

The logo for the International Continental Scientific Drilling Program (ICDP) features the lowercase letters 'icdp' in a black sans-serif font, followed by a vertical red bar and a white vertical line.

INTERNATIONAL  
CONTINENTAL SCIENTIFIC  
DRILLING PROGRAM

# ROADMAP FOR OPERATIONAL SUPPORT IN THE INTERNATIONAL CONTINENTAL SCIENTIFIC DRILLING PROGRAM

PLAN FOR 2017–2022

Roadmap of the ICDP 2016 Symposium  
**Supporting Continental Scientific Drilling:  
Perspectives from within and without**



## EXECUTIVE SUMMARY

### The different perspectives

The Operational Support Group (OSG) of the ICDP organized the symposium “Supporting Continental Scientific Drilling: Perspectives from within and without” in October 2016. The meeting was dedicated to celebrate the 20 years existence of ICDP and to plan the future of operational support within the program. This symposium summarized perceptions of panel members, proponents, and the agencies that fund the program.

This roadmap highlights the results of the meeting and provides routes to secure the future role of operational support in ICDP.

### Key recommendations

The main result of the symposium are four key recommendations: i) focus in education and outreach by addressing stakeholders at large; ii) set up additional standard blueprints for managing drilling projects; iii) invest in personnel and software to ensure data logging and data access; iv) acquire new instrumentation to ensure best

possible on site science. Implementing these measures will require augmented financial support by ICDP but such investment will lead to improved scientific output, better quality and availability of data gained and higher safety in ICDP.



Figure 1: Sample box showing sample number and IGSN

PROLOGUE.....	2
PERSPECTIVES IN ICDP FUNDING.....	6
OPERATIONAL SUPPORT GROUP – STATUS QUO.....	8
ICDP EQUIPMENT POOL.....	11
OPERATIONAL SUPPORT GROUP – PLANNING FOR WHAT LIES AHEAD.....	13
OPERATIONAL SUPPORT PLAN 2017 to 2022.....	15
WORKING GROUP I: EDUCATION & OUTREACH.....	16
WORKING GROUP II: PROJECT MANAGEMENT & ENGINEERING.....	19
WORKING GROUP III: MEASUREMENTS & INSTRUMENTS.....	22
WORKING GROUP IV: DATA – CURATION – PUBLICATION.....	30
OUTLOOK.....	36
ABBREVIATIONS.....	37



## PROLOGUE

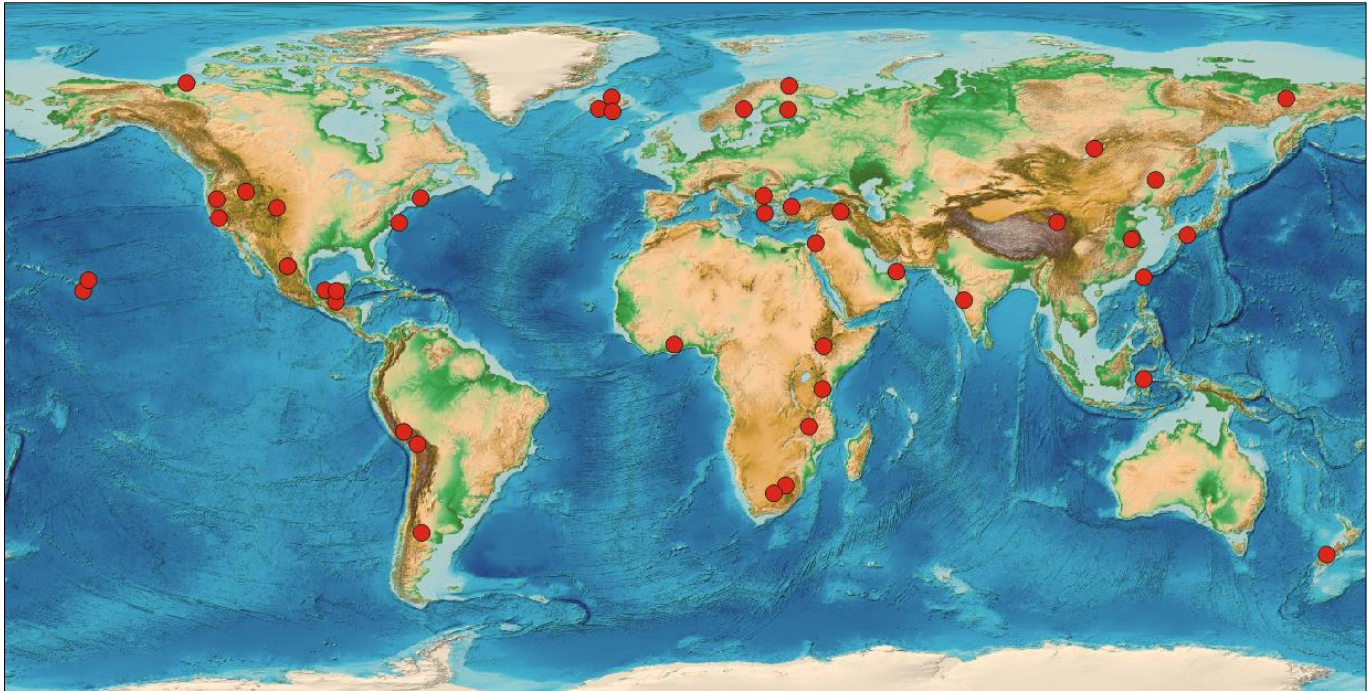


Figure 2: Drilling locations worldwide

### Introduction

The Federal Republic of Germany, the United States of America and the People's Republic of China founded the International Continental Scientific Drilling Program, ICDP in 1996. Since then the program has grown to 22 member countries. Over the same period there has been an ever-increasing number of scientists from around the world

joining the ICDP community by writing 362 proposals, participating in 80 ICDP workshops, and being members of science teams in 45 ICDP projects. All in all, ICDP has enabled the coring of about 72 km of hitherto unexplored Earth.

Our vision is to develop the full potential of continental scientific drilling, enabling excellent science to address socio-economic challenges.



Figure 3: Drill bits at the Alpine Fault drill site, New Zealand

### The strategy

The approach is to provide a strong science plan for scientists and funding agencies alike on one hand but to expand the number and scope of continental drilling projects on the other. One important step is to increase the annual budget by building membership portfolios with individual country members and business affiliates to point out specific benefits. ICDP will be professionalized by introducing a devoted management system and by linking the program with other organisations where it makes sense to do so.

The first strategic issue has been completed. The current [Science Plan for 2014 to 2019](#) has laid out some of the big questions confronting the Earth sciences and suggested ways to address them using scientific drilling. The dovetailing of understanding natural processes with addressing socio-economic needs has taken centre stage. All the remaining points are being addressed, with progress reported in the Executive Committee (EC) and Assembly of Governors (AOG) meetings.

To enable the Operational Support Group to meet the needs of the organization accordingly is our focus.

## The symposium

To celebrate the 20th anniversary of ICDP's founding and to address the third strategy item in the list, a Symposium "Supporting Continental Scientific Drilling, Perspectives from within and without" was held October 20-21, 2016 at the GFZ - German Research Centre for Geosciences in Potsdam. Specifically, the symposium was focused on the operational aspects of ICDP's main business.

## Community-driven needs

In light of an increasing number of proposals and projects an open key question concerns how requests for

support can be addressed satisfactorily.

On the one hand proposal pressure calls for budget growth but on the other hand services of the OSG must be adapted to maintain and expand its logistical, advisory and technical support to Principal Investigators (PIs). Therefore, the 2016 symposium was designed to focus on community-driven needs for operational support. The outcomes of the symposium presentations and discussions are summarized in this roadmap brochure. They have also been condensed into a proposal for operational support funding to the ICDP panels, laying out personnel and instrumentation requirements for the next couple of years.

