

ICDP Status and Future

CURRENT STATUS as of January 2023



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ICDP Project with drilling operations in 2022

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- Barberton Archean Surface Environments, Moodies Group (BASE)
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- Drilling the Ivrea-Verbano Zone (DIVE), to be continued in 2023

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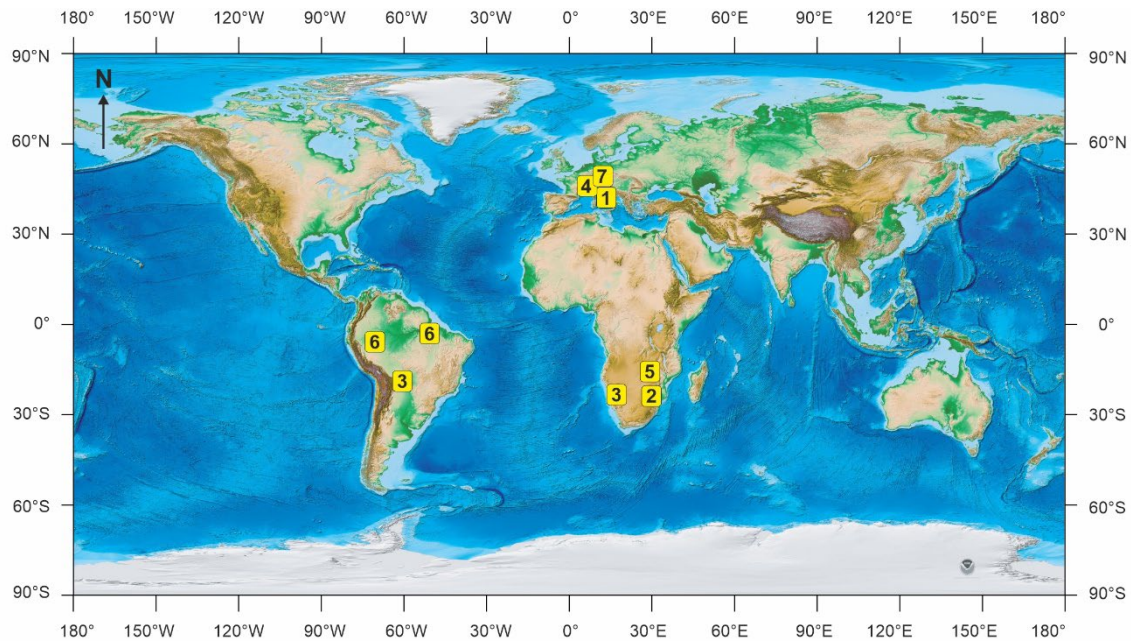
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ICDP Project Schedule 2022/2023



ICDP Projects with drilling operations in 2022

1 STAR	September 2021 – June 2022	Central Italy
2 BASE	November 2021 – July 2022	South Africa
3 GRIND	May – June 2022	Namibia, Brazil
4 DIVE	October 2022 – June 2023	Northern Italy

ICDP Projects scheduled for 2023

5 Bushveld	April – June 2022	South Africa
6 TransAmazon	April – August 2022	Brazil
7 EGER	June – July 2023	Germany

ICDP Projects with drilling operations in 2022



A Strainmeter Array Along the Alto Tiberina Fault System, Central Italy (STAR)

STAR aims to monitor slow (aseismic) deformation by strainmeter arrays in shallow boreholes to address questions about the relationship between creep, slow slip, dynamic earthquake rupture and tectonic faulting at the low-angle normal Alto Tiberina fault (ATF) in the Northern Apennines nearby Gubbio, where layers of Cretaceous and Tertiary carbonate rocks are only slightly inclined on top of each other. Thus, scientists preferentially expected creeping behavior and low earthquake activity of the ATF. Nevertheless, the opposite is observed at times: this portion of the ATF exhibits repeating earthquakes at shallow depth (~4 km), also described as low-angle normal fault paradox. Understanding the physics controlling both - seismic and aseismic slip on a single fault patch, has implications for seismic hazard and risk assessment globally.

