# Australian Membership of the International Ocean Discovery Program March 2013

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## a. Significance of research to be supported with proposed infrastructure, equipment and facilities

### i. Nature of the research, including aims and significance

The **International Ocean Discovery Program** (IODP) shall be the **world's largest collaborative research program in the Earth and Ocean Sciences.** Its primary aims include recovering cores, situating observatories, and conducting down-hole experiments in drill holes spanning all the world's oceans from their lowest to highest latitudes. During core recovery, observatory monitoring, sample analysis and modeling, IODP will engage a broad spectrum of scientific disciplines – from marine geophysicists and sedimentologists to microbiologists, from physical oceanographers to climatologists and volcanologists. Commencing in late 2013, IODP is scheduled to operate for a decade. **This proposal requests funding for Australian membership in this unique and prestigious discovery program for the first 5 years of its investigations.**

The IODP will supersede: i. Integrated Ocean Drilling Program (2003-2013); ii. Ocean Drilling Program (1985-2003); iii. Deep Sea Drilling Project (1968-1983), which included the International Phase of Ocean Drilling in its last 8 years. As the majority financial partner of the Australia-New Zealand Integrated Ocean Drilling Program Consortium (ANZIC), Australia has been an active member of (i) for the past 5 years inclusive of 2013. Australia was a member of (ii) for 14 years. **Currently 26 nations are IODP members, including 19 of the world's 25 largest economies and 23 of 34 OECD member countries**. International membership levels are comparable with the International Space Station or CERN, but at a fraction of these programs' costs. In contrast to the current model of centrally managing subscribers' "comingled funds" to operate all three platforms, the post-2013 IODP will be structured to allow autonomy and separate budgeting for the 3 major platform providers (USA – D/V *JOIDES Resolution*; European Consortium for Ocean Research Drilling (ECORD) – *mission-specific platforms*; Japan – D/V *Chikyu*).

C**overing ~71% of the Earth's surface**, oceans are the repository of sediments overlying stretched and rifted continental crust, oceanic crust, and some exposed windows into Earth's mantle. These **sediments** preserve histories of the physical, chemical, and biological characteristics of the oceans through space and time, thereby containing the temporal record of the evolution of the Earth's atmosphere, hydrosphere, cryosphere, biosphere, and solid interior. **Oceanic crusts** form through magma generation; their chemical and physical characteristics result from changes that have occurred in the Earth's **mantle** –volumetrically the most significant portion, but still a poorly understood and sparsely sampled part of the planet. Crustal evolution includes recycling of ridge-formed oceanic crust through subduction zones, marked at the surface by deep-sea trenches and chains of volcanic islands. These rocks underlying the ocean contain key clues to the formation and evolution of **continental rocks and their mineral and energy resources.**

Through host nation membership of these various drilling programs, researchers examine and analyse samples of the cores, sub-seafloor fluids, and microbes recovered by scientific ocean drilling, and develop testable models for how the coupled components of the Earth system work now and have operated in the past. Drilling also recovers geophysical and geochemical data through instrumentation and logging of boreholes and networks for improved understanding of real-time fluid flows, and **potentially hazardous earthquake- and tsunami-generating fault activity.**

The primary research aims of the IODP, as outlined in a new Science Plan for the next phase of scientific ocean drilling (http://www.iodp.org/Science-Plan-for-2013-2023), are to recover cores and monitor instrumented boreholes, tackling challenges within these four high-priority scientific themes:

1. **Climate and Ocean Change – reading the past and informing the future**
2. **Biosphere Frontiers – deep life, biodiversity, and environmental forcing of ecosystems**
3. **Earth Connections – deep processes and their impact on Earth's surface environment**

4. **Earth in Motion – processes and hazards on a human time scale**

Within these themes, research challenges include a number of complementary interests with national and international research programs, including the global climate and ocean observing systems (the Integrated Marine Observing System), past global changes, InterRidge, InterMARGINS, the International Continental Scientific Drilling Program, and the Antarctic Ocean Drilling Program (ANDRILL). According to the four scientific themes listed above, these challenges include:

