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Quo Vadis

Look to the *Future*

By Anthony A.P. Koppers, Carlota Escutia, Fumio Inagaki, Heiko Pälike, Demian M. Saffer, and Debbie Thomas

Over the last five decades, scientific ocean drilling has addressed a wide array of themes important to the Earth, ocean, and life sciences, adding valuable information to studies that required knowledge of the subseafloor environment to make progress. But it has also opened up new areas of research that would otherwise not be possible. This special issue of *Oceanography* can highlight only a few examples of such triumphs. Indeed, the repertoire and impact of scientific ocean drilling is far deeper than can be captured in these pages, transcending many disciplines, and enriching the work of thousands of researchers worldwide. Scientific ocean drilling has matured in parallel with emerging challenges in the Earth, ocean, and life sciences, remaining as relevant a scientific endeavor as it was in the early days of the Deep Sea Drilling Project in the late 1960s.

In the 2015 report by the US National Research Council, *Sea Change: 2015–2025 Decadal Survey of the Ocean Sciences* (https://doi.org/10.17226/21655), the importance of scientific ocean drilling to our community is powerfully highlighted. While understanding that scientific ocean drilling is a resource-intensive research enterprise, the report found its capabilities irreplaceable, fundamental, and—in some cases—critical to improving our understanding of sea level change, past ocean and climate variability, the processes that control formation of the ocean basins, geohazards, and the geophysical, chemical, and biological character of the subseafloor environment. These topics encompass five of the eight priority science questions identified in the *Sea Change* report. The four generations of scientific ocean drilling programs and their extensive research output continue to live up to their *transformative potential*, have accumulated findings that have had significant *societal impact*, have showcased *readiness* by mobilizing expeditions to investigate very recent geological events or hazards, and its 26-country membership has been a textbook example of true *partnership potential*.

The current 2013–2023 International Ocean Discovery Program (IODP) is adopting new scientific approaches, drilling strategic transects, and compiling regional scientific ocean drilling results while also scheduling multi-expedition missions to more comprehensively address major science questions. For example, the current program has emphasized work in three areas—mission monsoon, mission Antarctica, and mission earthquake—each potentially making use of all three currently available drilling facilities, *JOIDES Resolution*, *Chikyu*, and a mission-specific platform. Through these longer-term, multi-expedition efforts, IODP will dramatically advance our understanding of the on/off switching of the Asian monsoon and its influence on Earth's climate, the sensitivity of Antarctic ice sheets to changes in atmospheric carbon dioxide and the impact of this greenhouse gas on past and future sea level, and the mechanisms that cause large magnitude (M8+) earthquakes that can result in devastating tsunamis. While the new IODP mission approach aims to contribute significantly to our understanding of existing big science issues, as shown in the examples above, it is anticipated that results from the missions will also spawn new and exciting avenues of research to be addressed by a future scientific ocean drilling program.

The current IODP provides an excellent springboard for next-generation, post-2023 scientific ocean drilling. While the four IODP themes of *Climate and Ocean Change*, *Biosphere Frontiers*, *Earth Connections*, and *Earth in Motion* remain relevant across disciplines (the IODP science plan is available at https://www.iodp.org/about-iodp/iodp-science-plan-2013-2023), research

(a) Siem Offshore personnel on the *JOIDES Resolution* rig floor during coring operations, IODP Expedition 362, *credit: Tim Fulton, IODP JRSO*. (b) Scientists boarding the drillship *Fugro Synergy* in Corinth harbor, IODP Expedition 381, *credit: ECORD-IODP*. (c) A core sample in the core catcher, IODP Expedition 364, *credit: A. Rae, ECORD-IODP*. (d) Rig floor of *Chikyu*, NanTroSEIZE expedition, *credit: JAMSTEC*. (e) Structural geologist Carlotta Ferrando (University Montpellier II, France) examines the core and records her findings, IODP Expedition 360, *credit: Bill Crawford, IODP JRSO*

questions, expedition implementations, and techniques are changing rapidly. There is a need for deepening partnerships with, for example, the continental drilling, deep biosphere, astrobiology, and geodynamics communities. At the same time, focusing on multi-expedition missions that take advantage of efficient regional ship tracks and drilling along transects will allow the program to address science questions that cannot be answered within the timeframe of a typical single two-month expedition. New science challenges include the dynamics of climate variability at low latitudes and in the tropics, deep Earth geodynamics and its relation to surface processes, the fate of secure drinking water resources in coastal areas, how gas hydrates form, continental shelf stability and related landslide geohazards, the habitability of Earth and its environment in the past and projected into the future, and understanding the past M8+ seismology record in subduction zones.

On the heels of 50 years of extraordinarily successful scientific ocean drilling, there remains a need to continue the research endeavors that have produced a constant stream of high-impact knowledge of our Earth system. A refreshed IODP science plan will lay out the exciting new science challenges that can only be addressed through scientific ocean drilling, while a large community effort plans for replacement of the aging *JOIDES Resolution* with a modernized, more capable non-riser drilling vessel.

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