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The global and regional significance of IODP

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Globally, scientific ocean drilling has been a superb international scientific program since its real beginning as the US-funded Deep Sea Drilling Project in 1968, with the first Australian aboard a regional expedition being Gordon Packham from the University of Sydney, on the Southwest Pacific Ocean Leg 21 in 1971–72. Over the years, ocean drilling has moved from exploratory drilling – trying to discover what lies below all the world's oceans – to targeted drilling – seeking to address global scientific problems in suitable locations. It has always taken cores in sediments and rocks deep beneath the ocean floor, starting with the drill ship the *Glomar Challen*ger, which took discrete (sequential but intermittent) cores from depths averaging 500 m below the sea floor (mbsf). Now the *JOIDES Resolution* takes continuous cores from depths that are mostly in the range of 500–1,000 mbsf, and the *Chikyu* takes cores that can be as deep as 4,000 mbsf. Very sophisticated continuous wireline logs provide much additional information, and various instruments are left in many holes to record physical and chemical changes over time.

The aims of the present worldwide program are outlined in the International Ocean Discovery Program (IODP(2)) Science Plan for 2013–2023 *Illuminating Earth's Past, Present, and Future*, which was prepared under the aegis of a Science Plan Writing Committee of 14 scientists, including Richard Arculus of The Australian National

University and Peter Barrett of Victoria University of Wellington. It covers many scientific fields under the themes Climate and Ocean Change, Biosphere Frontiers, Earth Connections, and Earth in Motion. Ocean drilling research covers, among other things, the nature of the Earth's mantle and crust, and the nature of the related deep forces that drove or drive the Earth's tectonics; past and future climate change; the history of life as revealed in sedimentary strata; the nature of the extraordinary microbes found deep in the sediments and volcanic rocks beneath the sea floor; and major natural hazards such as earthquakes, tsunamis and submarine landslides. An average two-month IODP expedition recovers thousands of metres of sediments and rocks that provide a wonderful store of highly varied information for subsequent investigation.

Proposals for drilling anywhere in the ocean must address global themes in locations where this can be done particularly well. They are put together by an international group of scientists and are judged by panels and referees simply on their scientific quality and logistical feasibility. We have been involved in excellent regional proposals in recent years, and our region has had a disproportionately high success rate for proposals.

Opportunities exist for researchers (including graduate students) in all specialties – including, but not limited to, sedimentologists, petrologists, structural geologists, palaeontologists, biostratigraphers, palaeomagnetists, petrophysicists, borehole geophysicists, microbiologists and inorganic and organic geochemists. Ocean drilling provides wonderful training for students and researchers at all stages of their careers, and can be a career-changing opportunity. Scientists commonly form lifelong research partnerships with the international scientists they have worked with aboard these vessels, often in fields unrelated to ocean drilling.

The relevance of ocean drilling is not just confined to the oceans. Plate tectonics, which is driven by forces in the Earth's mantle and crust beneath the oceans, has also controlled the past and present nature of the world's land masses and explains, for example, why Australia and New Zealand are so different topographically and in the living and non-living resources that they support. Plate tectonics builds mountain ranges, and explains earthquakes and volcanic areas like those in the Pacific 'Rim of Fire'. Many of the land's rocks were laid down beneath the oceans, and some contain high-value metalliferous ore deposits as well as petroleum formed from marine organisms, so understanding how such resources have formed in the oceans can help exploration for them onshore.

Of course, scientific stratigraphic wells drilled on continental margins provide information of value for petroleum exploration, with many of the world's great petroleum fields offshore.

It should be noted that ocean drilling does not involve just geoscientists. Ocean drilling has shown that very unusual 'extremophile' microbes live deep in the sediments beneath the ocean, and in the warm basalts that have been poured out recently as parts of spreading centres in the world's oceans. Microbiological expeditions make up 10 per cent of ocean drilling expeditions, and are providing much information about these poorly known but globally huge accumulations of extraordinary organisms. Ocean drilling information is also vital to our understanding of past climate change and can constrain the possible scenarios of future climate change. It provides a great deal of information about the drivers of past sea-level rise, and how oceanographic and climatic changes constrained the rates of sea-level change – clearly important information for coastal planners.

The geological hazards of volcanic outbreaks, earthquakes and tsunamis are a major part of ocean drilling research. The recent IODP Expedition 343 off Japan studied the subduction zone and fault that generated the Tohuku-Oki Earthquake of 2011, with its associated devastating tsunami, by not only drilling through the active fault but also instrumenting the drill hole to study changes over time after the earthquake. Such studies and instrumentation lead to better understanding of earthquake hazards, and may well lead to better prediction of future earthquakes. These studies will be continued in the Hikurangi subduction zone east of New Zealand's North Island in 2017 and 2018.

Many hundreds of kilometres of ocean drilling cores and related data are accessible to all scientists from three large core repositories: the Bremen Core Repository at the University of Bremen in Germany (www.marum.de/en/Research/IODP-Bremen-Core-Repository.html), the Gulf Coast Repository located at Texas A&M University (iodp.tamu.edu/curation/gcr/) and the Kochi Core Center at Kochi University in Japan (www.kochi-core.jp/en/).

If policymakers were to ask what our membership of this international ocean drilling program gives us that could not be gained if we were not members and simply made use of ocean drilling research results and access to material, then part of our answer would be that we have helped to drive the science proposals that have brought many expeditions to our region in a way that would be impossible for non-members and that, without our ideas and hard work within the system, many of these expeditions would not have occurred or been scheduled. These activities have provided or will provide insights into questions of national and regional significance, which could not have been obtained in any other way. Among those being addressed are the geological history of the Great Barrier Reef, the Australian Monsoon and the Antarctic margin claimed by our countries. In addition, the study of the earthquake- and tsunami-prone Hikurangi subduction zone east of New Zealand's North Island is of great societal relevance.

Another answer to such a policy question is that having our students and scientists involved with the expeditions and their aftermath is wonderful training and allows the interchange of information at the highest levels of international science. Furthermore, these people form international alliances to address other aspects of geoscience or microbiology, to the benefit of both Australia and New Zealand.

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