum return from investment, a bright future is promised to the international communities and ECORD and Japan in their intentions to play a prominent role in post-2024 scientific ocean drilling.

Data availability. No data sets were used in this article.

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