<b>SUPPORTING CONTINENTAL SCIENTIFIC DRILLING</b>	
<b>- Perspectives from within and without -</b>	
<b>October 20, 2016</b>	
11:00	Welcome; M. Scheck-Wenderoth, Department Director, GFZ
11:15	The Future of Geosciences; J. Ludden, BGS, UK & A. Rudloff, GFZ
11:45	Transdisciplinary Work in Life and Earth Sciences; T. Wilke, Giessen, Germany
12:30	ICDP - Where we are on the Roadmap; B. Horsfield, ICDP Executive Chair
14:00	Funding for Scientific Drilling; G. Lüniger, DFG, Germany, J. Whitcomb, NSF, USA
15:00	Scientific Drilling in India; H. Gupta, CSIR, India
15:30	Scientific Drilling Platform Switzerland; F. Anselmetti, Bern, Switzerland
16:00	ICDP Operational Support Group; S. Hickman, USGS, Menlo Park, PI SAFOD project
16:30	ICDP Proposal and Funding Development; L. Soreghan, SAG Chair, U. Harms, OSG Head
17:00	Mission, Status and Challenges for the OSG; U. Harms, OSG Head
17:30	Discussion and Summary
19:00	Reception: 20 years of ICDP
<b>October 21, 2016</b>	
09:00	Parallel Sessions – Operational Support Group
	I. Outreach & Education; T. Wiersberg
	II. Project Management & Engineering; B. Prevedel, A. Liebscher
	III. Data – Curation – Publication; R. Conze, T. Gorgas
	IV. Measurements; J. Kück, S. Pierdominici
12:30	Plenary Session - Report of Working Group I - IV
14:00	Consolidation: OSG, the Way Ahead; B. Horsfield, Executive Chair
14:30	Summary of Recommendations and Conclusion; U. Harms, OSG Head

Figure 4: Meeting agenda of the 2016 symposium



### **The invitees**

Ninety scientists, who were mainly PIs, and members of all ICDP panels attended the symposium. Coming three years after the release of [ICDP's Science Plan](#) in 2014, it was a fitting opportunity to analyse where ICDP stands in terms of funding, operational support, and the role played by OSG at grass roots level for attracting newcomers to the program.

### **The agenda**

The symposium began with a pragmatic look into the future of geosciences and, after considering ICDP's current status, the strategies that ICDP might follow in implementing an interdisciplinary portfolio (see Figure 4). In the second session, the principles of funding for ICDP were highlighted and critically discussed. Program managers of the National Science Foundation (NSF) and the German Research Foundation (DFG) outlined perspectives for funding of continental scientific drilling and scientists from India and Switzerland explained their respective funding philosophies as example.

The final afternoon session served to explain the work, status and possible future of the ICDP OSG, and served to prepare participants for succeeding discussions. During the second day four parallel sessions discussed the specific undertaking of OSG's major tasks:

- Outreach & Education
- Project Management & Engineering
- Measurements & Instruments
- Data – Curation – Publication

The needs were then reported in an open plenary forum.

## PERSPECTIVES IN ICDP FUNDING



Figure 5: Commingled funding principle

ICDPs funding is based on contributions from the member countries. In most countries national funding agencies, science academies, or ministries of sciences provide funding to ICDP based on a long-term Memorandum of Understanding. The models by which a country contributes and how the national community partakes vary strongly from national support offices (e.g. USA), special funding programs (e.g. Germany) to coordination offices (e.g. Japan, Switzerland, Sweden). The essential

element of success in most member countries are convincing proposals and support from the community on a national level, either via single, big, high-profile proposals or pressure through a number of smaller proposals. The prospects for the future support of the ICDP by the members are very promising because the number of important proposals is increasing.

Our two key objectives, namely cooperation and cost sharing work extremely well.

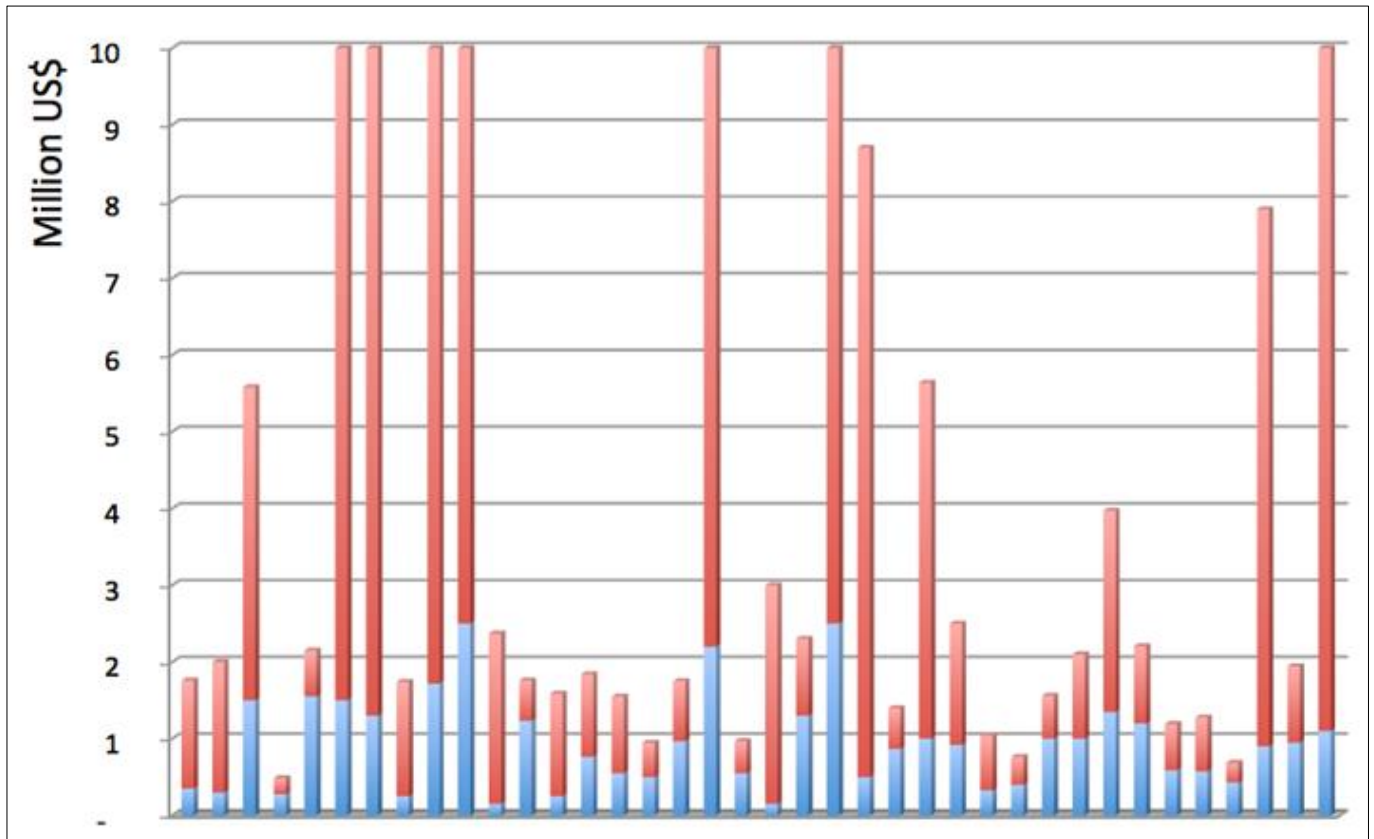


Figure 6: ICDP funding share (blue) vs. third party funding (red) for various ICDP projects; note cut-off at 10 Mio US\$

The leverage funding in ICDP projects continues to be stable at about 80%. In other words, the projects are conducted with 20% ICDP co-sponsorship of the operational costs. This success attracts new projects and enhances funding perspectives.

Our contributions of 35 Mio \$ have been matched by almost 160 Mio \$ from other sources over a period of 20 years.