The STAR project provides the international community with an opportunity to study creep at local scale and over periods of minutes to months poorly constrained by other geophysical instruments. Within the framework of STAR, six 80 -160 m deep boreholes were drilled in two campaigns in September-October 2021 and May-June 2022 and were instrumented with borehole strainmeters, seismometers and fiber-optic cables to monitor slow (aseismic) and seismic deformation along the ATF. Each of the six sites is also equipped with surface GPS and a meteorological station, allowing correlation between seismicity, degassing (CO₂, Rn) measurements and subsurface strain. Since June 2022, the STAR array has been fully operational.



STAR drilling at Gubbio (Italy, Northern Apennines).



Barberton Archean Surface Environments, Moodies Group (BASE)

With an age of about 3.22 Ga, the Moodies Group represents the oldest well-preserved pro-delta facies sediment layers in the world. Moodies sedimentary successions reaches almost 4 km in stratigraphic thickness, is lithologically variable and was deposited within approx. 1 to 14 Ma. The metamorphic grade is lower greenschist-facies; widespread early-diagenetic silicification preserved micro- and macrot textures virtually without strain. Through extensive biomats along the paleo-shorelines Moodies sediments show that microbial life was already well established in the early oceans and pose questions on the development of oxygenic photosynthesis in Meso-Archean Earth which resulted in the evolution and rise of eukaryotic and complex multicellular life.

The BASE project drilled eight boreholes in Precambrian sedimentary strata in the Barberton Greenstone Belt in South Africa between November 2021 and July 2022. The total drilled length of all holes is 3135.1 m, 93% of which is cored. The entire core was split in halves, the working half being shipped to the Core Repository of the German Geological Survey in Berlin, Germany for sampling and further analysis in January and September 2023.

At Barberton, a remarkable outreach initiative includes a visitor center in Barberton Town that informs the local population, external visitors, and scientists about the Archean geology, the Barberton Greenstone Belt, and the project through posters, samples, and guided tours. The visitor center also serves as a curational facility and for core description purposes.



*Impression from one BASE drill site (left) and activities at the BASE Outreach Center (right).
Photos: Christoph Heubeck.*



Geological Research through Integrated Neoproterozoic Drilling: The Ediacaran-Cambrian Transition (GRIND-ETC)

The Neoproterozoic Era (1000 - 541 Ma) is one of the most dramatic in Earth history: metazoans evolved, the supercontinent Rodinia formed and broke apart, the global carbon cycle underwent high-amplitude fluctuations, oxygen concentrations rose and climate experienced at least two episodes of worldwide glaciation and rapid deglaciation. The multi-stage three-nation GRIND project will obtain cores through archetype successions that record the environmental and biogeochemical context during which multi-cellular life on Earth exploded. The specific targets of the first GRIND phase are the Ediacaran-Cambrian transition strata (560-530 Ma) of western Brazil, southern China and southern Namibia. The objective is to create a core network of correlative ECT strata that will enable constructing a highly resolved, temporally constrained geobiological, stratigraphic and geochemical database, as well as to provide a legacy archive for future research. The goal is to understand the drivers of the Neoproterozoic Earth system revolution: it began with simple eukaryotes that populated Earth during the preceding billion years of the Mesoproterozoic, underwent multiple Snowball Earth events, and emerged with the oxygenated, diverse ecosystems of the Cambrian.

GRIND drilling operations in Namibia started in 2019 and were completed with a final core hole in the southern Namibian desert in May and June 2022. Core drilling in Brazil was also carried out in May and June 2022. In total, 10 holes drilled with a total length of 2686 m retrieved 2634 m (98%) drill core. In addition, drilling in China is planned to commence in 2024. All cores were split and working halves were sent to the German Federal Institute for Geosciences and Natural Resources (BGR) in Berlin-Spandau, Germany. A first sampling party on Namibian drill cores was held in August and September 2022.



GRIND drilling in Namibia and sampling party at the core repository in Spandau, Germany in 2022.