1. How will Earth's climate, ocean, and ice sheets respond to ongoing increases in atmospheric greenhouse gases? Future climate states are predicted to mimic past events; there were numerous periods during which Earth's climate changed dramatically and sometimes rapidly, in response to internal and external forcing. Ocean drilling is the primary means by which these records of past change can be sampled at high resolution in carefully selected locations, allowing us to sharpen our understanding of the causes and impacts of changes in climate states in Earth's past.
2. In the previous decade, ocean drilling has generated a wealth of new data concerning the nature and distribution of organisms living below the ocean floor under conditions previously regarded as hostile to life. Our next challenge is to understand the genomics, habitats, ecological niches and metabolic pathways of these life forms. In addition, the effects of environmental forcing during periods of dramatic and rapid ocean-climate change will be studied on scales ranging from microorganisms to ecosystems.
3. With the latest technology, recovery of cores spanning the entire thickness (~7 km) of the oceanic crust and underlying mantle (a long-term major scientific goal of ocean drilling) is finally possible. The oceanic crust reacts with seawater and can preserve a critical history of past ocean composition. The reaction products are also crucial in determining the subduction cycle, the characteristics of explosive volcanism, and world-class ore deposition at island arcs and their associated backarcs. With its unique capabilities, IODP is scheduled in 2014 to recover the volcanic outputs associated with the initiation of a subduction zone – an unsolved problem of global plate tectonics. Deep drilling of submarine, mineralizing hydrothermal systems, particularly in island arcs and backarcs is also planned.
4. The dynamic processes accompanying earthquakes, tsunamis, volcanism, fluid flow in sediments and volcanic crust, formation and stability of sub-seafloor gas hydrate, and sequestration of $CO_2$ in deep-sea reservoirs are potentially resolvable with instrumented boreholes, linked individually and in some cases networked to shore for real-time observations. Pristine fluids and microbial samples are also uniquely recoverable from these instrumented boreholes.

The three drilling platform providers have adopted the new IODP Science Plan as the guiding document for the next decade of highest priority scientific ocean drilling. The National Research Council of the National Academies of the USA has reviewed the scientific accomplishments of scientific ocean drilling, and the new Science Plan, *inter alia* stating "*each of the four themes...identifies compelling challenges with potential for transformative science that can only be addressed by scientific ocean drilling.*" ECORD has published a document entitled "The Future of ECORD 2013-2023" (http://www.ecord.org/pub/brochure.html#Future_ECORD), endorsing the new Science Plan and stating: "*ECORD plans to focus on issues of particular societal relevance such as climate change, resources, geohazards, and the exploration of the Arctic.*" The Natural Environment Research Council of the UK conducted a review of that country's involvement with the Integrated Ocean Drilling Program in 2010, and the potential benefits of joining the IODP, most likely through ECORD. The executive summary (http://www.nerc.ac.uk/research/programmes/ukiodp/events/documents/ukiodp-review-summary.pdf) stated *inter alia*: 1. The program has delivered excellent science with high impact; 2. Major advances in understanding of deep crustal structure, deep biosphere, paleoclimate, and subduction tectonics would not have happened without IODP; 3. An excellent group of trained post-graduate and post-doctoral researchers have been developed that are highly valued by industry and academia; 4. Industry makes extensive use of the data generated from the program, particularly published literature and archived samples.

ii. Relevance of the proposed infrastructure, equipment and facilities to the needs of ARC and other competitively funded research projects/programs

**Membership in the IODP creates a prime opportunity for Australian scientists to pursue global-scale, state-of-the-art multidisciplinary marine geoscientific and sub-seafloor microbiological research** with a range of aims identified in the preceding section. Membership will provide the Australian Earth Science community with the opportunity to develop research proposals and program support requests to the ARC. The arrival later this year of a new, world-class research vessel (R/V *Investigator*) with a full range of geophysical surveying capabilities for the Australian Marine National Facility will provide the local infrastructure necessary to complete competitively funded, pre-drilling site surveys on highly ranked (by the IODP science advisory structure) proposals, and to extend the results of drilling to wider geographic areas.

In 2012, Australia confirmed by proclamation a United Nations-validated claim to an enormous marine jurisdiction (11.65 million $km^2$), one and a half times the size of its land area (~7.6 million $km^2$). Fundamental research into the nature of the sediments and rocks that lie beneath Australia's oceans is essential if we are to sustainably manage and understand the potential for new wealth from this maritime domain, and recover the records of the physico-chemical and biological history of the oceans that surround our mainland. Complementing this national imperative to explore and document our own marine jurisdiction, the interconnectivity of the world's oceans and global processes means Australian scientists are motivated to pursue curiosity-driven research wherever the most interesting, significant and challenging problems exist.

iii. Enhancement of support for areas of existing and/or emerging research strength.

On the basis of publication and citation rates, **Earth Sciences (including Oceanography) is clearly demonstrated as an area of exceptional research strength for Australia**. Matthews *et al*. (2010) have shown that, internationally, geoscience is one of Australia's three flagship scientific fields as measured by its relative citation impact (average citations per paper for a given country in a given field divided by the global average number of citations per paper per field). Similarly Australia's publications are high relative to the global output of the field (FEAST, 2011), demonstrating the clear existing strength of Australian geoscience. And where Australian science is exceptionally strong, we should act to consolidate these leads (Office of the Chief Scientist, 2013).