## OPERATIONAL SUPPORT GROUP – STATUS QUO



Figure 7: Operational Support Group

### The OSG

Not every project team can be expected to develop the skills to plan, conduct, and document a drilling mission on its own, starting from scratch. The PIs can rely on OSG to fill such gaps. The OSG was formed as a key element of the program to guarantee most success with each project in addition to the financial support of drilling operations. It offers continuity in operational support over the long term. The GFZ German Research Centre for Geosciences continues to fund a major

portion of the scientists, engineers and technicians who compose the core of the OSG. The group is based in Potsdam, and is a separate organisational entity within Section 6.4 „Centre for Scientific Drilling“ of the GFZ. While the costs of salaries and workspace are provided by the GFZ, any additional costs for services are charged on a project-basis.

OSG is the key element that sets ICDP aside from other drilling organizations.

### Functions of OSG

The group has the following support functions:

- Provides technical liaison to EC and to the Science Advisory Group (SAG)
- Establishes cooperation with partner organizations (IODP, DCO)
- Utilizes web resources and social media to inform the science community, stakeholders and the interested public
- Acts as logistical interface between GFZ's Finance Department and AOG to facilitate financial planning
- Supports PIs in planning, design, management and execution of drilling projects
- Provides support for scientific and engineering drill-site operations
- Prepares funding agreements as Joint Research Ventures (JRV) for each project authorized by the EC
- Provides drilling equipment, downhole measurements and field laboratory facilities
- Supports ICDP Workshops
- Provides support for field facilities for core and sample description and management
- Provides training courses on scientific drilling as "training on the job" or in preparation of future ICDP drilling projects
- Provides all data obtained during each project through a data management system for ICDP projects, the Drilling Information System (DIS)
- Through the DIS Initial Reports are produced that describe drilling aspects of the operations and all sample or core material data
- Develops, purchases, and maintains the ICDP Equipment Pool comprising scientific-technical instruments and tools for on-site use during projects

### The ICDP Primer

A detailed description of services offered by the OSG, plus tools and instruments of the ICDP Equipment Pool is available on the [web](#). Furthermore, the OSG has summarized its expertise on preparing and conducting a scientific drilling project in the so-called [ICDP Primer](#). This regularly updated best practice document has become a well received and widely

used “recipe collection” in scientific drilling.

The Primer is available for download on the [web](#) and a digital object identifier has been assigned to this paper to assure easy long-term access.

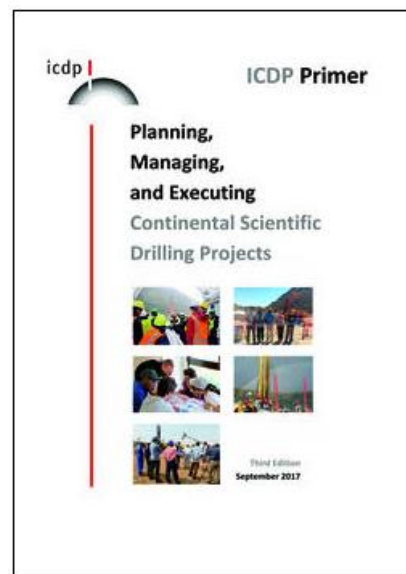


Figure 8: ICDP Primer

## ICDP EQUIPMENT POOL



Figure 9: Downhole logging campaign at the DeepChalla project in Kenya, 2016

The ICDP Equipment Pool was established when the program was founded 20 years ago. The basic idea was that tools and instruments required at a drill site should be moved from one project to the next assuring optimal usage of ICDP funded equipment. Core scanning and logging instruments, tools, and downhole logging equipment were acquired accordingly and deployed initially for a given project. After the field work, devices often are permanently integrated into the equipment pool. There are two ways of funding new equipment: (1) Project PIs include tools they intend to purchase in their application to ICDP

already, or (2) the OSG bundles requests from the grant proposals of smaller projects submitted to the ICDP. In addition, inherited instruments from both the KTB project in Germany and the GFZ populate the pool. An updated list of tools with details is available [online](#). Since 1999 ICDP has invested more than 4.5 Million US Dollars in equipment. Most of the funding was spent on drilling tools, purchased for specific ICDP projects such as the Deep Lake Drilling System, DLDS and its predecessor the GLAD 800, a dynamic positioning system and a 5 km wireline drill string. A second focus was put on downhole instruments and related equipment such as the recently acquired wireline hydrofracking system that is used for the Koyna drilling project in India.

Several geophysical sondes have been purchased over the years as well and have been deployed in many ICDP projects. A third group of tools obtained by ICDP comprise field lab instruments such as core scanners and core logging tools that are essential for a short time on site and are used sequentially in several projects. OSG's Drilling Information System (DIS) software can also be considered part of the equipment pool. The development, application and data input of the DIS has been funded through ICDP and the GFZ with major investments in OSG staff over the years.

Equally important as the tools and instruments are the services that we provide in order to keep our equipment operational.



## OPERATIONAL SUPPORT GROUP – PLANNING FOR WHAT LIES AHEAD

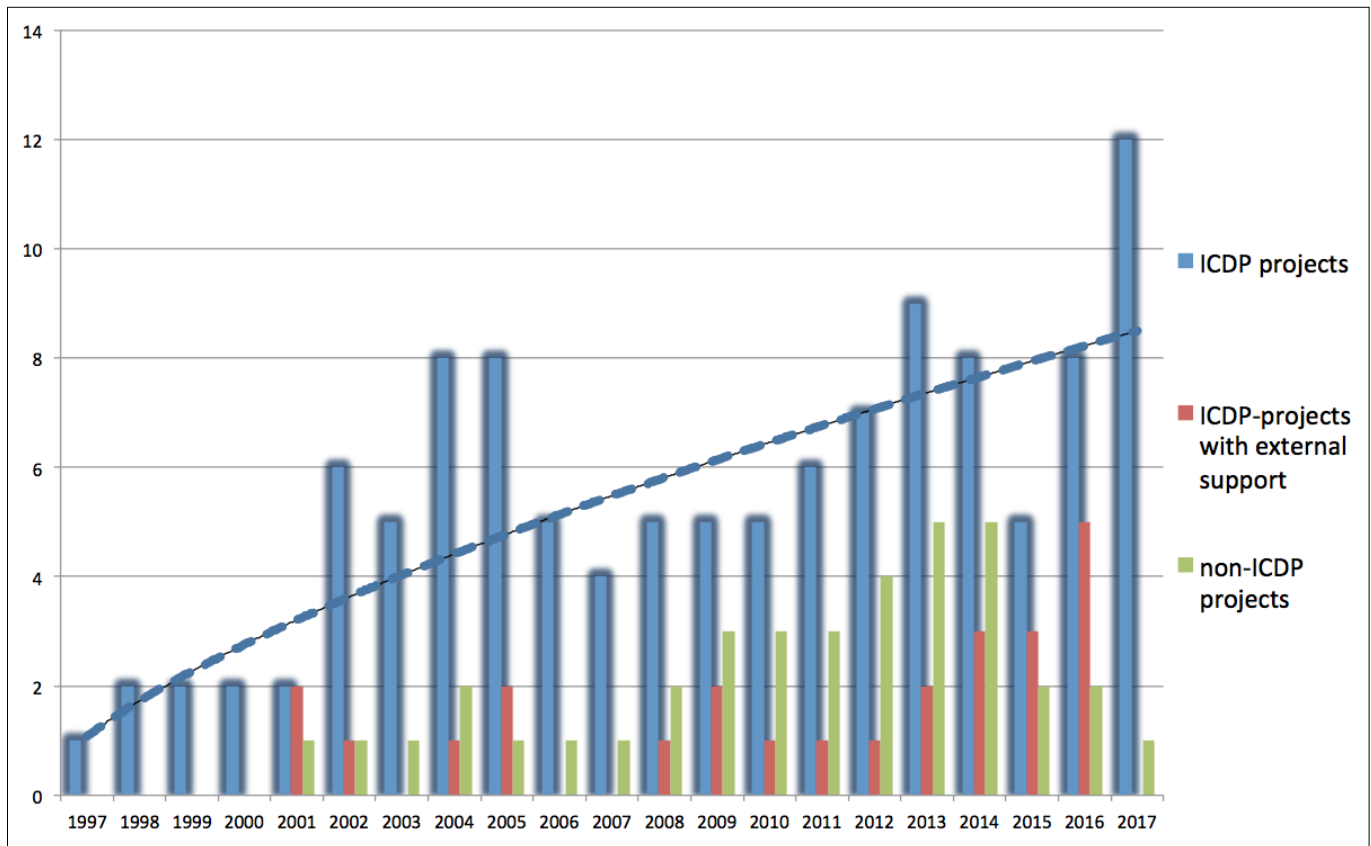


Figure 10: Distribution of annual utilization of the ICDP Drilling Information System (DIS)

Projecting future needs for materials and services in coming years will depend mainly on two aspects:

How many grant proposals of what kind can be expected in the future?