Drilling the Ivrea Verbano Zone (DIVE)

The Ivrea Verbano Zone in the Southern Alps (Italy) probably represents the most complete pre-Permian lower crust – upper mantle transition in the world. "Drilling the Ivrea Verbano Zone (DIVE)" proposes to approach and study the Ivrea Verbano Zone by two ~1000-m deep boreholes in a pilot phase of this drilling project. Scientific drilling includes petrological sampling sections of the lower continental crust and its transition to the upper mantle, geophysical characterization of the crust-mantle transition zone, to study the rheology of continental roots through the distribution of brittle and ductile deformation, and to shed light on the role of the lower crust as a dynamic environment for fluid flow, fluid-rock reactions, volatile cycles, and extreme niches for hosting microbial activities.

Two sites located 8 km apart in the villages of Megolo and Ornavasso within the Ossola Valley were selected to achieve initial scientific goals and provide baseline data for later deep drilling. Drill site DT-1b, located in the municipality of Ornavasso in Val d'Ossola, was drilled between October and December 2022 and reached its key targets already at 578.5 m depth. The hole was completely cored with an excellent core recovery rate of >99%. Scientific investigations at the site included surface seismic surveys, downhole geophysical logging, gas monitoring, and sampling for deep biosphere studies. Drill site DT-1a (Megolo) is expected to drill into pre-Permian mafic lower continental crust to investigate peridotite/pyroxenite-gabbro metasedimentary interfaces in until summer 2023.



Happy scientists in front of the final DIVE DT-1b drill core

ICDP Projects scheduled for 2023



Bushveld Drilling Project (BVDP)

With on the order of 1 million km³ of igneous rocks, the Bushveld Complex in South Africa by itself constitutes a Large Igneous Province that poses first-order questions about how such vast volumes of magma can be generated from the mantle. However, apart from its size, the Bushveld has several other features that make it remarkable. The Bushveld Complex is bimodal in composition, with subequal proportions of mafic and felsic igneous rocks, providing an opportunity to study relationships between mantle and crustal sources of magmatism in detail. The complex also holds an enormous wealth of mineral resources including ores of strategic importance.

Most of the 8 km-thick layered sequence of the Bushveld Complex is below the surface. Mining operations or fortuitous outcrop reveals only parts of the sequence in detail, and without vertical continuity. However, understanding how the Bushveld magmas accumulated and crystallized into layers and how ores formed within them, requires studying a continuous vertical sequence including the roof and floor zones. Furthermore, some of the most interesting science topics require techniques or conditions such as oriented core, or fluid and biological sampling, which will be provided by dedicated new scientific drilling boreholes.

The first phase of the Bushveld Complex Drilling Project, BVDP, was launched at the University of the Free State in Bloemfontein in April 2021 with logging and description of a pre-existing 6-km-long drillcore section, provided by the company Impala Platinum Ltd as in-kind contribution. This core section covers the upper two-thirds of the 9 km-thick Bushveld layered intrusion. BVDP plans drilling approximately 3 km through the lower section of the intrusion and through the base of the intrusion in 2023.



Marking and logging drill cores from the Bushveld Complex Main Zone. Photo: J. Magson, University of the Free State, South Africa.



Trans-Amazon Drilling Project

The Trans-Amazon Drilling Project will address fundamental questions about the geologic and biotic evolution of the Amazon, focusing on (1) how Cenozoic climate and geologic history, including uplift of the Andes and development of the Amazon fluvial system, influenced the origins of the Amazon rainforest and its incomparable biodiversity; and (2) the origin of the Amazonian “Pentecaua” diabase sills, one of Earth’s largest intrusive complexes, and the impacts of this intrusion on the atmospheric gas composition and mass extinction at the Triassic/Jurassic boundary. It is planned to drill the entire Cenozoic sequence (and for two sites also the underlying diabase sequence) in at least three continental sites in sedimentary basins that are aligned along the modern Amazon River and that transect the entire near-equatorial Amazon region of Brazil, from the Andean foreland to the Atlantic Ocean. This transect, coupled with proposed IODP sites on the Amazon continental margin, will encircling nearly 10% of Earth’s equatorial circumference. Spud in of the first well is currently planned for April 2023 while one set of cores from the Central Amazonian basin near Manaus provided by the mineral exploration industry was already described and sampled in summer 2022.



