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INTRODUCTION TO THE SPECIAL ISSUE ON

Scientific Ocean Drilling

Looking to the *Future*

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

This special issue of *Oceanography* on Scientific Ocean Drilling: Looking to the Future celebrates the more than 50 years of investigating the subseafloor of the world's ocean and seas that began in the summer of 1968 with Leg 1 of the Deep Sea Drilling Project (DSDP, 1968–1983). Since those early years, scientific ocean drilling has evolved from a US-only program to a fully fledged international one, now including more than 26 countries. It transformed from a focus on exploration during DSDP to more targeted, hypothesis-driven science aimed at understanding fundamental processes during the Ocean Drilling Program (ODP, 1985–2003), the Integrated Ocean Drilling Program (IODP, 2003–2013), and the current International Ocean Discovery Program (IODP, 2013–2023). Together, these programs have recovered more than 490 km of core and engaged more than 5,000 scientific participants from around the globe. The drilling vessels *Glomar Challenger* (1968–1983; see Spotlight 1) and *JOIDES Resolution* (since 1985; see Spotlight 4) have been the workhorses, carrying out 90% of the science missions, whereas the *Chikyu* (since 2007; see Spotlight 7) provides specialized capabilities to reach very deep targets, and mission-specific platforms (since 2004; see Spotlight 11) allow individual expeditions in locations where drilling is challenging, for example, in ice-covered seas or in waters that are too shallow for *JOIDES Resolution*. Analysis of cores and geophysical data collected by scientific ocean drilling have yielded insight into first-order questions about how our planet works, and have resulted in more than 11,000 peer-reviewed publications (see Spotlight 9), with more than 500 appearing in the leading *Nature* and *Science* journals.

Scientific ocean drilling can count many significant discoveries in the Earth, ocean, and life sciences. This long list includes, among others:

- Key validation of the seafloor spreading hypothesis
- Discovery and characterization of subseafloor microbial life and the deep biosphere
- Sampling and measuring the energy budget of a mega-earthquake
- Uncovering numerous details concerning the evolution of Earth's climate over the past 150 million years
- Documentation of the evolution and stability of the polar ice sheets and their roles in past oceanographic conditions and sea level changes
- Assembling a multimillion-year record that defines the biogeochemical and magmatic fluxes between deep mantle reservoirs and the lithosphere that together make up Earth's interconnected system

Along with these groundbreaking results, new questions have emerged, often based on previous scientific ocean drilling expeditions and the detailed analysis of cores and logging data carried out by the shipboard scientific party as well as other researchers who have obtained samples and data from the programs. For most of these studies, drilling provides the only way to access materials from the below the seafloor, collect a wide variety of measurements, and develop a long-term presence in the subsurface that is needed to improve our understanding of Earth's climate history, structure, dynamics, and deep biosphere.

The overall goal of this special issue is to celebrate 50 years of scientific ocean drilling and to reflect on the wide-ranging accomplishments made possible through DSDP, ODP, and the two recent IODP programs—and also, importantly, to document the need for continuation of scientific ocean drilling into the future. As the articles in this volume attest, scientific ocean drilling is an invaluable tool through which an extraordinarily interdisciplinary, vibrant, and diverse community in the Earth, ocean, and life sciences addresses fundamental and acutely societally relevant questions. Scientific ocean drilling fosters strong collaborations between scientists from different

(a) *Chikyu*, *credit: JAMSTEC*. (b) Expedition 381 Science Party in the IODP Bremen Core Repository, *credit: V. Diekamp, ECORD-IODP*. (c) *JOIDES Resolution* docked in Colombo, Sri Lanka, for Expedition 360, *credit: Benoît Ildefonse, IODP JRSO*. (d) Scientists aboard *JOIDES Resolution* carry the last Expedition 362 core, *credit: Tim Fulton, IODP JRSO*. (e) Expedition 302 mission-specific platform operations, credit: *M. Jakobsson, ECORD-IODP*

disciplines, institutions, and countries. The drillships are ideal platforms for graduate students and postdocs to gain valuable seagoing experience and network with scientists from around the globe. The chapters in this special issue show that there remain many outstanding scientific problems that can only be solved by analysis of new core samples and other types of data collected through scientific ocean drilling. With drilling, coring, logging, and borehole observatory technologies rapidly improving, and with anticipated future enhancements to the scientific ocean drilling facilities, this international science program will serve the needs of the ever-broadening community for years to come.

This special issue is organized into four themes that transcend DSDP, ODP, and IODP. The driving questions within the **Climate and Ocean Change** theme capture the urgent need to explore past changes in climate at higher spatial and temporal resolutions. Articles highlight significant recent advances toward addressing two of these questions based on reconstructions of ice sheet and sea level variations in the context of climate change and by gaining a deeper understanding of the processes that impact monsoon variations. Articles in the **Probing the Dynamic Earth and Assessing Geohazards** theme show how, through scientific ocean drilling, researchers are characterizing the various processes that generate earthquakes, tsunamis, and explosive volcanism. In this special issue we focus on key IODP contributions that significantly enhanced our understanding of Earth's largest tsunami-genic earthquakes and the particular importance of slow earthquakes. The third theme investigates the **Window into Earth's Crust and Mantle**, where we look at the initiation of subduction and its influence on global-scale plate tectonics, the architecture of the ocean floor created at slow and fast spreading centers and where large igneous provinces have formed, and the history of the mobility of deep mantle plumes. In the final theme, **Microbial Life Deep Beneath the Seafloor**, we review advances in our knowledge of the makeup of subseafloor life, the deepest expanses of Earth's biosphere, and the limits of life in extreme environments, all enabled by scientific ocean drilling.

For the last five decades, scientific ocean drilling has been a foundational tool that provides the Earth, ocean, and life sciences communities access to the subseafloor not achievable in any other way. The programs' interdisciplinary approaches to addressing difficult scientific problems, to advancing and maintaining the technical capabilities of the drilling vessels and onboard laboratories, and to nurturing productive and enduring international collaborations have resulted in numerous significant scientific achievements. Many stellar scientific careers have been launched through involvement in scientific ocean drilling programs. A vibrant new generation is ready to take the helm and apply scientific ocean drilling to test the newest hypotheses on the frontier of the Earth, ocean, and life sciences.

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