How do the community, the panel members, and the funding agencies set priorities for OSG services and tools?

The issues are easy to answer as the 2016 fall symposium of ICDP focused on exactly these questions and the discussion details are summarized in the four session reports in the following chapter. The issue of proposal development can be projected into the future based on the experience over past years.

In 2017 we were dealing with more than 10 projects in parallel.

The table in Figure 10 shows that 2017 was the first year OSG had to deal with more than 10 projects in parallel. Looking at the number of full proposals submitted to ICDP since 1999 allows a projection into the future. Over the past years, about eight full drilling proposals have been submitted each year and usually three to four of those proposals have been approved by ICDP. Overall, the panel representatives of the national funding agencies confirmed their interest in scientific drilling and their continued support as long as excellent proposals are submitted to ICDP and other funders.

During the ICDP symposium in Potsdam it was discussed whether the governing panels of ICDP should determine to support as many projects as possible with the consequence of reducing the quality of support; or to focus on providing the highest possible quality of support, yet for a limited number of projects. This question can only be answered in the light of the proposals submitted annually to ICDP.

Due to increasing proposal pressure our leading funding agencies NSF and DFG have meanwhile increased their annual contributions to 1 Mio \$ each.



Figure 11: Proposal success rate listed throughout the years (green-accepted; red-rejected; higher level = resubmissions)

## **OPERATIONAL SUPPORT PLAN 2017 to 2022**

**Working Group I: Education & Outreach**

**Working Group II: Project Management & Engineering**

**Working Group III: Measurements & Instruments**

**Working Group IV: Data – Curation – Publication**

## WORKING GROUP I: EDUCATION &amp; OUTREACH



Figure 12: ICDP training course at the KTB in 2017

Outreach is important for the successful execution of a scientific drilling project and must be prioritized and addressed from the beginning on. A lack of outreach may lead to the loss of public acceptance and can in the worst case even wreck a project.

Moreover, scientific drilling projects are to a large degree, if not fully, financed by public science funding agencies, which in turn are funded through tax money. Underlying the societal relevance and benefits of scientific drilling activities

by public outreach is therefore of great importance. Thus, ICDP and each of its projects need mission statements and have to convey goals, methods and benefits of the program and its ventures through messages to the stakeholders and to the public.

## Public outreach

A common tool nowadays used to reach the public is social media. Since 2013, ICDP is on [Twitter](#) and YouTube and, as one first result of the discussion during the symposium, also on [Facebook](#). However, the use of social media can be time-consuming and needs continuous upkeep by young enthusiasts in order to reach specific communities such as students or the general public. It is also necessary to analyse target groups of ICDP outreach and design appropriate outreach tools and channels for the program on the international level and ICDP-funded projects. Therefore, the discussion group suggests implementing a designated social media position preferably for a young social media expert.

The 24-pages brochure "[The Thrill to Drill](#)" published by ICDP is designed to inform the general public about the background, the need and the societal benefits of continental scientific drilling. The title is short and concise and may attract people

from the science community, but might be somewhat misleading and could have a deterrent effect on the general public. Since the second edition of "The Thrill to Drill" published in 2012 is outdated a new image brochure shall be published in 2017. As for the previous edition, a professional writer shall be engaged but the title should either be renewed or some subheading shall be added.

A travelling exhibition for museums would improve the ICDP visibility and branding. Exhibit objects could be provided by OSG and ICDP projects but the exhibition concept and realization would be subject of a commercial experienced company and will cost approximately 200,000 US Dollar or more.

Another option to increase the ICDP visibility could be organizing a local TED event with experienced ICDP scientists. TED delivers a communication platform for spreading word about a topic around the world. A local TED event can be organized by anyone who obtains a free license from TED, agreeing to follow certain principles. TED events are non-profit and speakers are not paid, but would require ICDP sponsorship to cover costs.



Figure 13: Film team at Koyna, India

Suitable outreach measures should never be underestimated and contribute to public acceptance.

## Public outreach by ICDP projects

ICDP projects engage in public relations to different degrees. Outreach guidance should be provided by the OSG. The PIs should be trained prior to drilling on how to use media and how to communicate with media representatives. Future management training courses should include lessons e.g. from media representatives and public relations officers.

There is already a chapter in the [ICDP Primer](#) that shall be extended and updated, including a chapter or guidebook how to communicate with media in case of setbacks and disasters. Press release and the use of Social Media (e.g. Blog, Facebook, Project Website) should become mandatory for future ICDP projects. Concrete outreach plans and the use of social media should be implemented already in the Memorandum of Understanding between ICDP and the project PIs. Local communities, including teachers/ schools shall be contacted and informed way before concrete drilling actions and e.g. invited for town hall meetings at an early project stage.

## Training and science outreach

ICDP training measures include annual courses that cover all relevant aspects of scientific drilling. The training courses take place either on operating ICDP drill sites

with on-site ICDP equipment and service or in core repositories to enable hands-on and practical exercises. For the training courses, experts from the OSG plus invited speakers with a background in the respective training course topic (e.g. soft sediment and lacustrine sediment drilling, fault zone drilling, downhole monitoring and testing....) are invited. The annual ICDP training courses are well received in the community, not least since all costs are covered by ICDP. ICDP could improve the already high quality teaching standards by 1) providing teachers with a guideline on how to prepare and organize a lecture, 2) making practical exercises and active involvement of the students an important part of each presentation, 3) providing preparatory material for the students, prior to the training course. Outreach training elements (e.g. how to use and produce on-site videos, blog posts, press releases, social media etc.) should become part of the training. Video equipment provision and training should become available for all ICDP projects and shall become part of the annual ICDP Training Course and as stand-alone training on demand, e.g. in combination with the DIS training.



Figure 14: Training course participants

## WORKING GROUP II: PROJECT MANAGEMENT & ENGINEERING



Figure 15: Engineering discussion at the Alpine Fault Drilling Project, New Zealand, 2016

Most projects had been relying in the past on the personal project management skills of the leading PIs and the private support he/she was able to lean on. It is ICDP policy to give the projects the freedom to choose their own field support as the PIs see fit and there is no need seen to change this. Although the ICDP “Joint Research Venture” funding contract stipulate reporting requirements for operations, science and finances, some projects failed to fulfil these requirements in the past and

could not be motivated to do so. There is for various reasons a resistance by some projects to provide daily drilling data, as required for inclusion in the DIS. For the reasons outlined, this work group also believes that end-of-well reports should be required of project PIs and submitted to the OSG after finish of drilling operations in a timely manner.

Because of the past inconsistent daily reporting and no requirement for end-of-well reports, new projects were not able to benefit from the lessons learned. The establishment of a learning culture in ICDP is therefore seen of high priority, so that new and developing projects can learn from the technical challenges faced by previous projects and the manner in which those challenges were (or were not) overcome. These reports should be prepared soon after field operations are completed, while memories of problems and issue resolution are still fresh.

ICDP has also no corporate health, safety and environment (HSE) mission statement and no established HSE program, except a recommendation of minimum HSE requirements. In order to protect project personnel and remain viable as a scientific research organization, ICDP should ensure that ICDP-supported projects are brought up to today's acceptable industry safety standards. With the high visibility the ICDP brand has throughout the world, this

working group considers the establishment of a robust HSE culture within ICDP to be of high priority, as significant and recurring safety and environmental incidents associated with ICDP projects could severely damage its image and standing.