The Amazon region is target of upcoming ICDP drilling activities. Photo: Paul Baker.

EGER

Drilling the Eger Rift (EGER)

The Eger Rift in Central Europe (Czech Republic & Germany) offers a worldwide unique location for studying intra-continental earthquake swarm (ES) activity which appears related to fluid-flow in the crust between 5 and 10 km depth, in combination with deep crust and mantle degassing as well as their interaction with the deep biosphere. Four boreholes were already drilled in 2019/2020 and were instrumented with high-frequency 3D seismic arrays and continuous real-time fluid monitoring tools within the framework of the ICDP project 'Drilling the Eger Rift' to study seismicity, microbial life and origin, heat and fluid flow, fluid pathways, and composition. A 109 m deep pilot hole was drilled in early 2016 to study the impact of CO₂-rich mantle-derived fluids on the geo-bio interaction. In October 2018, the HQ-size borehole Studenec, Czechia, cored mainly phyllites to 400 m depth. Drilling resumed in May-July 2019 with coring a 402 m deep borehole at Landwüst, Germany, and the Hartoušov mofette field in August-September 2019. An additional borehole was drilled in November 2021 at the Bazina Liba site in the Czech Republic (well S4) and reached target depth of 400 m after only 10 days of wireline coring operations to complement the seismic borehole network. After recovering core of high quality and excellent recovery rate, the well was investigated by geophysical logging and equipped with devices for long-term seismic measurements.

Drilling is foreseen to resume in 2023 with drilling operations in Neualbenreuth, Germany. Here, a dry maar renders a suitable drilling target to provides detailed information about the environmental history of the penultimate glaciation, the so-called Saalian Glacial and the subsequent interglacial, the Eemian Warm Period.



Core boxes from the Drilling the Eger Rift project, Czech Republic.

ICDP Workshops and ICDP Training Course

ICDP funds workshops to support groups of international scientists with an outstanding scientific theme of socio-economic relevance that requires drilling. The workshops serve to form a broad and competent Science Team and to develop full drilling proposals to ICDP and other co-funding agencies or industry. ICDP also supports post-drilling workshops after completion of the operative work and basic core and sample description for e.g. discussing of initial results and organizing individual sampling. Over the past years, ICDP supported the conduction of workshops with a broad topical spectrum addressing various future drilling projects.

Workshops 2022	Date and Venue	Participants	Countries
Deep Drilling Turkana Basin (DDTB)	18-20 July 2022 Nairobi, Kenya	43	8
Lake Victoria Drilling Project (LVDP)	25-27 July 2022 Dar es Salaam, Tanzania	49	11
Lake Izabal Basin Research Endeavor (LIBRE)	August 2022 Guatemala City	65	13
US Margin PETM	June 22 and Nov. 17, 2022, virtually and Rutgers Uni., USA August 24 and 31, 2022, at MARUM, Uni. of Bremen, Germany, resp. Grieghallen, Norway	42	10
Gabon and Oxygenation of Earth – Drilling Early Earth Project (GOE-DEEP)	November 1-3, 2022, Trondheim, Norway	43	12
Workshops 2023	Date and Venue		
Connections Among Life, geo-Dynamics and Eruptions in a Rifting Arc caldera (CALDERA)	24-27 January 2023, Tauranga, New Zealand	--	--
Drilling an alkaline-carbonatite complex to understand how fluid-rock interaction influences rare earth element mineralisation, groundwater and deep life (REEDRILL)	22-26 May 2023, Zomba, Malawi	--	--



Lake Victoria Drilling Project workshop (July 2022) in Tanzania.

