icdp INTERNATIONAL CONTINENTAL SCIENTIFIC DRILLING PROGRAM

SUPPORT

for geothermal drilling projects

icdp STRATEGY

01 INTRODUCTION

4 key research themes of icdp

The International Continental Scientific Drilling Program (ICDP) offers international science teams the opportunity to compete for funds to support drilling and drilling-related operations.

This support is being provided based upon the ICDP Science Plan 2020-2030 that defines our **four key research themes.**

The questions outlined for each theme address fundamental science, but many also link to wider societal challenges encompassed in the United Nations Sustainable Development Goals. The program boasts a strong and active participation of twenty-two member nations plus UNESCO and has undertaken more than 60 drilling projects and run over 80 workshops.

icdp *Science Themes*

Geodynamic Processes

Geohazards

Georesources is one key theme addressing the question of **'How to improve our understanding of and gain access to low-carbon energy sources, particularly for geothermal energy?'**.

To identify current knowledge gaps in geothermal research and to define funding priorities for ICDP, a Task Force of leading geothermal researchers and ICDP panel members was formed to discuss and prepare a geothermal funding strategy. The results were formulated in a detailed **Strategy Paper** and condensed as this **Guideline for Proponents on Geothermal Research Projects** in ICDP.

Our 4 KEY OBJECTIVES

Geodynamic Processes, Geohazards, Georesources, Environmental Change

Georesources

Environmental Change

02 FUNDING PRIORITIES

in geothermal research

1. World-Class Science

In order to gain ICDP support, each proposed drilling project must undergo a strict review process, in which panels of international experts evaluate its scientific merits, managerial maturity and societal relevance. In each case, the first guiding principle that must be assessed is whether or not a proposed drilling project addresses key research questions which Earth sciences have not yet been able to answer. The proponents of a proposed drilling project must demonstrate that their plan is relevant to the grand science challenges facing humankind.

2. World-Class Site

Projects funded by ICDP address questions of global importance to the Earth science community and society at large. Accordingly, geothermal drilling should take place at a location which is considered to be a 'World-Class Site,' where one or more of the fundamental questions in geothermal sciences can be successfully tackled and thereafter the findings transferred to other locations and/or parts of the world.

3. World-Class Opportunity

ICDP values potential linkages between commercially driven drilling projects and science. Accordingly, opportunities to integrate scientifically outstanding experiments in public or industry funded commercial geothermal projects may be considered for ICDP support. However, in each case of such a 'piggyback' project, it must enable scientists to understand underlying processes of overarching importance and must go beyond answering a specific, local question or one small aspect of a research project. As in all ICDP projects, all data acquired in such a 'piggyback' project must be made fully available to the (ICDP) community.

03 RESEARCH FIELDS
in geothermal research

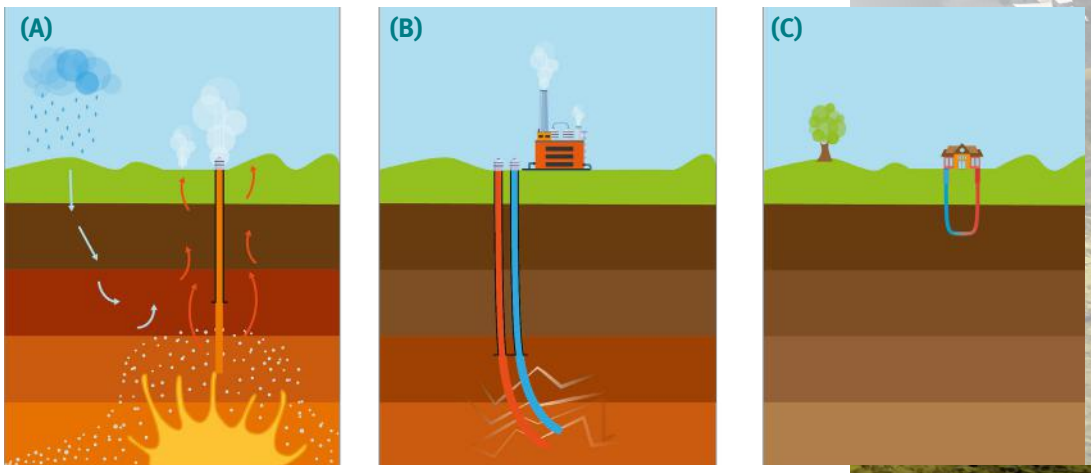
Three main categories of geothermal projects sorted with targeted temperature range have been identified:

1. Supercritical and Ultra-High Temperature Systems, which are so far not operational, and are seen as high risk – high gain. There are significant knowledge gaps and high investments in technology development are required. However, they promise high return on investment and have potential for extremely enhanced energy output.

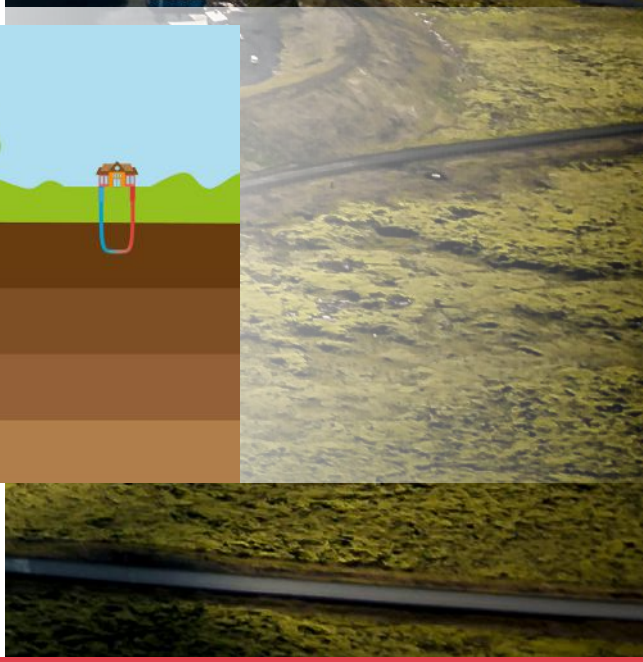
2. Enhanced Geothermal Systems, which in most cases are so far neither operational nor economically profitable. They bear significant knowledge gaps and investment risks – mainly due to potential issues linked to induced seismic hazard resulting in acceptance issues, and uncertainties in achieving sufficient flow rates.

3. Low to Mid Enthalpy Geothermal Systems, where a significant number of units are already operational and economically feasible. They typically hold only few overarching scientific knowledge gaps, but bear low risk per unit.

Our **3** GEOTHERMAL ***Project categories:***
(1) *Supercritical and Ultra-high Temperature Systems,*
(2) *Enhanced Geothermal Systems &*
(3) *Low to mid Enthalpy Geothermal Systems*



Research fields in geothermal scientific drilling
(A) *Supercritical and Ultra High Temperature Systems,*
(B) *Enhanced Geothermal Systems,*
(C) *Low to Mid Enthalpy Systems*



For each of these geothermal temperature ranges there are **similar components** that ensure that the best possible data is acquired for reservoir characterization and long-term utilization in order to minimize the risk of failure in a project. These are:

1. Monitoring

Large geothermal research endeavors need to be accompanied by an integrated and complete observational high-end high-resolution monitoring program that includes but is not limited to rock and fluid parameters, seismicity, stress orientation and magnitude, fault geometry and fracture characteristics.

2. Simulation

Simulation and modelling are seen as key tools to shed light on complex coupled processes in geothermal reservoirs. In particular, understanding structural controls in order to quantify flow features over time and to understand a range of aspects - such as fracture propagation and seismic versus aseismic behavior. Both need high-quality information on reservoir rock and fluid parameters such as, but not limited to, temperature, pressure and permeability from tests on all scales.

Technology Challenges

There is a critical need to develop monitoring instrumentation for (long-term) operation at >100°C under hostile conditions, but this may not yet be available. This is particularly notable for High and Ultra-High Temperature projects were well integrity is key and where secure cementing and casing are critical.