### **Actions**

OSG to be present at every project workshop with a checklist to ensure that steps necessary for planning a successful project are taken. The OSG presence is also to answer operational feasibility and cost questions posed by PIs, and to help transfer "lessons learned" from previous projects, as documented through end-of-project reports, to future PIs.

When requested by the PIs or suggested by SAG, OSG will assist PIs in preparation of detailed drilling, completion, downhole measurements and sampling plans. However, selection of service providers should remain the PI's responsibility.

After a project is designed and service providers selected but before drilling begins, a technical review exercise, e.g. Drilling-Well-on-Paper (DWOP) shall be conducted by the PIs together with service providers and science team representatives, and with participation by the OSG (either in person or remotely). PIs should have the freedom to conduct this event in person or use external experts for consultation and exercise moderation.

It is our policy to give projects the freedom to choose their own field support.



A reliable and timely operational reporting of on-site activities during drilling, including daily rig reports through ICDP's DIS, is seen as the basis for a functional and efficient field support. OSG must be given the authority to enforce timely reporting by project PIs, e.g., by withholding transfers of funding.

The development and acquisition of a portable rig data recording system to be installed together with the DIS on drill rigs working for ICDP co-funded projects should be pursued. However, use of this system with ICDP funded projects is considered as an option and not mandatory.

ICDP shall require a final technical report describing drilling, rock/ fluid sampling, wellbore completion, and downhole measurements achievements as well as problems and issue resolution (if appropriate) after the end of field operations. This "lessons learned" report will be filed by the leading PI to OSG within three months of completion of drilling and then published on the ICDP web site for the benefit of other investigators. Future funding shall be contingent upon receiving this report. The reports will be the mechanism for the technical lessons learned to be relayed to the OSG and future PIs. Although preparation for this report is the responsibility of the project PIs, the

report may include additional statements from OSG.

SAG shall review project management plans and science team/ contractor qualifications as well as HSE compliance for every full proposal submission and may request a project manager (drilling supervisor) or an HSE supervisor to be included in the on-site personnel for selected projects.

To ensure uniform standards for on-site health and safety as well as protection of the environment, the OSG should initiate a general ICDP-QHSE System to be implemented mandatorily for all ICDP projects. The preparation of an HSE checklist has already started with the Oman project as a pilot and shall be made available to all future projects.

Results of EC and AOG decisions and recommendations on funding and OSG support of all ICDP proposals shall be published on the ICDP website.

Future EC and AOG meetings shall be held in May instead of June to insure faster turnaround and better synchronicity with Japanese fiscal year planning and funding cycles.

This road map is based on the assumption that this work is to be conducted with the current OSG staff at no extra cost to ICDP. Acceleration of this implementation plan would require extra manpower.

We want new projects to benefit from lessons learned in previous projects.

## WORKING GROUP III: MEASUREMENTS &amp; INSTRUMENTS

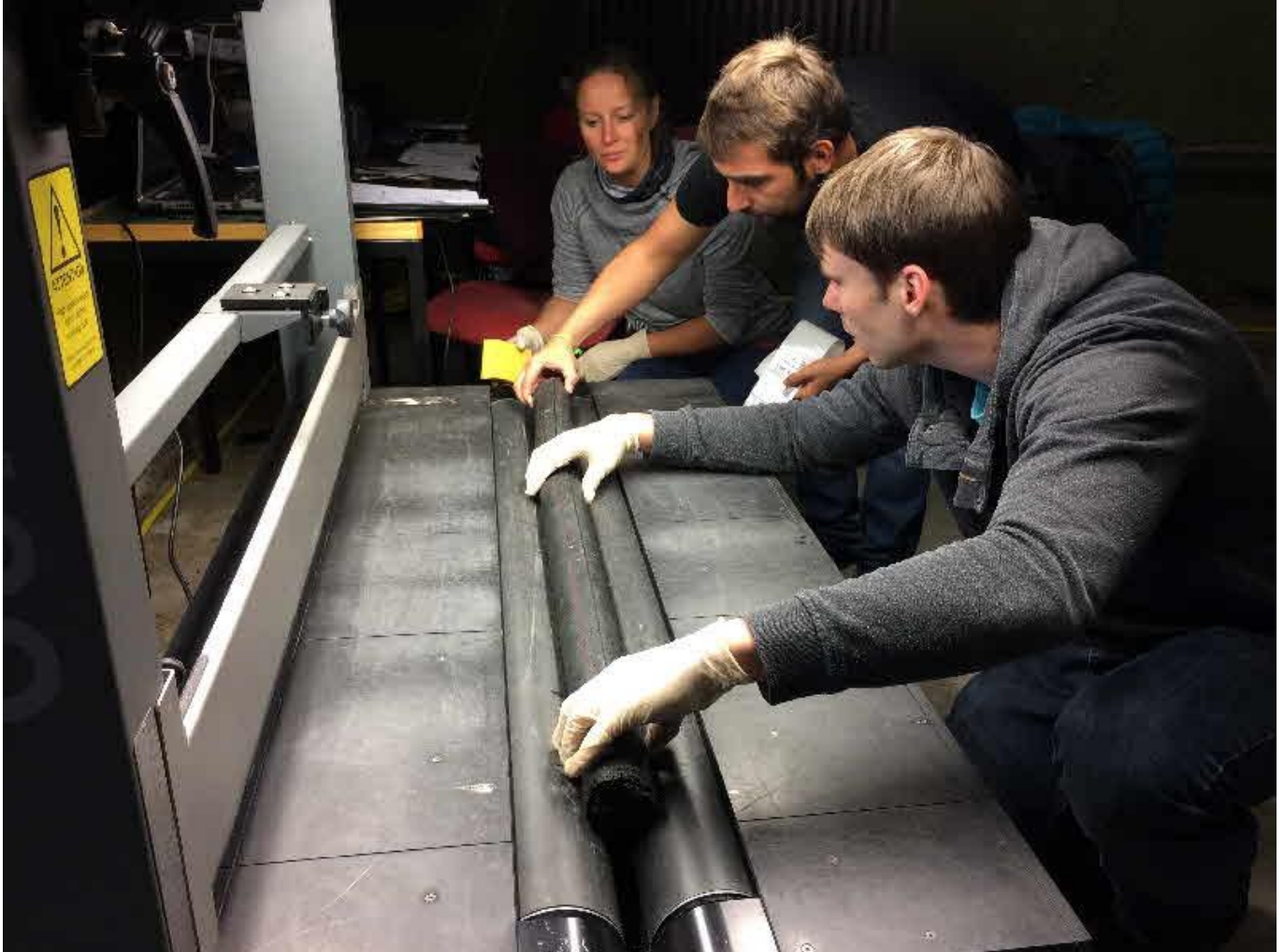


Figure 16: Core scanning at the Surtsey Drilling Project, Iceland 2017

The OSG provides a unique set of skills and equipment that is otherwise not readily available to the research community. Much of the success of the ICDP can directly be attributed to the contribution of the OSG that has supplied service for downhole

Logging, fluid sampling, borehole seismic measurements, and gas monitoring, as well as core scanning and core logging instrumentation. OSG has trained personnel to assist in planning and in

deployment or during campaigns and conducts training sessions to educate geoscientists about methods/techniques available Geophysical Downhole Logging. The philosophy of OSG offering a certain amount of slimhole logging service, core scanning and logging instruments and online gas monitoring is to enable also low budget projects or projects with a minor focus on e.g. downhole data to acquire the most commonly desired parameters. Bigger projects usually with a broader scope of scientific questions have always and will continue to hire services from commercial providers (downhole and at surface) to gain parameters exceeding the basic set offered by OSG or other groups from academia. OSG services never were and must not be in competition with commercial service providers.

### **Instrument pool**

OSG does currently neither have sufficient personnel nor equipment to provide services to an increasing number of projects. Hiring of additional long-term technical staff to handle the increasing tasks and an expanding instrument pool could alleviate this problem. Another measure shall be to improve the network over which logging resources might be shared with other institutes.