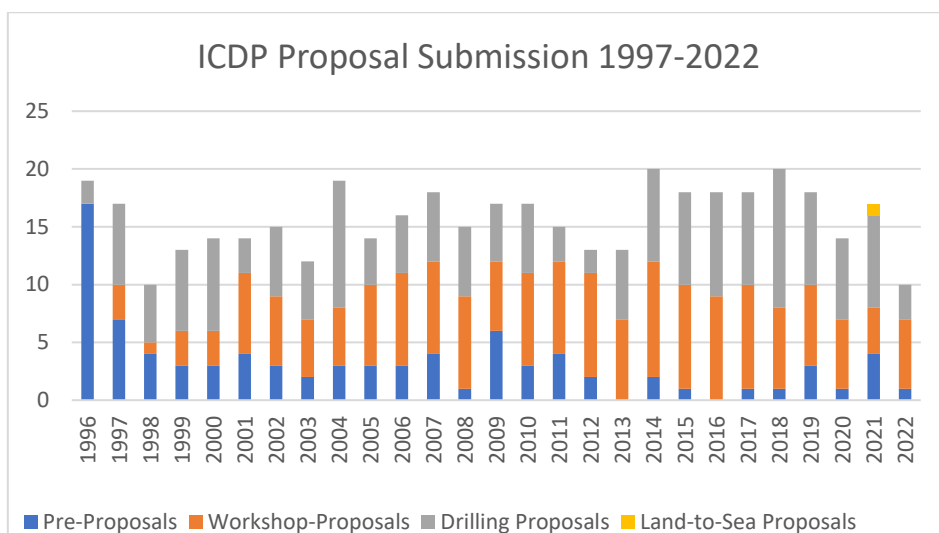
After a hiatus of over two years, ICDP was pleased to conduct the ICDP Training Course on Continental Scientific Drilling in September 2022 at the KTB Geocenter in Germany. 29 attendees from 13 countries followed lecturers and conducted exercises on project planning and management, drilling engineering, rock and fluid sample handling and storage, downhole logging and seismic monitoring, data management, and outreach. The course was topped by a field trip to a geothermal drilling site in Kirchanschöring, Germany, guided by ICDP's drilling engineer.



ICDP Training Course 2022 group photo (left) and ICDP's drilling engineer Said Kamrani (right) explaining drilling techniques at the rigfloor of a geothermal drill in lower Bavaria.

ICDP proposal submission 2022

Three Full Proposals, six Workshop Proposals and one Pre-Proposals were submitted by January 15, 2022. The Corona pandemic and the resulting limited opportunities to conduct workshops and joint studies, such as pre-site surveys, may account for the comparatively low number of full proposals.



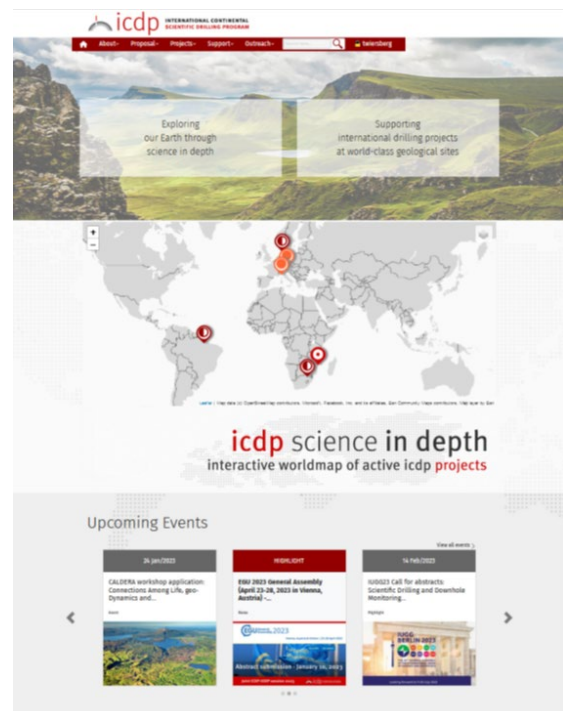
Strategy for new ICDP geothermal proposals

In order to prioritize the increasing number of drilling proposals with a focus on geothermal energy science in recent years, ICDP has implemented a task force to define ICDP's role and strategy in promoting and supporting geothermal-focused projects. To this end, a virtual workshop was held in August 2022 where scientists from the geothermal community and the task force discussed current and future research challenges and gaps. Based on the results of the workshop, the task force published a paper that serves as a guideline for PI teams of future ICDP geothermal applications, but will also support decision making in ICDP panels. The paper was presented at ICDP booths on the European Geothermal Congress (October 17-20 in Berlin) and the AGU Fall Meeting (December 12-16 in Chicago) and is available for [download as a PDF](#).