4. New Horizons

There are a number of new horizons in the geothermal sector currently under discussion or under development. Among them are: Closed-loop systems with several parallel boreholes to build a completely artificial heat exchanger; Tapping Mid-Ocean Ridge heat; Ultra-Deep Drilling beyond 15 km depth. ICDP will welcome proposals in these new horizon fields, if the above listed funding priorities of the program are met.

Research field versus challenges matrix for geothermal research in ICDP.
The size of the white circles reflects the magnitude of research gaps and needs.

04 SOCIETAL ASPECTS

attention and acceptance

Public acceptance plays a key role in paving the road for a wide application of geothermal technology, especially in urban areas where the energy is needed.

Geothermal drilling to support sustainable green energy has the potential to embrace the concept of 'good/clean drilling' in contrast to hydrocarbon exploitation. In this respect, ICDP-funded projects need to have a detailed, transparent and project-specific outreach concept to tackle societal needs, potential skepticism, and potential geologic hazards. Such concepts are needed to demonstrate that geothermal (and more general: scientific) drilling is different, clean, and a key tool to address fundamental scientific challenges, e.g. in the context of the energy transition.

Societal challenges and public acceptance issues should be a vital part of any geothermal proposal submitted to ICDP. Every proposal should include an outreach plan addressing these needs and should address project-specific issues.

05 PROPOSALS

submission and evaluation

ICDP offers international science teams the opportunity to compete for funds to support drilling operations. All proposals must be **submitted via email** by the annual deadline of **15 January**.

ICDP considers four types of proposals for evaluation: 1) preliminary proposals, 2) workshop proposals, 3) full proposals, and 4) Land-to-Sea proposals. An independent panel of science experts - the ICDP Science Advisory Group (SAG) - evaluates all proposals submitted based on their scientific merits as well as review criteria outlined above, and gives recommendations to the ICDP Executive Committee (EC) and Assembly of Governors (AOG) for final decision making. The ICDP Operational Support Group (OSG), located in Potsdam, Germany, handles all aspects of the proposal submission and organizes the review process.

Successful proponents of full proposals receive an ICDP grant to cover parts of the drilling and operational costs. In addition, the OSG provides a full suite of services for initiating and planning scientific drilling projects, as well as their management and execution, including scientific instrumentation and downhole logging services. Regular ICDP training courses on handling, studying and interpreting drill cores and well logs are also part of their OSG repertoire.

Details about submission, evaluation, and implementation of ICDP projects are available on the ICDP website at www.icdp-online.org.

This brochure is based on discussions and conclusions of the **ICDP Task Force on Geothermal Strategy** including:

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Our icdp GEOTHERMAL ACTIONS

support up to now

	ICDP STATUS	PROJECT STATUS	TOPICS ADDRESSED
Long Valley Coring Project, LVCP	Full proposal funded 1997	Drilled 1998 - 1999	Geothermal resource beneath resurgent dome
Iceland Deep Drilling Project 1, IDDP-1	Full proposal funded 2002	Drilled 2008 - 2009	Supercritical Zone drilling
Iceland Deep Drilling Project 2, IDDP-2	Full proposal funded 2012	Drilled 2016 - 2017	Coring of Supercritical rocks
Hotspot: Tracking the Yellowstone Plume	Full proposal funded 2007	Drilled 2011 - 2013	Mantle-Crust interaction, low enthalpy exploration
Campi Flegrei Drilling Project, CFDDP	Full proposal funded 2008	Pilot well drilled in 2013	Eruption history, hazards, geothermal resources
Krafla Magma Testbed, KMT	Feasibilty study funded 2020	Feasibility study started in 2022	Magma-rock interaction, magma drilling, testing
Mutnovsky Volcano Scientific Drilling, MVSD	Workshop funded 2007	Not further developed	Hydrothermal system at active stratovolcano
Japan Beyond Brittle Project, JBBP	Workshop funded 2013	Full proposal in preparation	UHT drilling and heat production
Newberry Deep Drilling Project, NDDP	Workshop funded 2017	Full proposal in preparation	UHT enhanced geothermal systems
Cornell University Borehole Observatory, CUBO	Workshop funded 2019	Monitoring well proposal in preparation	Low enthalpy geothermal from low permeable rocks

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