**Marine geoscience is fundamentally important to our national interests**, as elaborated later in this proposal with respect to research priorities. Many other nations are already actively exploring the seafloor in the Australasian region for economically important resources. A large proportion of the proposals to use the R/V *Investigator* operating as the Marine National Facility are in the marine geoscience field. Australia's National Research Investment Plan released late in 2012 emphasises the importance of international research and infrastructure collaboration for our wellbeing, and the need to support collaborative activities such as the IODP on a sustainable and ongoing basis. Australian membership of the IODP will address three of the Research Investment Principles in the Plan: Principle 3 – increase the stock of knowledge; Principle 4 – support global quality and scale; Principle 5 – deliver a strong cohesive research fabric.

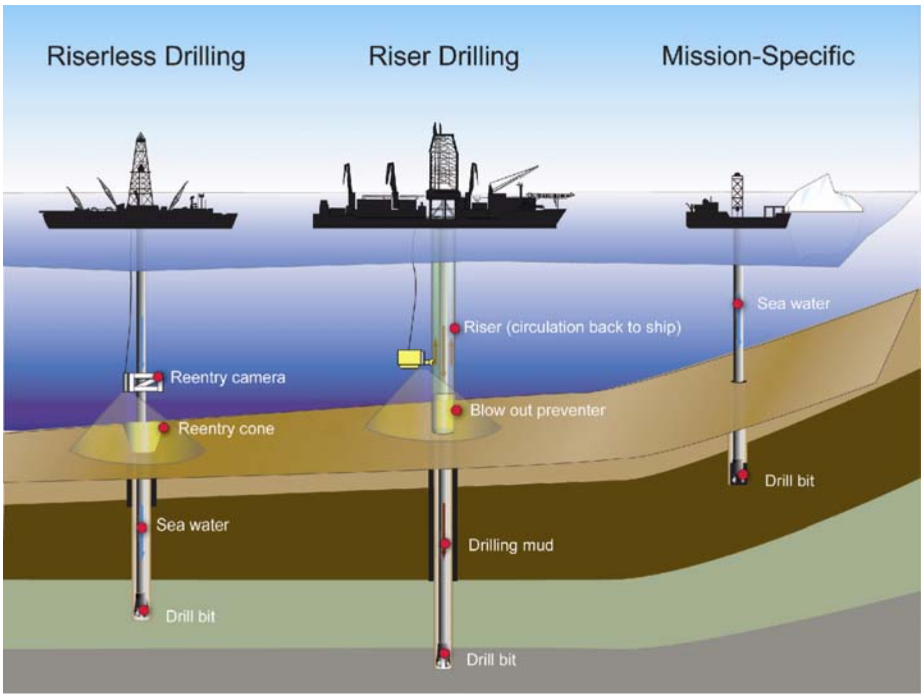
## b. Need and use of the proposed infrastructure, equipment and facilities: 30%

### i. Availability of and access to similar infrastructure, equipment and facilities at organisational, regional, national and/or international level

The drilling technology and borehole instrumentation operated by this program is **the only infrastructure accessible by the academic research community for seafloor penetrations in excess of ~ 50 metres**. In particular, D/V *JOIDES Resolution* and D/V *Chikyu* (see further detail below) are globally unique floating laboratories with facilities tailored to maximise the scientific value of recovered core. To access similar infrastructure outside of the IODP would be prohibitively expensive (with a single drilling leg costing tens of millions of dollars). Of significance for a relatively small nation such as Australia, **the major capital costs of the infrastructure deployed and its significant amortization have all been borne by America and Japan.** The infrastructure operated by America, Japan and ECORD is complementary in terms of the accessible targets and depths, and capable of tackling three general categories of drilling, coring, instrumentation, experimentation and monitoring:

1. Multiple holes with penetration from shallow (~100 m) to intermediate depth (~2 km) with ~100% core recovery routinely to depths of 500 m
2. Deep drilling (~2-7 km) at a limited number of locations
3. Drilling in shallow water (e.g., reef), unstable lithologies, or extreme (high latitude) environments

**Figure 1. Drilling Platforms to be deployed by the IODP**




The principal drilling platforms to be used by the IODP are the D/V *JOIDES Resolution* and the D/V *Chikyu*. The *Resolution* was extensively refurbished by America during 2006-2008 at a cost of ~$US115 million. The ship drills in **riserless drilling mode** where seawater is generally circulated down through the drill pipe and upward through the open hole, tackling targets in category (1). The ship cannot drill in situations where highly pressured fluids and gases may escape into the environment. Japan built D/V *Chikyu* at a cost of ~¥60 billion ($US640 million at current exchange rates) in 2002. The ship is designed to operate with a **riser** for targets in category (2) wherein dense drilling mud is pumped down the interior of an inner drill pipe and returned to the ship via a larger concentric pipe called a riser. This technology permits very deep drilling safely, even in geological settings with pressured hydrocarbons. For some targets such as those in category (3), identified as excellent through peer-reviewed selection but inaccessible using the *Resolution* or *Chikyu*, **mission-specific platforms** (MSPs) are chartered by ECORD. For example, in 2004 (as part of the Integrated Ocean Drilling Program) an ice-strengthened platform supported by two icebreakers achieved hugely successful, pioneering drilling in the Arctic Ocean (Backman et al., 2006). MSPs have also been used for coring off Tahitian marginal reefs (Camoin et al., 2007), the shallowest parts of the New Jersey continental shelf (Mountain et al., 2010), and an expedition led by an Australian Co-Chief Scientist (Dr J. Webster) to the Great Barrier Reef (Webster et al., 2011).