New ICDP website

By the end of the year 2022 ICDP's Operational Support Group launched a completely new [ICDP website](#). The previous website, published in 2013, no longer met the increased demands of users in terms of design, functionality, and security. The new website serves for improved visibility and as a flagship for the ICDP and provides researchers relevant information about the program, results and achievements of ICDP-funded projects, as well as access to the ICDP data server. In order to improve the user experience according to the needs of the users, input from the ICDP community, including stakeholders, scientists, and panel representatives was taken into account. The new ICDP website was created, designed and implemented almost entirely by the ICDP-OSG with only minimal external input and budget.



Journal SCIENTIFIC DRILLING

The open access ICDP-IODP program journal SCIENTIFIC DRILLING serves to communicate developments from current projects as well as workshop reports and announcements for future scientific-drilling related activities. The continued high number of manuscripts submitted to SCIENTIFIC DRILLING in 2022 enabled the publication of two volumes of the SCIENTIFIC DRILLING, published in February and October on behalf of ICDP by Copernicus Publications and jointly issued with the International Ocean Discovery Program IODP.



Two volumes of SCIENTIFIC DRILLING (SD 30 & SD 31) were published in 2022

ICDP Profile

Scientific Drilling is an indispensable tool of modern Earth Science research, because it provides the only means of obtaining direct information about on-going processes below the surface of the Earth and at depth. Drilling allows determining *in-situ* properties of solid materials and fluids, and permits testing of hypotheses and models derived from surface and remote sensing observations. Drill holes may be used as a natural laboratory for experiments and observatories for long-term monitoring of ongoing active geological, microbiological processes. Earth drilling, therefore, plays a critical role in scientific research directed towards improving our understanding of the workings of our planet and has a key role in solving urgent societal problems.

Multinational efforts in continental scientific drilling have been coordinated by ICDP since 1996. The concept for this program was developed in response to the geosciences community's need for scientific drilling as an essential tool to achieve a better understanding of fundamental Earth processes and structure. The program is based on comingled funding and international cost sharing, joint efforts of international science teams, as well as technology and knowledge sharing. The program concentrates on topics of high international priority, and drilling projects are conducted at locations of global geological significance. The organization is simple and flexible, comprises an independent science review board and executive and oversight committees. Administrative assistance and substantial operational support are provided by the GFZ German Research Centre for Geosciences in Potsdam. Funding is provided by a growing number of member countries, usually through corresponding national funding agencies.

ICDP fosters proposals through international workshops that assist researchers in the development of a drilling proposal. To date, more than 90 ICDP workshops have been funded and have resulted in almost 60 ICDP-supported and successfully executed drilling projects. Thematically the activities have focused on paleoclimate investigations, earthquake and volcano research, impact events, geodynamics, and potential energy resources (see below for current and future themes). Many scientific results from these drilling and Earth observation projects have been published in high-ranking scientific journals. Training of scientists in engineering, on-site science and data management technologies is also an important component of ICDP's strategy to foster the success of ICDP-related drilling proposals.