It is also obvious that not all projects will have the same level of logging

requirements. Shallow drilling in lakes, in particular, could possibly get by with a much smaller range of tools (perhaps as little as natural gamma spectrum and magnetic susceptibility) deployed by the smallest OSG logging winch. Alternatively, such an additional small tool set could be of memory-type to allow for drill-pipe deployed logging (no wireline). This so-called logging-while-tripping-method is furthermore the only way to guarantee continuous downhole data in unstable lake drilling holes.

OSG has had difficulty obtaining sufficient resources to carry out their work particularly in attempts to purchase new and/ or upgrade existing equipment. That said, the OSG charges still remain quite low particularly when compared to other commercial and even academic groups worldwide who must recover costs. As such, there is probably some latitude to increase the fees charged for carrying out OSG services.

### **Data usage**

As noted above, traditionally OSG has not played a large role towards the final interpretation of the downhole logging data; and given that in many circumstances geoscientists may not be well prepared to use such data one recommendation is that

It is our philosophy to enable also low budget projects to acquire the most commonly desired parameters.

the OSG play a stronger scientific role to ensure that the data are properly used. It would allow for increased visibility of the OSG and for increased opportunities for the continuing professional development and retention of OSG personnel.

### **Post-job report**

The OSG logging group should establish a standardized technical-scientific post-job report. It will contribute to the lessons learned knowledge base at OSG. Furthermore, OSG is aware of a strong interest of the industry in such experience reports.

### **Downhole parameters**

Most ICDP projects were not fully satisfied with the available downhole parameters (logging tools) be it from OSG or from other providers from both industry and academia. Some tools simply do not exist for slimhole sizes or they are available from the service industry but are unaffordable for projects at remote locations and/or with a long stay time of the equipment. Across the very different projects in ICDP the range of desired but unavailable downhole parameters/ measurements is of course wide but with a clear prioritization according to the frequency those parameters were desired.

Some of the desired downhole instruments are available on the market for purchase but are not offered as logging service. Those easily can be purchased by OSG. Others do not exist in a manner suitable for the typical ICDP slimhole conditions. The effort needed to develop those will necessitate research programs together with the industry. Funding for most of these has to be sought outside of ICDP. OSG should take the leading role in identifying both desired tools and the potential partners, and to initiate and guide the development.

### **Actions – downhole logging**

The gains from OSG logging sonde fees from projects are not anymore sufficient to entirely cover the average annual maintenance costs. The suggestion is therefore to raise the sonde fees by a factor of 2.

In order to ensure logging of the most essential parameters for stratigraphic correlation in lake drilling projects (SGR & MSUS) even under very difficult logging conditions such as collapsing holes, the purchase of a set of Memory Logging Sondes for logging while tripping (conveyed by the drill string) or alternatively rope conveyed will be key.

Priority	Action	Start	Duration	Costs	Source
1	Higher OSG sonde fees	now	permanent	10/project	projects
2	OLGA system	2017	< 0.5 years	160	ICDP
3	Memory sondes (MS), MSUS & Spect-GR MS, sonic & ind. resist.	2017/18 2019	1 year 1 year	300 200	ICDP ICDP
4	Extra OSG assistance	now	permanent	none	OSG
5	Electric borehole imager	2017	2-3 years	300	ICDP
6	Density, XRF or gamma sonde w/ industry	ongoing 2018	1-2 years > 3 years	100 300	ICDP ICDP
7	Gyroscopic orientation sonde	2018	purchase	150	ICDP
8	Elemental slimhole sonde	2019	2-3 years	1000	undetermined
9	Tests w/ new Luleå HF sonde	2017	1 year	25	Project
10	Logging through casing – ind. Resis.	see in 3	1 year	none	OSG
11	UH-TEMP slimhole sonde	2017	1 year	30	ICDP
12	Gravity sonde service	2017	1 years	20/project	projects
13	Monitoring data logger	2017	1-2 years	unknown	ICDP
14	Monitoring experience DB	2017	permanent	none	OSG
15	Spooling unit for multiple cable drums (monitoring installattons)	2018	0.5 years	50	ICDP
16	Inventory of valuable old holes	2017	permanent	none	OSG

Figure 17: Table of actions and costs for enhancing measurements in OSG  
all costs in kUS\$

Further parameters desired are Resistivity & Sonic. As the main target will be lake drilling projects these memory tools can have a low T/p rating of 70 °C/20 MPa (-> lower costs) and are available on the market.

Stronger scientific OSG assistance with the logging data analysis requires mandatory involvement of OSG in the scientific logging data analysis. OSG should develop a standard procedure of an integrated analysis of core and logging data and a

standard minimum set of logging parameters. Its application should become mandatory for all ICDP projects, probably different standards for a few types of projects (e.g. lake drilling vs. hard rock drilling or shallow vs. deep drilling). OSG has already started forming of a standard analysis with a broader concept of core-log-seismic integration. Furthermore, OSG has started to analyse existing but previously untouched logging data from earlier ICDP projects in collaboration with PIs.

High-resolution oriented images of borehole walls even in rough boreholes (enlargements, breakouts, washouts) should be addressed through the acquisition of a slimhole hi-res electric borehole imaging sonde (development needed, no tool available on the market).

### **XRF density sonde**

In order to expand the OSG capabilities to log also the bulk density of the rock the acquisition of a slimhole density sonde without a chemical radioactive source is important. OSG is already involved in the development of an XRF density sonde within a currently running GFZ/ SME project.

### **Borehole orientation**

For determination of the borehole orientation (borehole path) in cased holes

and/ or in areas with strong magnetic disturbances a slimhole gyroscopic survey tool (mechanical or optical) is desired. It could be purchased or preferably, OSG could establish a project-wise availability from the service industry, as only few projects require for such a measurement.

### **Geochemical slimhole sonde**

The acquisition of a slimhole geochemical sonde without nuclear source is recommended in order to expand the OSG capabilities to log quantitative element composition of borehole rock for enhanced core-log integration. Sonde development is needed as there is no such slimhole sonde available on the market. Two alternative development lines are optional:

- miniaturization of an existing standardized tool from the oil & gas market together with the industry (very high costs)
- X-ray fluorescence sonde for analysing chemical element contents along the borehole wall, a current GFZ development with a small enterprise (operability in-situ has yet to be proven).

### **Hydraulic fracturing**

Orientation and magnitude of the mechanical stress field using hydraulic fracturing (HF) sondes is desired. OSG already purchased a complete wireline HF system for the ongoing Koyna project,

India. This is however not suitable for slimholes but can be modified with moderate effort by the tool manufacturer. Additionally the University of Luleå, Sweden is just about to run the final tests for a new HF stress sonde, which even includes electric imaging of the wall during the fracturing process, it will be available also for ICDP projects.

### Other sondes

Establish availability from the service industry of a slimhole version of a dipole shear sonic sonde for improved sonic data. Development is needed, as there is no such sonde available on the market. OSG could participate in a development project.

Expand the OSG capabilities to log more parameters inside a casing (currently at OSG these are GR, SGR, hole deviation, and mud parameters, MSUS works through a plastic casing). The desired memory induction-resistivity sonde is able to measure through a plastic casing. Also the above itemized gyroscopic orientation tool fits in here.

It was desired to establish the ability to measure the borehole temperature at very high temperatures (> 260 °C). The first approach is to check whether the existing standard sized analog GFZ sonde ( $T_{max} \approx 300$  °C) is sufficient and can be miniaturized to slimhole size (new sonde housing etc.).

Enable determination of a microgravity profile (gravity & density) in slimholes. OSG shall investigate and establish its availability from the service industry.

### Actions – core, cuttings & fluid measurements

The parameters gained with the existing OSG-owned MSCLs and core scanners are sufficient for the on-site core survey.

The OSG-suggested tools Hyperspectral Scanner, XRF Scanner, CT Scanner were considered not to be necessary on-site, although desirable for later measurements at core inventories or labs.