In addition to seaborne infrastructure, land-based core storage repositories are operated by nations within the current Program. Repositories with cores dating from 1968 (commencement of the Deep Sea Drilling

Project) and totaling 370 km in length are kept at Kochi (Japan), Bremen (Germany), and College Station (USA). These are stored under temperature- and humidity-controlled conditions. **Samples from past expeditions can be obtained from these repositories through submission of research plans – another important advantage of program participation**. While each of the platform operators is responsible for its own data management, including expedition-generated core descriptions, analytical measurements, logging data, publications and post-expedition data, IODP will further develop its extant "Scientific Earth Drilling Information Service", which harvests metadata from the platform operators' data systems.

ii. Demonstrated needs (including level of demand) from the researchers and/or research projects that will utilise the proposed research infrastructure, equipment and facilities

The needs of Australian researchers for access to all the infrastructure and facilities provided through membership in the IODP can be measured in two ways: 1. **The effort involved by individual scientists in preparation and submission of drilling proposals** (even when Australia was not a member of the various incarnations of deep-sea scientific drilling programs) and **the substantial lead times** (five years or more) for execution of selected proposals. These efforts include participation in collaborative international teams working on proposal preparation and submission, and in workshops such as those led by Australian scientists in India (October, 2011), Sydney (October, 2012) and Tokyo (April, 2013), respectively planning future drilling in the Indian Ocean, SW Pacific, and the global use of *Chikyu*; 2. **Excess pan-Australian demand for shipboard scientific participation** compared with the availability of places on all three platforms of the current scientific drilling program, the subsequent research commitment of the successful participants, and their publication rates.

iii. Value for money and budget justification for cash and in-kind contributions, and the expected rate of use of the proposed infrastructure, equipment and facilities

The value for Australia of the money provided (through the current LIEF grant combined with cash contributions from the university and government agency sector) for membership in the Integrated Ocean Drilling Program can be judged in a number of ways, and serves as a model for the value of projected participation in the IODP. **Value for money can be judged by the fact that our membership fee represents ~ 0.9% of the annual operational costs of IODP, representing a leveraging of ~110:1**. In the simplest terms, any allocation of infrastructure, transfers of funds, and dedication of scientific personnel to projects and locations of direct Australian interest in excess of that percentage can be regarded as particularly beneficial to our nation. **Recent publication rates of Australian scientists are an order of magnitude in excess of 0.9% of the totality of the output** (see Table below), and reflect an outstanding performance. The value of drilling legs in waters of Australian interest (shown below in the Figure 2) is considerable; independent of scientific labour costs, every two-month leg of the D/V *JOIDES Resolution* currently costs about $US8 million. Accompanying stopovers in Australian ports by the drill ship are worth ~ $US1.5 million each in "over the counter" revenue for supplies and services; four of these stopovers have occurred during the current Program. For every leg, about 30 international scientists are committed to research of direct Australian interest. Inclusive of the post-leg research effort, cumulatively this represents ~ 30 person-years worth ~ $US3 million.