Global Partners

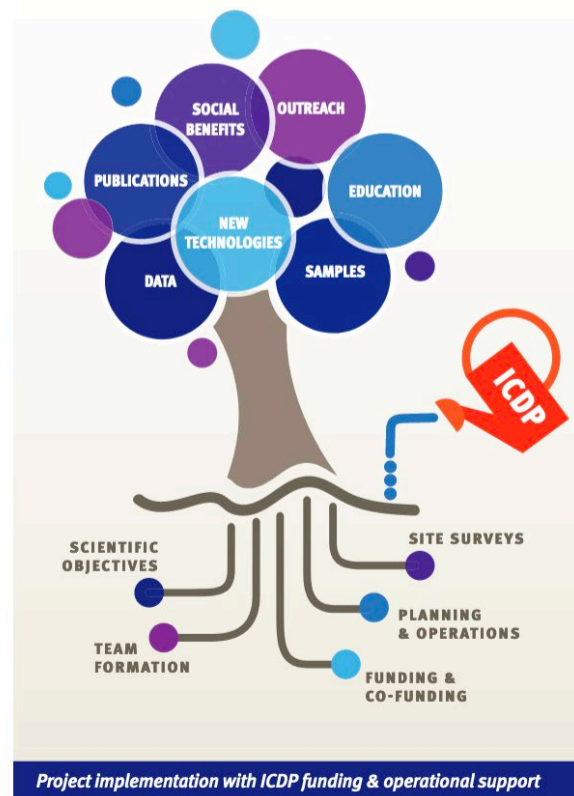
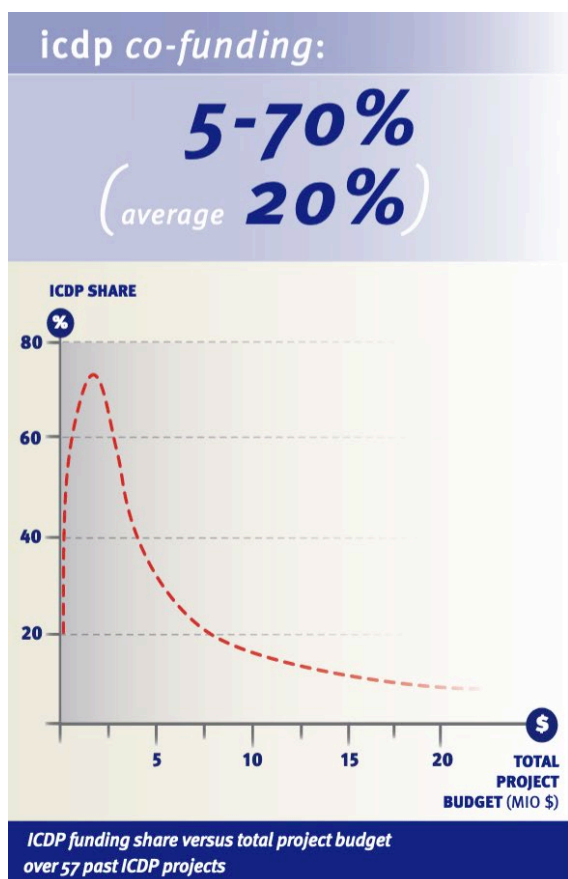
ICDP currently has (as per December 31st, 2022) 23 members including 22 countries (Austria, Belgium, China, Czech Republic, Estonia, Finland, France, Germany, Iceland, India, Israel, Italy, Japan, the Netherlands, New Zealand, Norway, South Africa, Spain, Sweden, Switzerland, the United Kingdom and the USA), and, in addition, UNESCO as member organization. The GFZ German Research Centre for Geosciences in Potsdam is the Executive Agency of the ICDP and acts on behalf of the ICDP members.

Support Level

Drilling projects are an integral component of major geoscience research programs, including comprehensive pre-site investigations, accompanying laboratory studies, drilling (directly supported by ICDP), and measurements and tests in the drill hole. Drilling programs are costly and only realizable to a limited extent by any entity acting alone. International cost sharing, optimal utilization of all available resources, incorporation of international leading experts, and application of the existing knowledge combined with selection of optimal drilling locations ("World Geological Sites"), are all essential elements of the international continental scientific drilling program ICDP.

ICDP is financed through the annual contributions of its members. The membership fees are negotiated between new members and ICDP and vary, based on a number of criteria that include economic factors, scientific impact, manpower and population of the respective country. Low-income developing countries can become ICDP member under the UNESCO membership umbrella.

The ICDP funds are, for the most part, used for co-funding of approved ICDP projects and for executing ICDP workshops and training courses. In addition, funds cover expenditures for the maintenance of the ICDP Equipment Pool which includes the ICDP Drilling Information System (DIS). The annual membership income to support ICDP activities is approximately \$3.5M. The philosophy of ICDP support for projects is based on the ‘comingled funding’ principle. This means that the ICDP –after an in-depth scientific and strategic evaluation- provides partial funding of a project that then typically serves as a door opener for acquiring matching funds. The financial contribution by ICDP to directly support a drilling project varies between about 5% to about 70% (in rare cases) of the total operational costs.