Several projects had initial problems to get the MSCL up and running (detailed reasons were not known in the session). It is common practice that few of the future on-site personnel are trained at GFZ on how to set up and operate the MSCL. These personnel later will distribute the knowledge on-site in the course of the project. The responsibility to organize this lies with the PIs of the project. OSG shall remind the PIs explicitly of their responsibility to make sure trained personnel will be available on-site at all times.

### OLGA – On-Line Gas Analysis

OSG should replace the currently operated old and worn GFZ-owned OLGA system by a

new one. The need for a new OLGA system has been confirmed already by the ICDP SAG (see Technical Proposal from 2015 for details).

The OLGA system performs real-time measurements of: N<sub>2</sub>, O<sub>2</sub>, CO<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>, He, Ar, C<sub>1</sub>-C<sub>4</sub>, <sup>222</sup>Rn and allows sampling for later laboratory studies, e.g. on noble gas isotopes. The new OLGA would also include on-line carbon isotope measurements (δ<sup>13</sup>C) on methane. In addition, also pH and conductivity of the drilling mud are monitored minutely. This online method has been successfully applied on several ICDP projects, e.g. SAFOD, UNZEN, and Mallik.

Beside its great scientific value, it also helps making decisions on site e.g. on fluid sampling and coring. It is often the only chance to get information and gas samples from depth at all because the gas reservoir might be depleted due to mud circulation by the time of a later dedicated sampling or just because the respective zone had to be cased and sealed.

As there was no one in the session group being familiar with cuttings measurements and also not with biological measurements on-site any demands or recommendations were discussed on this topic.

## **Actions – downhole installations/monitoring**

Technology is available from industry but usually has to be adjusted to the individual project requirements. Demands depend strongly on the individual project.

The classification below was stated:

Short-term installations (weeks to months), wireline technology (OSG could provide in part);

Long-term (> half year, years), specialized, not OSG responsibility;

Investigate the potential to use some of the envisaged memory logging tools as possible short-term monitoring instruments.

OSG should initiate the development of a standard 'data logger' unit.

Recording of experiences - OSG as a clearinghouse but should not be driving this.

For short-term installations of diverse cables OSG should provide an electric motor-driven spooling unit (down & up) for typical drums on which electric and/or fibre optic cables are delivered on. The individual sensors, sondes and cables still have to be provided by each project. Specifications of the cable drum size etc. maybe can be defined by a specific





Figure 17: OSG slimhole sondes at the HSPDP drillsite, Kenya 2016

questionnaire to the PIs of upcoming projects. OSG should purchase/ build this Spooling Unit for multiple Cable Drums (SUCD).

Maybe ICDP should insist that PIs consider longer term potential of the boreholes. With piggyback proposals a 2nd set of researchers

could make short/ long-term use of an ICDP borehole after it was drilled and measured.

OSG could make an inventory of existing boreholes that might be available for further investigations.

## WORKING GROUP IV: DATA – CURATION – PUBLICATION



Figure 18: Core boxes from COSC-1, Sweden

The ICDP's practices regarding data management and publication have distinct advantages and disadvantages.

ICDP is characterized by a highly individual, autonomous, and self-organized local project management style, which is in contrast to more platform-

driven, centralized service approaches (e.g., IODP). The question arises for ICDP and associated clients: "How do we strike a balance between these two approaches?", and with that the next pressing question is asked: "Should ICDP look for new ways to conduct its projects?"

ICDP's current organizational framework defines options for data management and publication procedures: Funding and support are closely related to the operational project phase, although data management and publication support services do not end at that point. Since ICDP has only loose controls on a project, (e.g., suggested start and end dates), multiple simultaneous projects can create logistical challenges and high pressure on OSG members. This situation can lead to disruptions in service for ICDP clients. In addition, little or no onsite presence of OSG staff during drilling and the dependence on cooperating external facilities to accomplish project research goals further complicate the conduct and execution of a typical ICDP project.

With 20 years of ICDP support for drilling projects and a growing pressure for project activities, there is an urgent need to define priorities for future ICDP modes of project support regarding data management and publication. Perhaps at the highest level, ICDP must determine whether to support as many projects as possible, at a possible cost of reduction in quality of support; or to focus on providing the highest possible quality of support, but for a limited number of projects.

During the workshop assignment on DATA - CURATION - PUBLICATION, a group of 24 individuals discussed and

summarized their thoughts on defining future-binding directives and recommendations on these pressing questions, and how improving corresponding and existing ICDP practices, workflows and policies can be developed and realized regarding 1) Data and Sample Management in the Framework of ICDP; 2) Standards and Tools; and 3) Data Sharing and Publication.

### **Actions – data and samples**

Develop common and obligatory data management plans to be associated with all ICDP proposals. The plan should include data and metadata acquisition and dissemination, moratorium agreements detailed in a MoU, Open Access policies, and best-practices/ policies for data acquisition and data/ sample curation to accommodate the highly diverse workflows applied among different ICDP projects.

Establish a working group experienced in both data-publication-cyberinfrastructure, drilling and coring workflows and practices to streamline a unified data curation; include use of mobile systems, where applicable, to acquire and access data. This requires changes to the currently existing Drilling Information System (DIS) to accommodate the use of mobile devices (mobile phones, tablets, etc.). Leverage a cooperative network of international partners (e.g. CSDCO and LacCore/ USA, CSIRO/ AUS, Core Repositories in

Our data management and publication support services do not end with the operational phase.

Germany, and elsewhere) for open source software development.

Enhance ICDP's Web Portal to make access to metadata and research data easier. This important aspect for all ICDP data-related issues requires a more permanent ICDP staff base to manage and maintain currently existing data dissemination tools and add modifications as required.

Identify suitable data formats and create machine and user interfaces, which allow connecting with other external data management systems (e.g. the evolving "Open Core Data" architecture of CSDCO/LacCore, I-EDDA, and IODP-JRSO; other IODP; other organizations) to acquire and merge data obtained during the initial field campaign, including Visual Core Description data.

Improve on Project MoU's and licenses (incl. with other agencies) and enforce them through centralized oversight by ICDP while allowing adjustments to planning and execution for each specific ICDP project; establish clear guidelines, milestones and deliverables for the "What", but not necessarily the "How", of data -and sample management plans throughout the entire lifecycle of an ICDP project; the "What" is overseen and managed through a project-assigned ICDP staff scientist together with OSG's data management team.

Discuss planning and project management in its initial phase with experienced PIs from other successful projects and thereby follow "Blueprint Projects" (e.g. COSC; Koyna); foster technical evolution of DIS/Web tools which serve all stakeholders (i.e. the entire science community with an interest in ICDP drilling data).

Data management plans must take into account national and international Open Access data policies. Post-workshop discussions with respective sub-topic leaders have already led to a stronger collaboration between ICDP and other respective scientific drilling organizations (i.e., CSDCO/LacCore and CSIRO) with the goal to match and merge data, tools and management plans.

### **Actions – standards and tools**

Define, create and maintain Accredited Repositories with standardized workflows, data, and data formats, and thereby following best-practices from well-established repositories in Germany (MARUM, SPANAU, GEOMAR) and elsewhere (KOCHI/ Japan; GCR and LacCore/ USA).

Establish and maintain sufficient Staff Resources to support ongoing projects, thereby ensuring proper implementation of standards and use of tools. Personnel and

contractors from partner institutions (e.g. CSDCO/ LacCore and others) could be entrained to support projects as needed to provide sufficient staff capacity at times of greatest demand for support. A “shared contract” personnel base was discussed in the aftermath of this workshop as means to optimize sharing of personnel resources across different organizations (e.g. GFZ, US CSDCO).

Sufficient Instrumentation Resources to support ongoing projects (following the same recommendations and conclusions as above).

Define a Repository Accreditation Process to establish federated repositories around the world that follow a commonly accepted sample material storage, processing workflows and distribution service to the scientific community. It was recommended that there should be criteria for evaluating the suitability of such a repository for ICDP projects, perhaps analogue to re3data.org criteria established for accrediting data repositories.