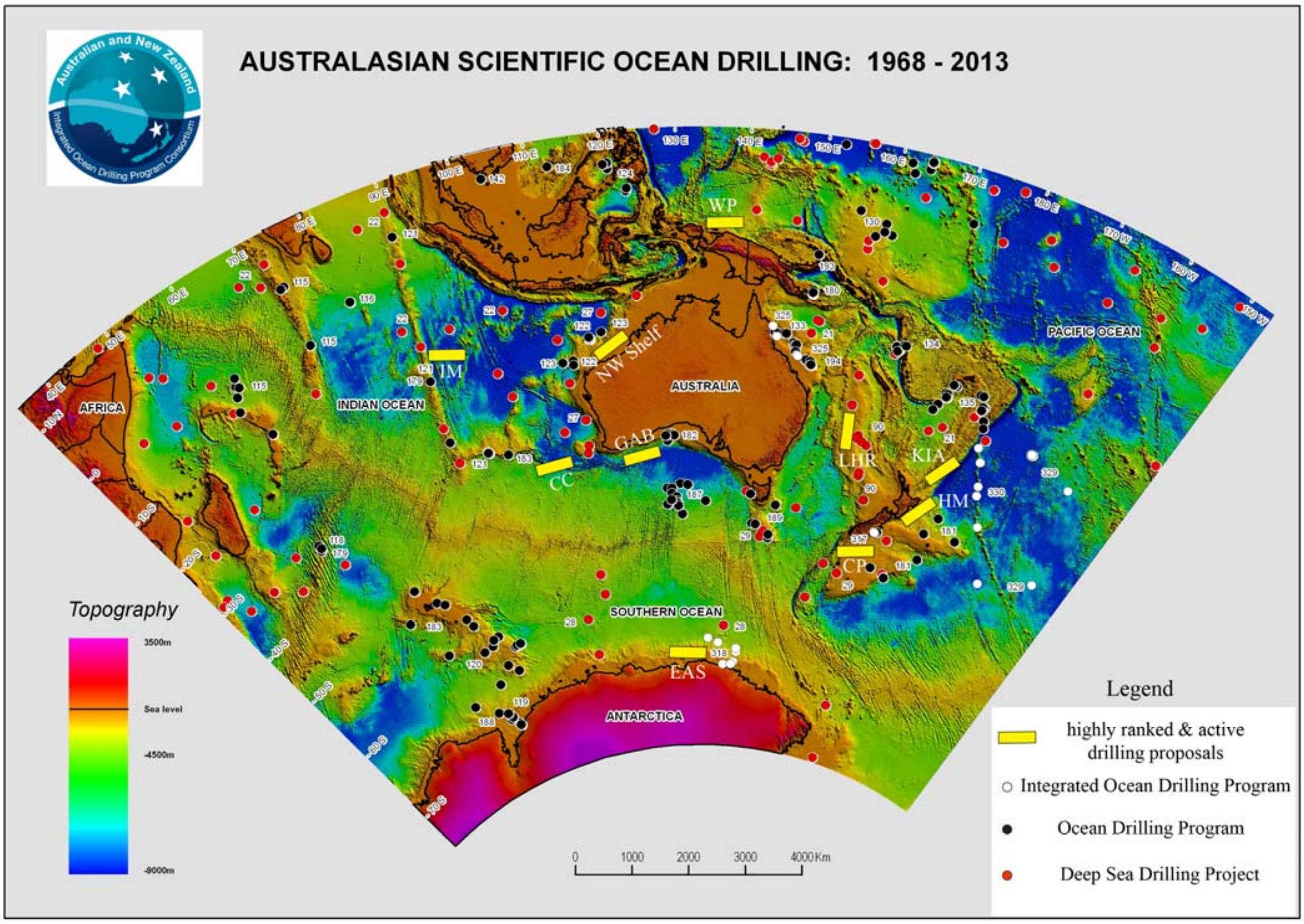



**Fig 2. Australasian site locations accomplished and proposed by ocean drilling programs.**

Five extremely successful Integrated Ocean Drilling Program expeditions have been conducted in Australasian waters in the past few years: Canterbury Basin (Expedition *317*); Wilkes Land (*318*); Great Barrier Reef (*325*); South Pacific Gyre Subseafloor life (*329*); and Louisville Seamount Trail (*330*). The locations are shown in Figure 2. Highly ranked and active drilling proposals currently being considered and due for submission to the science advisory structure of the Integrated Ocean Drilling Program are also highlighted in yellow; these are likely to be targets for the IODP from 2014 onwards. They include the NW Shelf, Great Australian Bight (GAB), Lord Howe Rise (LHR), and Cretaceous Climate (CC) of Australia, the East Antarctic continental shelf (EAS), New Zealand's Hikurangi Margin (HM), Campbell Plateau (CP), and mineralized hydrothermal systems of the Kermadec island arc (KIA), the Pacific Warm Pool (WP), and Indian Monsoon (IM). **If fulfilled, scientific drilling in waters of direct, unequivocal Australian interest would be worth in excess of $A40 million over the next 5 years.**

In early 2013, we commissioned an independent cost-benefit analysis of Australian membership of the Integrated Ocean Drilling Program by the Allen Consulting Group, available at http://www.allenconsult.com.au/clients/1361491526ACG_Review_of_IODP_Final_report.pdf ; a prime conclusion is **"Benefits to Australia of direct membership of the IODP consortium far exceed the modest costs of participation."** In 2012, the annual fractional membership fee we paid to belong to the Program was $US1.4million. For this and other allowable infrastructure costs, the ARC provided $A1.55million. University and institutional members contributed an additional $A0.63million constituting a 0.71:0.29 ARC:university + institutions cost split. In-kind contributions to our engagement with the guidance and management of the Integrated Ocean Drilling Program include time spent by university and government agency employees serving on the ANZIC Science Committee and Governing Council; additional in-kind contributions stem from service on the current Program's science advisory structure (e.g., Proposal Evaluation Panel). The Allen Group Report estimates that over the past five years, the total indirect researcher costs borne by these host universities and agencies is ~$3million. Research supported by the ARC through Discovery Projects and senior academic fellowships, for study of ocean drilling program results and samples, have comprised $6.7 million over the past 5 years.