The program is based on a reliable budget with regular financial contributions by the member institutions, strict expense policies including moderate project funding with no long-term financial commitments and very low program administration costs. This allows to attract new Earth science communities through opportunities to get workshop and project proposals

funded. ICDP's organization, its financing through commingled funding, and the bottom-up project policy, which relies on unsolicited proposals and thus drives the program at large, serves as a model for other programs.

ICDP Organizational Structure and Management



The Assembly of Governors (AOG) provides financial and scientific oversight of the ICDP. It determines the program policies, decides on EC-recommended full proposals and allocates the amount of commingled ICDP funding for each individual drilling project. In addition, the AOG decides on the annual program plan, associated budget and discusses the long-range plans of the ICDP as they are prepared and proposed by the EC.

The Executive Committee (EC) is responsible for the scientific orientation and objectives of the program. It decides on workshop and technical proposals, reviews the operational, technical, managerial and financial feasibility of full proposals, recommends funding of full proposals to the AOG, assembles the scientifically prioritized projects into an annual and multi-year program plan. The EC is made up of one appointee from each ICDP member country and nominated by the respective funding partners of the program. EC members are typically science managers with expertise in drilling and/or coordination of major research projects.

The Science Advisory Group (SAG) is an independent body of internationally renowned experts in the research fields covered by the program. Its task is to carry out thorough scientific evaluations of all pre-proposals, full proposals and workshop proposals as they are submitted to the ICDP. The SAG also assigns priority to each proposal based on expected scientific impact, outreach and educational potential. The SAG recommendations are the primary input to the EC as it develops projects for both annual and long-range programs. The SAG has developed the following set of evaluation criteria:

- Quality of Science
- Need for Drilling
- Qualifications of Proponent
- Societal Relevance
- Budget

- Responsiveness to previous recommendations
- Technical Feasibility
- Adequacy of Site Characterization
- Cost Effectiveness
- Project Organization
-



The Executive Director (ED) represents the ICDP internationally and has the executive responsibility for carrying out the program. She or he plays a key role as the international spokesperson and ambassador for the ICDP and oversees the OSG during the planning, implementation and termination of ICDP-supported scientific drilling projects. Another key duty is to translate the program plan into annual and long-range program and budget plans.

The Operational Support Group (OSG) plays a major role in supporting the management of the program and in providing expertise and stability to planning and operation of the overall program. The GFZ German Research Centre for Geosciences in Potsdam handles the administration of the program, including financial accounting and contractual support. Currently the GFZ finances a group of six scientists, engineers and technicians from its own budget who compose the core of the ICDP Operational Support Group and are based at the GFZ. The OSG serves to support the following functions:

- Providing technical and scientific liaison to SAG and EC
- Developing Joint Research Ventures for each project authorized by the EC
- Managing and supporting the Secretariats for AOG and EC
- Assisting in contracting and permitting
- Supporting scientific and engineering drill-site operations
- Supporting field facility for core and sample description and management
- Providing all data collected during each project through a readily accessible data management system for ICDP projects, the Drilling Information System (DIS)
- Preparing – through ICDP's DIS - Initial Reports that describe drilling, engineering, sample and core description, and also procedures for each project
- Providing training courses in scientific drilling prior to and during drilling projects
- Organizing outreach activities on major international geoconferences (AGU, EGU, IGC)

- Editing the IODP-ICDP journal 'Scientific Drilling'
- Developing, purchasing and maintaining an ICDP Equipment Pool comprising scientific-technical instruments and tools for on-site use during ICDP projects
- Providing management support for individual ICDP projects
- Providing and operating ICDP equipment

Management of ICDP activities at the GFZ is conducted by the following personnel:

- Prof. Dr. Marco Bohnhoff (Executive Director)
- Dr. Ulrich Harms (Executive Secretary and Head of the ICDP Operational Support Group).

Credits: Topographic/Bathymetric world map (Page 2) with courtesy from NOAA. All photos by ICDP, if not mentioned otherwise.