Depending on the science community’s call for “Full Service” (e.g. containerized labs deployed to the drill site for full core processing on site; dedicated repository service; and others — the group recommended against this approach) vs. “Lightweight Service” (e.g. variations on the status quo — the group embraced this approach), ICDP must provide and

accommodate sufficient staff resources, perhaps utilizing staff from other organizations in periods of greatest demand, for technical and scientific service and support of each ICDP project on a more permanent basis if possible. As consistent personnel perform this work routinely, a strong institutional memory is created, which can lead to a greater degree of consistency among the various and diverse ICDP projects and ease of data integration across projects.

Maintain an Instrumentation Pool on a shared-cost base (as recommended for “personnel”), which pertains to lending, exchanging, and possibly purchasing certain instruments of common usage for typical ICDP projects (e.g., borehole logging tools, and/ or core images/ MSCL scanners in mobile operation modes). Since instrumentation often requires special care and knowledge of workflows and troubleshooting, this aspect of extending a global ICDP-service also warrant the expansion of a trained personnel pool.

Define a solid and explicitly dedicated budget within the project for data and sample management and publication procedures, i.e. ICDP funding that is reserved and not accessible during drilling operations.

## Actions – data sharing and publication

Follow a well-established data publication workflow, which defines clearly Basic Data among the science community prior to project start.

Make an Operational Report (OP) mandatory within a well-defined operational moratorium period which includes core opening, initial measurements, and lithological descriptions. This must take place before the science moratorium (i.e. the actual scientific evaluation) starts, associated with a sampling party and/ or post-drilling workshop. Basic Data sets should be added as a mandatory supplementary publication to expected research publications. Both are feeding an overall ICDP Metadata Catalogue.

Establish IGSN Registration as one component of best practice. However, the allocating agent and methods used to register and track the IGSNs must be allowed to vary. The DIS workflow and GFZ allocating agent is a readily-used option for ICDP projects without existing workflows and allocating agents in place.

Clearly define “protection plans and licenses for data generation and origin”, i.e. OPEN ACCESS policies and practices to control the access to and usage of data.

Develop a system to integrate new datasets and publications generated during the post-

drilling phase of a specific ICDP project with the already existing project database, publication list and ICDP Metadata Catalogue.

Discuss, refine and test the IGSN granularity (incl. sub-samples, pieces etc.) throughout upcoming ICDP projects, which use the DIS as auto-assigning IGSN tool during the data entry process.

Overcome conflicting requirements between MoU-based restricted access to the Basic Data during the moratorium period and recent requests by Copernicus to make them available when publishing the initial paper in the Scientific Drilling Journal (following the “COPDESS Statement of Commitment”).

Tie the publication of the OP report to a funding payback obligation if not delivered in time. Conversely, in the case of fulfilling this requirement, ICDP commits to sponsor the funding of a post-drilling workshop (WS) as progress incentive and bonus to the entire project portfolio.

Extend ICDP’s services, such that a harmonized data acquisition and sample registration schema across the various database systems of various institutions (e.g., CSDCO/ LacCore ”Open Core Data”; AWI/ Pangaea; IODP/ LIMS, etc.) is established and maintained.

Define a Feedback System with and for Science Team Members (STMs) to funnel their post-drilling research and

publications into ICDP's web portal information dissemination system; the question here is what stimulus and incentive can be created to provide this information to ICDP beyond the active drilling phase of the ICDP project.

Suggested action steps are in alignment with "ingredients" recommended by Fran Berman (UCSD) for successful data management procedures:

- Economic support (funding)
- Policy
- Political support and public acceptance
- Stakeholder support and responsibility (social norms)

## **Costs**

- Human Resources (web data manager; staff scientist; additional programmers/software developers)
- Technical developments (Web Portal; Mobile Apps)
- extra (yet worthwhile) ICDP funding for post-drilling workshops
- same applies for data sharing procedures and corresponding hard/ software developments

## OUTLOOK

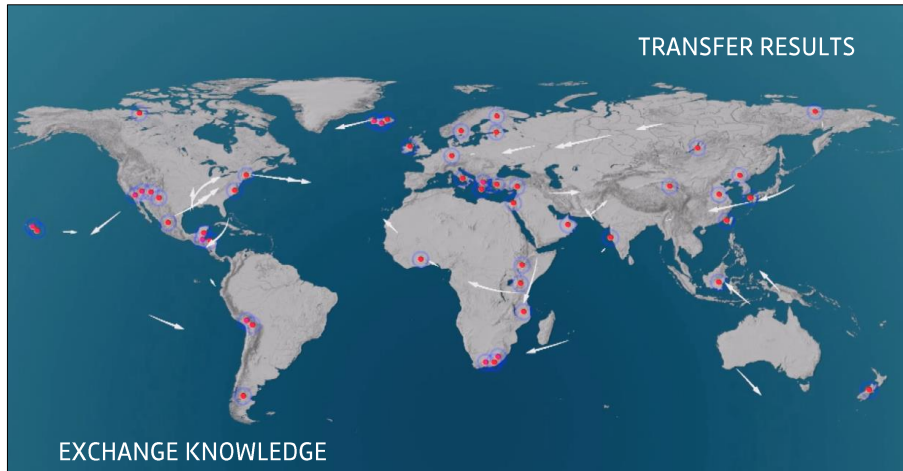


Figure 19: The ICDP Network shown in the [ICDP image video](#)

Since over two decades now, the ICDP showcases a prime example of successful commingling of international funding. Drilling and sampling Earth’s subsurface can be prohibitively expensive but ICDP’s upfront funding approval is often key for science teams to overcome the financial threshold and ignites further third-party funding.

A second pillar for ICDP’s success is the provision of operational support through the OSG at the GFZ. It offers instruments and services for project science teams critical for best possible on-site science and engineering as well as ensuring long-term transfer of know-how from one project to

another.

This document summarizes the open forum discussion on the future of operational support in ICDP held during the 2016 symposium. It serves as a guideline for all ICDP stakeholders where to focus and how to invest in operational support in the future. Nevertheless, the dynamic development of science and instrumentation will require additional adaptations to project needs addressing the overarching goal of ICDP “enable world-class science using drilling to address key Earth-science questions of high societal relevance”.

Overall, the workings of planet Earth are far from understood. We provide key insights by scientific drilling for the benefit of future generations.



## ABBREVIATIONS

AOG	Assembly of Governors	IODP-JRSO	Joides Resolution Science Operator
COSC	Collisional Orogeny in the Scandinavian Caledonides	KTB	Kontinentales Tiefbohrprogramm (German Continental Deep Drilling Program)
CSDCO	Continental Scientific Drilling Coordination Office	LacCore	National Lacustrine Core Facility
CSIRO	Commonwealth Scientific and Industrial Research Organisation	MARUM	Center for Marine Environmental Sciences at Bremen University
DCO	Deep Carbon Observatory	MoU	Memorandum of Understanding
DFG	Deutsche Forschungsgemeinschaft	MSUS	Magnetic susceptibility
DIS	Drilling Information System	NSF	National Science Foundation
DLDS	Deep Lake Drilling System	OP	Operational Report
DOI	Digital Object Identifier	OSG	Operational Support Group
DWOP	Drill Well on Paper	PI	Principal Investigator
EC	Executive Committee	SAG	Science Advisory Group
GCR	German Core Repository	SGR	Spectral gamma ray
GEOMAR	Helmholtz Centre for Ocean Research Kiel	SUCD	Spooling Unit for multiple Cable Drums
GFZ	German Research Centre for Geosciences	TED	Technology, Entertainment, Design (conference)
GR	Gamma ray	UCSD	University of California San Diego
HF	Hydraulic fracturing	XRF	X-ray fluorescence
HSE	Health and Safety Executive		
I-EDDA	The Innovative Exploration Drilling and Data Acquisition Network of Infrastructures in the EIT KIC RawMaterials.		
IGSN	International GeoSample Number		
IODP	International Ocean Discovery Program		

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