Future membership of the IODP (at levels and costs similar to those borne over the past 5 years) would return major scientific and economic benefits to Australia. Our preferred target for the level of fractional membership of the combined USA-ECORD platform providers, recognising primarily the level of funding required, and the anticipated size of the marine science community that will become engaged with the Program, has been set at 0.5, requiring an annual payment of $US1.5 million. This would entitle us to:
a. one scientific berth per *JOIDES Resolution* and MSP expedition, equating to 5 to 7 berths (10 to 14 months ship time) per year, dependent on other partner funding;
b. full membership of the *JOIDES Resolution* Facility Board, which will determine the vessel's schedule;
c. full membership of the MSP Facility Board, which will determine MSP scheduling; and
d. participation in IODP Forum and all Science Assessment Panels and Committees.

For participation in the Japanese platform, an annual membership fee of ¥25 million (~$A300k) is requested. This would entitle us to one scientific berth per *Chikyu* expedition (expected to equate to 4 months ship time per year) and anticipated leverage in planning.

We intend to retain the current consortium arrangement with New Zealand. Combined Australian and New Zealand funding will provide more flexibility in expedition participation and may increase ANZIC's range of roles and responsibilities within the new IODP management and science planning structures. Our New Zealand partners are currently seeking research sector and government commitment to the next phase of IODP, and aim to raise sufficient funds to be entitled to at least one New Zealand IODP expedition participant per year (~$US300k per year). Under the current dual funding model (USA-ECORD and Japan), New Zealand will only be able to participate in IODP if it is in consortium, with Australia as the larger contributor. We expect that demand from Australian researchers to use the IODP infrastructure, equipment, and facilities will steadily increase beyond the levels that have successfully developed over the past 5 years because of the likely implementation of ANZIC research proposals as expeditions.

iv. Planned use of the proposed infrastructure, equipment or facilities and the alignment of this planned use with other similar existing facilities within Australia and/or internationally

All three platform providers have accepted the new Science Plan as the guiding document for the next decade's direction of scientific ocean drilling. Similarly, these providers have agreed to use the current form of scientific advisory structure to accept proposals for drilling, obtain peer reviews, rank projects, and decide on the sequence of targets for drilling. **Australian scientists have had a remarkably high, positive participation level and degree of influence on the advisory structure of the Integrated Ocean Drilling Program relative to the scale of our membership contributions**. **Future panel participation will depend in part on our membership level, and the Program-wide recognition of the abilities of the scientists involved. It is important to note that drilling legs are driven by scientific merit, and by this criterion, compared with other countries, Australian-based proposals have a disproportionately higher success rate.**

**Two thirds of the current proposals for drilling expeditions identify targets in the Pacific, Indian, and Southern oceans**. **The majority of the targets to be tackled in the first few years of the IODP will be drawn from this pool,** and proposal pressure will continue to drive the location of the drilling platforms. For 5% of these proposals, the lead proponent is from ANZIC. The distribution by theme of the current ANZIC proposals is: 49% Climate and Ocean Change; 15% Biosphere Frontiers; 17% Earth Connections; 19% Earth in Motion. The proposed locations of drilling legs within Australian waters that are currently within the science advisory structure or shortly to be submitted are shown in yellow in Figure 2.

**Participation in the IODP will provide Australian researchers with access to unique samples, addressing scientific problems of global significance that cannot be otherwise sourced**. In part, these samples will be analysed within Australia, utilizing the existing world-class facilities and geoscience expertise within Australia's universities and scientific agencies. **These international drilling and infrastructure facilities also add to the benefits of Australian-owned and operated infrastructure, such as the new research vessel R/V *Investigator*.**

v. National benefit of the proposed research infrastructure, equipment and facilities to the research community

**The IODP will operate state-of-the-art drilling platforms that can only be accessed by the Australian scientific community through IODP membership. We assert that the scientific and economic return to the nation far exceeds the cost of the membership**, as elaborated below in terms of scientific impacts. The IODP infrastructure to be accessed by Australia's membership is coincident with the following goals in the "Environmentally Sustainable Australia" priority of the nation's **"National Research Priorities":** 6. Developing deep Earth resources – smart high-technology exploration methodologies, including imaging and mapping the deep Earth and ocean floors, and novel, efficient ways of commodity extraction and processing (e.g., minerals, oil, and gas) while minimising negative ecological and social impacts; 7. Responding to climate change and variability – increasing our understanding of the impact of climate change and variability at the regional level across Australia and addressing the consequences of these factors on the environment and on communities.

There is burgeoning international and commercial interest (moderated by the International Seabed Authority) in the growing probability of exploitation of polymetallic and hydrothermal sulfide deposits, and energy resources, on and beneath the ocean floors. The Western Pacific and Indian Oceans are particular areas of interest. **In order to access resources safely and responsibly, much more must be understood about the geology, hydrology, and biology of these deposits.** If we are to gain this knowledge, then seafloor drilling is essential and **Australia is geographically and scientifically well-positioned, to use the infrastructure assets of the IODP, to engage in research on these resources and their genesis.**

**c. Nature of the alliance and commitment between the organisations named on the Proposal30%**

i. Relevance of the research to the strategic priorities of the organisations

**Membership of the Integrated Ocean Drilling Program is enabled by a pan-Australian scientific consortium that currently involves 14 Australian universities and 4 government agencies as ANZIC members with ARC LIEF support**. Within the university sector, several institutions have flagship geoscience research and teaching elements with component marine science schools, centres and departments. These include the Institute for Marine and Antarctic Science at the University of Tasmania, the Earth and Marine science education program at the Research School of Earth Sciences, ANU, and the Bachelor of Marine Science at Macquarie University. For others, the involvement of the majority of Australian universities in our current membership of the Integrated Ocean Drilling Program has revealed latent and successful research commitments to study materials recovered by the Program. For example, **through open competition, staff at the Queensland University of Technology have been prominent in obtaining shipboard research positions, and have then been committed to prosecuting research on recovered materials and data**. **For non-university institutional members, research in areas targeted by the scientific drilling programs is explicitly part of the organisations' strategic priorities.** Examples include the "Wealth from Oceans Flagship" and "Energy Flagship" of the CSIRO, and the "Coastal, Marine, and Climate Change Group" of Geoscience Australia (GA).

ii. Evidence that each of the organisations is genuinely committed to, and prepared to collaborate in the Project

**For the past five years, all 22 contributing organisations have unequivocally demonstrated a steadily growing commitment and successful collaborative engagement with the aims of the Integrated Ocean Drilling Program through ANZIC.** The truly pan-Australian involvement of the university sector accompanied by the major government science agencies (16 in total) involved with marine science and geoscience (renewable annually) is testimony to the level of commitment that has been achieved. **Examples of the most recent annual reports of ANZIC documenting these commitments and collaborations are available on the internet (e.g., http://iodp.org.au/publications/anzic-annual-reports/).**

The simplest measure of commitment is the "earnest money" required for institutional membership. And yet, for host institutions **the endorsement of staff time** (required in service of scientific assessment of Australian-based science and managerial committees, and the high-level, global science planning and managerial committees of the Program) **is more significant in terms of real costs.** Examples include the dedication of CI Arculus' time to join the internationally selected group of 14 scientists who wrote the new Science Plan, and his ongoing service as Chair of the "Earth Connections" group of the Proposal Evaluation Panel. A similar level of in-kind financial support for the aims of the current LIEF grant has been the CSIRO's endorsement of CI Yeats as a member of the "International Working Group Plus" of the IODP. The purpose of this Group was to frame a new multinational program architecture that promotes delivery of the best possible, most exciting and relevant science to the broad science community and the public through scientific ocean drilling. **These very high levels of organisational commitment and collaboration displayed in the past (and now represented in this current proposal) will continue to grow in the next five years.**

### iii. Existing or planned strategic research alliances between the higher education organisation(s) and other organisation(s)

**Australian membership of these sequential scientific ocean drilling programs has been a prime stimulus for research alliances between the university sector and government research agencies**. For example, the funding support for membership of the Ocean Drilling Program from 1985 through 2003 was derived mainly from the ARC and GA, with collective contributions from the universities. There was movement of personnel between GA and the universities in terms of staff appointments. The bulk of the essential site survey data for eventual drilling was generated by the GA's strategic marine mandate. However, scientific staffing of the expeditions was spread broadly across GA and the universities. In terms of university-government organisation mobility, examples are Professor Neville Exon, (current Program Scientist of ANZIC located at the ANU) and Professor Mike Coffin (current ANZIC Science Committee member and Chair of the Steering Committee for the *Chikyu* +10 Decadal Planning Workshop), both former employees of GA and Co-Chief scientists on ocean drilling legs.

During ANZIC membership of the Integrated Ocean Drilling Program, joint CSIRO-university engagement in planning future drilling legs has occurred through the Indian Ocean, SW Pacific, and most recently "Arc Hydrothermal" Planning Workshops. While not formalised, **it is implicitly understood that both university and government agency staff will collaboratively participate in future scientific drilling expeditions**. Similar synergies have characterised of a number of voyages of the Marine National Facility over the past few years.

### iv. Effectiveness of cooperative arrangements for the management and sharing of the proposed infrastructure equipment and facilities

We propose to establish a management structure for Australian involvement with the IODP, (requiring financial accountability and reporting, interactions with the platform operators, government facilities, planning committees, local planning and staffing of drilling legs) which reproduces the current model; it has functioned successfully for the Integrated Ocean Drilling Program. Presently, a Program Scientist (0.7 FTE) and an Administrator (0.4 FTE) staff the ANZIC office.

Management of Australian involvement with IODP (and hence the sharing of infrastructure, equipment and facilities) is currently structured around the ANZIC Governing Council and a Science Committee. The Council is a steering committee responsible for broad policy, providing scientific and financial oversight of the ANZIC Office and Science Committee, in conjunction with the ANU Delegate (Director, Research School of Earth Sciences) responsible for overseeing ANU's financial obligations to the ARC. Members of the Council are drawn from the ARC, government research organisations, major contributing universities, and rotators among the lesser contributors. The Science Committee encourages and assists with the development of science proposals, organises topical workshops, assesses the merits of drilling leg applicants and IODP panel memberships, and invites high-quality international speakers to visit Australian institutions thereby advertising the Program's scientific aims and achievements. It also allocates post-expedition science funding using member funds.

## d. Investigator(s) 20%

i. Research opportunity and performance evidence (ROPE);

Applications to participate in drilling expeditions are open to any scientist of an organisation contributing to the LIEF grant. It is a matter of record that **exceptional opportunities for young scientists** (especially those from outside the "Group of 8" universities) have been created to garner their participation in an internationally competitive, state-of-the-art research program. **Through these opportunities, ANZIC has helped create the next generation of globally networked Australian marine science leaders.** We anticipate that such research opportunities will continue to be generated with the type of management structure planned for Australian involvement in IODP.

The Table below summarises bibliometric data obtained from Jamus Collier, Data and Publications Manager at Management International of the Integrated Ocean Drilling Program, for publications generated by Australian scientists engaged with scientific ocean drilling programs from 1989 onwards. These data show the number of publications and their percentage of the global total produced by Australian scientists. The output is outstanding, especially when compared with the relatively small contributions by Australia to the running costs of the respective programs.

| **Date of Publication** | ***Nature, Science, Nature Geoscience*** ***Australia/world*** | **Other major geoscience journals*** ***Australia/world*** | **All Peer-Reviewed Publications** ***Australia/world*** |
|---|---|---|---|
| 1989-1995 | 8 / 63<br>*12.6%* | 10 / 415<br>*2.4%* | **1099/5918**<br>*18.5%* |
| 1996-2002 | 5 / 75<br>*6.7%* | 22 / 568<br>*3.9%* | **963/5906**<br>*16.3%* |
| 2003-2012** | **7** / *117*<br>*5.9%* | **75** / *840*<br>*8.9%* | **632/7135**<br>***8.9%*** |

**Geology, Journal of Geophysical Research, Geophysical Research Letters, Earth and Planetary Science Letters, Micropaleontology, Paleoceanography, Palaeogeography, Palaeoclimatology, Palaeoecology.*
** ***world*** figure covers 2003-10 only. Australia joined ODP from 1989 to 2003, and IODP from 2008 to 2013. Membership strongly affects publication with a time lag of some years.

ii. CIs who will manage the purchase, design, manufacture, installation, maintenance and coordination of access to the proposed infrastructure, equipment and facilities, a demonstrated record in these activities

**All the CIs who will have leading management roles in the Australian membership of IODP have a strong and successful record in the respective activities required.** They represent a pan-Australia, multi-university-government organisational alliance. Many are (or have been) Heads of School/Department/Centre in their respective organisations, and many have been directly and prominently involved at national and international levels with antecedent ocean drilling programs. CI Arculus was a shipboard (ODP Leg 125: the Izu-Bonin-Mariana Forearc) and shore-based (Leg 145: NW Pacific) scientist, and has been selected as Co-Chief Scientist for IODP Expedition 351, targeting the inception of the Izu-Bonin island arc, scheduled for drilling by the D/V *JOIDES Resolution* in 2014. Professor Exon led two research proposals drilled on ODP expeditions, serving as Co-Chief Scientist on one.

CI Arculus has been the lead proponent of the LIEF grant (2008-2013) for Australian membership of the Integrated Ocean Drilling Program. He has served *ex officio* in this capacity on the Australian Council of ANZIC since 2007. Previously he was the Director of the Australian ODP Secretariat at the University of New England (1991-1994), a member of the National Scientific Committee, and long-term member of the Council. He was one of 14 internationally selected individuals charged with writing the new IODP Science Plan for 2013-2023. He is currently a member and Deputy Chair of the top-level Proposal Evaluation Panel of the Integrated Ocean Drilling Program. He has been invited to serve as Co-Chief Scientist of IODP Expedition 351 (June-July 2014), to explore the subduction inception of the Izu-Bonin-

Mariana Island Arc. He was a Head of Department for 13 years, Director of Research at the UNE, and interim Dean of Science at the ANU. Arculus is Professor of Geology in the ANU Research School of Earth Sciences. ANU Geosciences has been rated as the top university program in Australia and in the top ten of its class in the world. Professor Exon led Geoscience Australia's deepwater research program for many years, participated in or led 45 research voyages, mostly in the Australasian region, was a member (and Chair) of the National Scientific Committee and Governing Council of the Australian ODP, and has been Program Scientist for ANZIC for the past 5 years. He instigated the recent Indian Ocean and SW Pacific Ocean Integrated Ocean Drilling Program workshops.

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